BOA® Group

Expansion Joints Guide — Module 1

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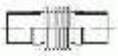
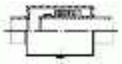
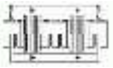
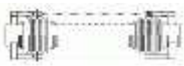
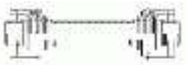
Expansion Joints Guide

Summary Module 1

2 Expansion Joints General

The main function of expansion joints in their various constructions is to compensate for movements in pipe systems, machines and equipment. The movements to be compensated are always relative motions between two parts of a system, caused by temperature differences, misalignment during installation, inertial forces or foundation lowering. Expansion joints are universally applicable in almost every industrial sector. Particularly in pipeline engineering, they allow space-saving pipe routing for transporting a variety of media such as hot water, steam, fuel, heat transfer fluids, hot gases and various types of chemical products. Another application field is the apparatus and motor engineering, where the expansion joints decouple vibrations and structure-born noise from diesel engines, turbines, pumps and compressors, preventing their transfer to the continuing lines. At the same time, expansion joints allow nearly force-and torque-free connection of pipes to sensitive fittings, appliances and equipment (e.g. to turbine nozzles). Moreover, expansion joints serve as assembly aids for pipe elements such as valves, where they are used as dismantling pieces or couplings.

Overview Expansion Joints

Type	Design		Pressure thrust restraint	Movement				
				Axial	Angular		Lateral	
					Single plane	Multi plane	Single plane	Multi plane
Axial Expansion Joint	Non-pressure balanced internally pressurized		No	X	(X)	(X)	(X)	(X)
	Non-pressure balanced externally pressurized		No	X	(X)	(X)	(X)	(X)
	In-line pressure balanced		Yes	X				
Angular Expansion Joint	Hinge		Yes		X			
	Gimbal		Yes		X	X		
Lateral Expansion Joint	Two tie-bars spherical		Yes		X		X	X
	Two tie-bars pinned (plane)		Yes				X	
	Three or more tie-bars		Yes				X	X
	Double hinge		Yes		X		X	
	Double gimbal		Yes		X	X	X	X
Universal Expansion Joint	Unrestrained One or two bellows	 	No	X	X	X	X	X
	Pressure balanced		Yes	X	X With two tie-bars only		X	X

NOTE 1 X – Applicable

NOTE 2 (X) – Limited use

The table shows an overview of expansion joints types, laid out according to their main function and construction characteristics with the possible movement compensation. Particularly to be remarked: all unrestrained types, while under pressurisation, perform a pressure reaction force **(= product of pressure x cross-section of expansion joint)** on the piping. Therefore these pipings need to be particularly fixed and guided.

2.1 Main elements and their functions

As the above displayed overview table shows, there are expansion joints designs, depending on a variety of different compensation tasks. Usually, expansion joints have the following components:

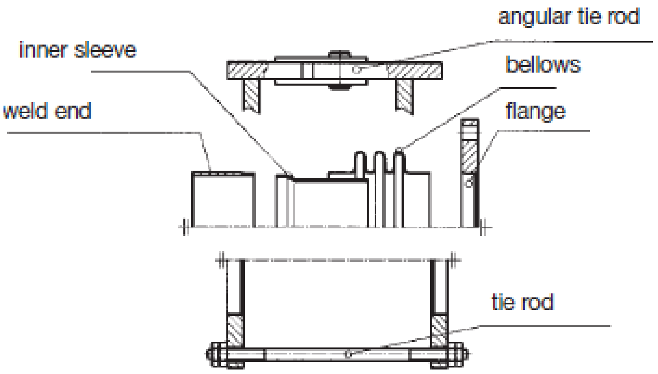
Bellows:
They are the flexible element oft the expansion joint and are designed, depending on the requirements, with different numbers of corrugations and layers.

Guide sleeves:
They protect the bellows against the flowing medium and reduce the flow resistance

Protective tubes, guiding tubes:
They protect the bellows against mechanical damage and, depending on the design, prevent the expansion joint from lateral deflection (buckling).

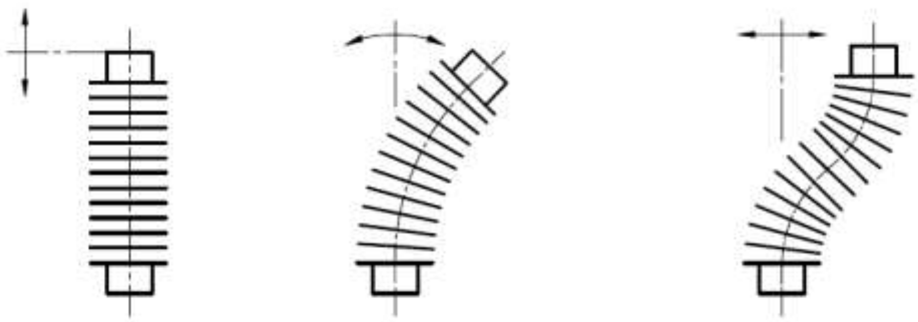
Fittings:
They make the connection to the continuing piping. Depending on the design, the following fittings are available: weld ends, ends to be soldered, flanges, threaded nipples.

Restraint (only for lateral-, hinge or pressure balanced types):
The restraint transmits the pressure reaction force over the single or, depending on the design, multi bellows. Simultaneously the restraint determines the kinematic flexibility of the expansion joint by incorporating different types of hinge bearings, such as ball joints, single axis bearings with bolts, U-joint or gimbal bearings.



By combining the above shown main elements, depending on the compensation task, the various types and designs can be generated, which are displayed in the following standard programs of the BOA Group, by types, sizes, pressure ratings and expansion compensation.

2.2 The bellows and its function



axial movement *angular movement* *lateral movement*

The core element of every expansion joint is the metal bellows (*), which by its corrugation geometry and thin-walled design has a large flexibility in axial, lateral or angular direction, as well as a high pressure resistance. As a condition to be used as an expansion element, the bellows must meet the following basic requirements:

(*) Exceptions are the rubber expansion joints with their particular operating conditions

The bellows must

- withstand the operating and test conditions (pressure, temperature) of the pipe system,
- be corrosion resistant against internal and external influences,
- be able to compensate for flexible expansions or possible oscillations, and achieve a specified life time or number of load cycles and
- have sufficient stability against buckling

Using corrugations in form of a lyre (see fig.1) is a good compromise between the contradictory requirements for high flexibility combined with high compressive resistance. They are the preferred corrugation shape for standard bellows. By changing the radii, the profile height, the number of layers and the wall thickness, their geometry may be adapted to the requirements on pressure and expansion capability.

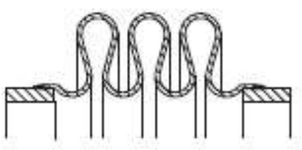


fig. 1

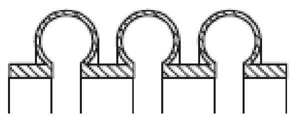


fig. 2

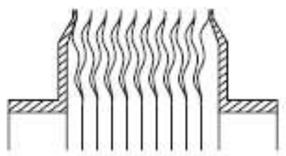


fig. 3

In contrast, a toroidal corrugation profile (see fig. 2), has a high compressive resistance with reduced flexibility, whereas a membrane-shaped corrugation profile (fig. 3) has the highest flexibility, but a low compressive resistance.

Within BOA Group, all profile shapes are produced and may be supplied on request.

2.2.1 The one to five-layer bellows, produced by hydraulic complete forming (Hydraulic Formed Bellows HFB)

Traditionally, BOA BKT produces one-layer bellows, but at higher pressure and movement requirements up to five layers can be manufactured by nesting in sleeves one into the other.

fig. 4

The bellows cylinders are made of strip material following the procedure steps shown in fig. 5: cutting, rounding and longitudinal welding.
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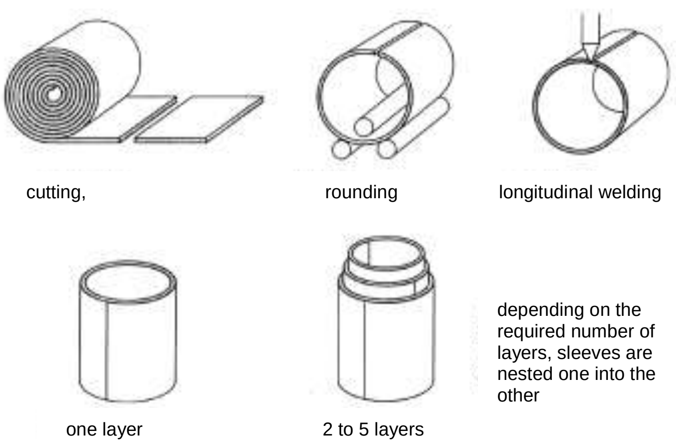
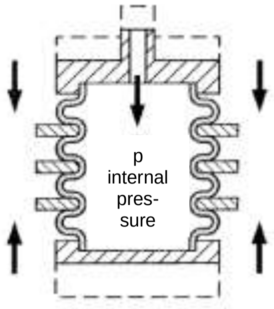


fig. 5

The bellows is manufactured as shown in fig. 6, out of one or several thin-walled cylinders, nested one into the other, using the hydraulic complete forming procedure.



Bellows manufacture

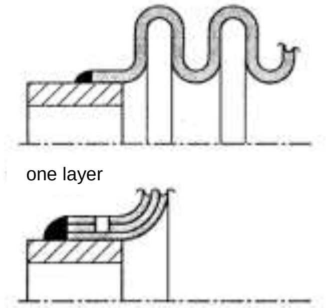


fig. 6

To ensure that the inner bellows layer is welded tightly to the weld end, the outer support layers of bellows consisting of more than one layer are provided with a relief bore. In this way it is possible to check the tightness of the inner layer by means of a leak test.

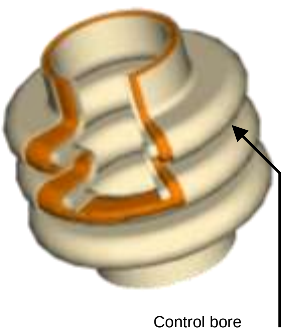
2.2.2 The several to multi-ply bellows (2 to 16 layers), produced by elastomer single convolution shaping (Elastomer Formed Bellows EFB)

BOA AG as the inventor of the several or multi-ply bellows, continues to evolve this procedure, manufacturing bellows made of austenitic and other high-quality materials. The number of layers of the standard products can vary from a minimum of 2 to a maximum of 16 layers.

Using thin strip material, two leak tight inner tubes and one outside tube are manufactured by longitudinal welding. Between them, depending on pressure and temperature, starting from a certain number of layers, strip material is spirally wound up and put together to a compact cylindrical pack (see picture at left). The single cylinders may consist of different materials, e.g. to obtain cost-effective solutions **for increased corrosion resistance**.

By pressing out annular corrugations through elastomer cold forming, the multi-ply bellow is manufactured with the particularly favourable technical properties:

- **high flexibility**
- **short construction length**
- **small displacement forces**
- **large movement capacities**
- **small corrugation height**
- **vibration absorbing**



These virtues bring cost-effective solutions, such as small number of expansion joints, small dimensions of shaft structures or low cost solutions for anchor points. The multi-ply bellows has also a positive effect on the safety of the expansion joint.
If ever the layer in contact with the medium should start leaking, e.g. by overstress or fatigue, the medium will try to find its way slowly through the labyrinth of the multi-layers. Once arrived out-side, it will automatically display the leak at the control bore.
This principle has the following safety benefits:

- **early detection of leaking**
- **possibility of permanent leaking control while using dangerous media** (by means of the relief bore)
- **despite weak leakage, pressure resistance and functionality of the expansion joint are maintained for a certain time (weeks, months)**
- **no need of immediate replacement**
- **spontaneous bursting is impossible.**

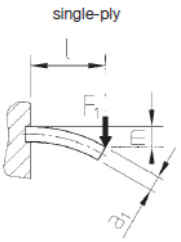
Multi-ply bellows also show their advantages used in vibration absorbers. Thanks to the compact layer structure, friction effects arise inside the bellows pack, and as the bellows is moving, the force-deflexion-graph develops hysteresis.

• **Thus, the principle of the multi-layer bellows is an excellent solid-borne sound absorber. Similar results are reached as with rubber elements, plus the advantage of higher resistance against temperature, pressure and ageing.**

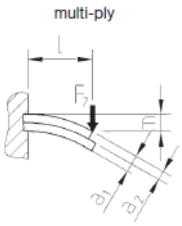
Properties of single-ply compared to multi-ply expansion joints

- high plane and column stability with the same wall thickness
- high corrosion resistance due to thicker wall thickness
- reduced vulnerability to external damage
- own repair welding may be possible at leakage

2.2.3 Calculating the multi-ply bellows



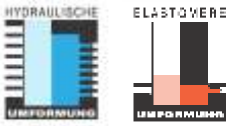
The positive effect of the very flexible multi-ply bellows compared with the single-ply expansion joints is easy to demonstrate with a simple bending bar. It is evident, that at the same bending rate and the same dimensions, with half of the bar's thickness a, the bending stress F2 is also halved, and the displacement force of the two-layer bending bar is only one quarter of the original value.



Usually, the bellows are exposed to extreme static or dynamic forces generated by internal pressure, temperature, vibrations etc. Compared to a fix pipe system, the calculation of the effects of the varying forces on a multi-ply bellow becomes very complex.

STANDARDS OF THE EXPANSION JOINT MANUFACTURERS ASSOCIATION, INC.

To meet the high safety requirements, engineering must be supported by a reliable and tested calculation method. BOA makes use of the results and knowledge of the group of American expansion joints manufacturers (EJMA), published since 1958. This calculation method has been proven for multi-ply expansion joints and is recognized by all international certification authorities.



2.2.4 Criteria for problem-oriented choice of bellows

The following standard programs of BOA enable the user to choose the type of bellows and expansion joint particularly suitable for the targeted application. For better understanding, the different options available in bellows technology (HFB / EFB) will be explained with an example.

Let's first consider a **single-layer** bellows with **4 convolutions** and a wall thickness of **s = 1mm**.
With a profile height of H = 28mm, the bellows is suitable for an operating pressure of p_{adm} = 10 bar, and has an expansion capability of Δ_{ax} = ± 12mm at an axial spring rate of c_{ax}.

If we want to realize the **same performance** for pressure resistance and expansion capability with a **multi-layer** bellows, we already need 4 layers (each one with a wall thickness of **s = 0.5 mm**) to achieve the same pressure resistance. However, the individual layer thickness being only half, the expansion capability per convolution doubles, so that for a movement capacity of Δ_{ax}= ±12mm **only 2 convolutions would be required**, or keeping the same number of convolutions (4), we reach now the double expansion capability Δ_{ax}= ±24mm at about half the spring rate (0.5 c_{ax}).

In the next step we further reduce the layers' wall thickness to 0.3 mm. Again, to achieve the same pressure resistance, 9 bellow layers are now required, which, at the same number of convolutions (4), triple the expansion capability to Δ_{ax}= ±36mm and lower the spring rate to a third.

The dependencies are summarized in the table below:

admissible working pressure p_{adm} = 10 bar, profile height H=28 mm				
layer thickness s (mm)	number of layers n	number of convolutions W	expansion capability Δ_{ax} (mm)	spring rate
1	1	4	± 12	c_{ax}
0,5	4	4	± 24	0,5 c_{ax}
0,5	4	2	± 12	c_{ax}
0,3	9	4	± 36	0,33 c_{ax}

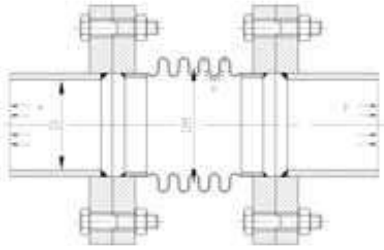
If the **primary compensation task is to absorb a specific thermal expansion**, regardless of the length and the displacement forces of the expansion joint, as in the case e.g. of axially compensated district heating pipelines, **a bellows of one or few layers** will sufficiently solve the compensation task.

If **space conditions for installing the expansion joint are restricted**, a **multi-ply bellows** will significantly reduce the overall length.

However, if the **connection forces or moments** on a sensitive turbine or equipment nozzle are the main argument, then these can be reduced to one third by choosing **a multi-layer bellows,** compared to the single-ply solution with equal length.

If the compensation task is **to isolate or damp oscillations of small amplitude**, the use of **few or multi-ply bellows** has a dampening effect on the upcoming forced vibration, due to the layers friction.

2.3 Unrestrained expansion joints



Expansion joints without tie rods (axial and universal), while under pressurization, act a reaction force FP (= product of overpressure p x cross section area [AB]) upon the pipe system and the anchor points.

The bellow's cross-section [AB] may be taken from the dimension tables of the expansion joints types. At high pressure rates and large nominal sizes, the reaction force increases considerably, e.g. at a pressure of 40 bar and 400 mm nominal size, the reaction force is approx. 600 kN. Therefore the anchor points have to be massive.
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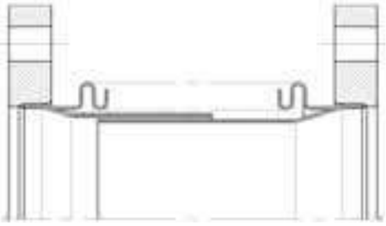
2.4 Restrained expansion joints

The reaction force, explained before, is taken up by a tie bar system, i.e. articulation elements or tie rods. Depending on the pipe routing and the occurring movements, the appropriate type of restrained expansion joint is chosen. Despite the restraining element, the overall length of the expansion joint remains short, thus being also advantageous for system solutions.

If high pressures or pressure impacts occur, and to avoid massive and expensive anchor point constructions, the experienced engineer will choose restrained expansion joints.

Along with taking up the reaction force and its correct transmitting into the connecting parts, the tie rods support the articulation elements, thus ensuring the motional function. Besides, very often there are additional loads and moments to transmit. It is evident, that the dimensioning of the restraining elements has to be supported by a reliable and tested calculation method. BOA engineers are using FEM, calculating with the non linear limit analysis. Their results mainly meet the values received during many practical experiments and burst pressure tests.

2.5 The inner sleeve (protection tube)

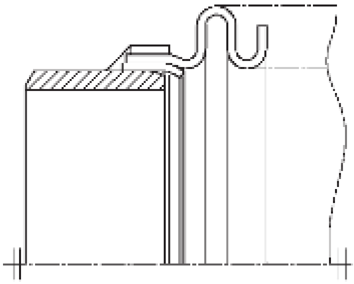


Inner sleeves protect the bellows and prevent it from being activated into vibrations, caused by the medium's high speed. The installation of an inner sleeve is recommended,
- if abrasive media are used
- if large temperature variations are expected
- to prevent the deposition of solid parts in the corrugations
- if the flow rate is higher than approx. 8 m/sec for gaseous media
- if the flow rate is higher than approx. 3 m/sec for liquids

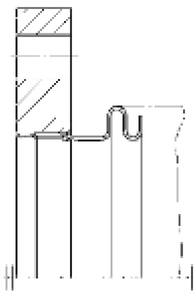
For further instruction see "Installation and Operating Instructions"

2.6 Types of connection

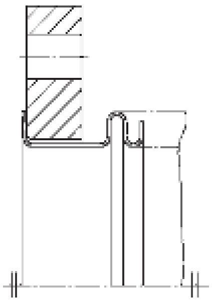
Depending on the application, replaceability, safety or pressure rate, usually three methods for connecting the expansion joint to the pipe system or to the unit are distinguished.



Expansion joint for welding in



Expansion joint with welded flange connection

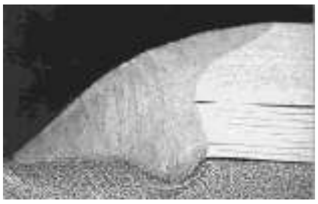


Expansion joint with loose (movable) flange connection

2.6.1 Expansion joint for welding in

The advantages of this connection type are:

1. The outside dimensions of the connection are compact to the continuing piping
2. The leak tight weld seams (which may be examined by non destructive test methods) for the application under elevated pressure conditions or with dangerous fluids.



Welding the multi-ply bellows made of austenitic steel to the ferritic weld end (or flange) is a process which requires particular measures, skills and experience. It is one of the decisive points for the quality of the expansion joint. With the necessary checks, BOA guarantees the capture of bellows' layers into the welding, a massive and continuous weld structure and a minimal heating zone. With our tested and optimized welding process, weld flaws, heat cracks, inclusions, pores and blowholes are excluded.

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2.6.2 Expansion joint with welded flange connection

The advantages of this connection are rapid replaceability and the expansion joint's short overall length. Regarding the connection weld between flange and multi-ply bellows, the same high standards apply as for weld ends.

2.6.3 Expansion joint with loose (movable) flange connection

The advantages of this connection are, as with welded flanges, easy replaceability, fast assembly and the short overall length.

Furthermore, the austenitic bellows, forming a collar on both sides, allow flange rotating. In case of non-aligned hole patterns and aggressive media inside, the bellows' collar protects the flanges, so that no specific flange material is required. However, this type of flange connection is not available for all pressure levels.

2.7 Determination of movement parameters

Expansion joints compensate for various movements, caused by different sources, such as

- installation misalignment
- vibrations
- installation gap
- extension caused by pressure force
- soil subsidence
- elongation

Elongation usually causes the highest movement value.

Installation misalignment
Misalignment occurs very often during pipe installation. These imprecisions may be compensated by expansion joints, if they were already considered in the system design. In this case, the expansion joint's life time is hardly affected, because it is a one-time movement. On the other hand a complete or partial blocking of the corrugations may be caused, if short axial expansion joints are installed. The indicated movement compensation would be hindered, leading thus to early failure of the expansion joint.

Vibrations
Vibrations of different frequency and amplitude are caused by rotating or shifting masses in installations such as pumps, piston machines, compressors etc. These vibrations not only make annoying noise, but stimulate connecting pipes to the extent of fatigue causing early failure. Thus the operating stability and economic efficiency of the installation is at risk.

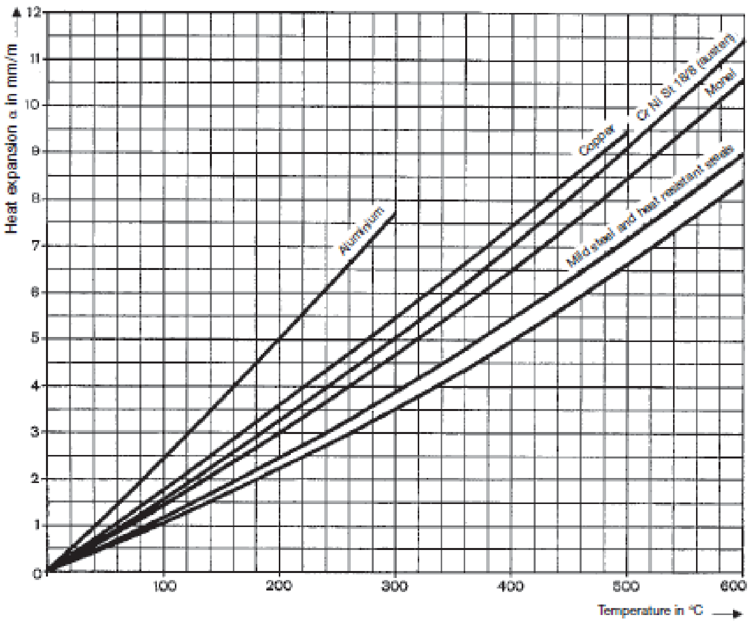
Installation gap
During the installation of pipe systems, particularly when subsequent removal and replacement of individual components is necessary, an axial installation gap is essential for easy replacement of the modular elements. The so-called disassembly joint may bear a larger movement up to block position of the convolutions, as the frequency of replacement is usually low.

Extension caused by pressure force
Extensions occur in vessels and piping put under pressure force. Their values only have to be considered at larger diameters.

Soil subsidence
Expansion joints may take up larger subsidence movements, because it is a singular occurrence (no stress cycles). The expansion joint may even endure an excessive deformation of the bellows without leakage.

Elongation

Thermal expansion of different metals



Changes in the length of a piping are mainly caused by temperature variations. These changes in length have an insignificant effect in radial direction due to the pipe geometry and can be neglected, since pipe diameter is much smaller than pipe length. However, lengthwise variations of volume deserve close attention, since it can become quite significant when temperature and pipe length increase.

Each material has its own expansion coefficient which for the different types of iron and steel varies in rather narrow range. The differences become more significant for steel alloys such as heat resistant steel, stainless steel or high heat resistant metals and their alloys such as nickel, Monel, titanium, Inconel, Nimonic etc. Copper and aluminium and their alloys have even bigger expansion coefficients.

Using the specific BOA slide rule, the elongation may be determined quickly and almost exactly.

For thermoplastic lines the length elongation is more than twice as large as for steel pipes.

2.8 Criteria for choosing the type of compensation

Basically there are three types of compensation to consider:
- elastic bending of existent pipe legs (natural expansion compensation)
- expansion compensation with unrestrained expansion joints
- expansion compensation with restrained expansion joints

Which of the three types is to be chosen also depends on the following criteria:
- extension and type of the movement to compensate for
- pipe design
- installation and assembly conditions
- dimensioning of anchor points and connections with regard to forces and moments
- total cost of the compensation (compared to costs of the anchor points)

Movements

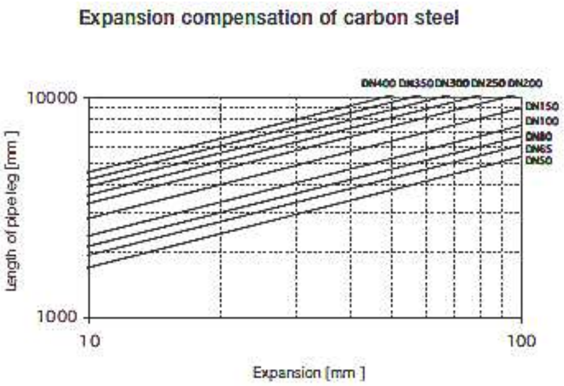
Axial and lateral expansion joints
With axial and lateral expansion joints the occurring expansion corresponds to the real compensation movement.

Angular and gimbal expansion joints
With angular and gimbal expansion joints the occurring expansion must be converted into an angular movement. This conversion is described in detail in Module 3a, angular expansion joints.

2.8.1 Natural expansion compensation

If local conditions allow the alignment of the pipe system between two anchor points in such a way that heat expansions of the pipe are compensated by the elastic reaction of the pipe elbows and legs (bending, twisting), these effects have to be exploited. However, installing extra pipe legs is not an economic solution. Natural compensation is only useful, if the pipes are able to compensate, additional to the stresses caused by internal pressure, the stresses resulting from the movement cycles, and that without early ageing.
Using your own software and tables, we can advise customers whether a natural expansion compensation is possible or if expansion joints are to be provided.

Expansion compensation of right-angled pipe legs

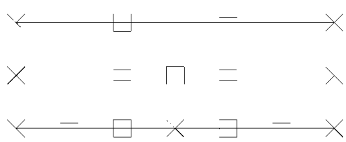


2.8.2 Expansion compensation with unrestrained expansion joints

The reaction force and spring rate of unrestrained expansion joints shall be taken up by the anchor points at both ends of the pipe section. In a longer pipe system, where several expansion joints are installed in series, pipe sections should be created by means of intermediate anchor points. An axial expansion joint shall be placed in each section. The anchor points at both ends of the straight pipe section shall withstand the full reaction force. The intermediate anchor points have primarily to take up frictional and displacement forces.

Axial expansion joints compensate for axial pipe elongations. Therefore, the piping shall be coaxial with the expansion joint. Small lateral movements of a few millimetres are acceptable, however, they reduce the life expectancy of the axial expansion joint, if the allowable axial movement is simultaneously fully used.

Advantages:
- simple way of compensation
- no change in flow direction
- minimal space requirements



Disadvantages:
- strong anchor points and good axial pipe guiding required
- several axial expansion joints are needed for large elongations
- many anchor points and pipe guides are needed for long pipe sections

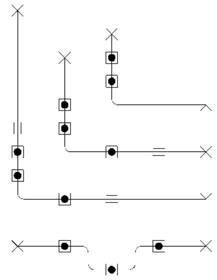
Between two anchor points only one unrestrained expansion joint shall be installed.

2.8.3 Expansion compensation with restrained expansion joints

Compared with unrestrained expansion joints, those equipped with tie rods only need light anchor points (sufficiently firm supports). The reaction force coming from the bellows is taken up by the restraints and acts as an anchor point load. Only the spring rate of the bellows and the friction forces of the restraint act effectively on the anchor points. The anchor points shall be calculated to resist to the friction forces at the pipe guide supports and to the displacement forces of the expansion joints. Restrained expansion joints may be of the angular and lateral type. As another possibility, the use of pressure balanced expansion joints is given.

2.8.3.1 Expansion compensation with angular expansion joints

Angular (or hinged) expansion joints are used for large pipe elongations. A system of expansion joints is built of standard elements. This requires two or three expansion joints. The installation of angular expansion joints always requires a change in the direction of the piping. Therefore, they are preferably placed where a 90° bend has originally been foreseen. The elongation absorption of hinged expansion joint systems is practically unlimited. It is determined by the piping size, allowable movement's angle of the hinged expansion joints and the length of the pipe section between two angular expansion joints.

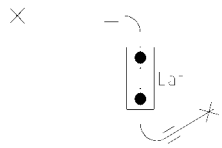


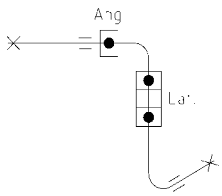
Advantages:
- almost unlimited expansion compensation
- small load on anchor points
- modular concept application
- use of normal guides

Disadvantages:
- change in pipe direction is always required
- more space required compared to axial expansion joints
- two or three expansion joints required for a system

2.8.3.2 Expansion compensation with lateral expansion joints

Lateral (or swing) expansion joints, equipped with ball joints, can move in all directions within one circular plane. They are used for simultaneous or staggered movements from two directions. At sufficient length, these expansion joints can take up considerable amounts of movements. More frequent is the use of short lateral expansion joints with ball points for small elongations when the pipe layout is complex, or for stressless connections directly before sensitive equipment, such as pumps, compressors and machines.
If two ball joint expansion joints are arranged at right angles, such a system takes up elongations in all three directions (lateral expansion joints possible only with 2 tie rods, observe the installation position of the tie rods). The installation of lateral expansion joints always requires a change in direction of the piping.





Advantages:
- movement compensation in all directions in one plane
- expansion compensation in all three directions possible, if a lateral and an angular expansion joint are used (construction detail of lateral expansion joint: only with two tie rods, observe the installation position of the tie rods)
- small load on anchor points

Disadvantages:
- change in pipe direction is necessary
- more space required compared with axial expansion joints

Provide a double ball joint for vacuum applications!

2.8.3.3 Expansion compensation with pressure balanced expansion joints

There are many types of special constructions such as pressure balanced axial expansion joints, pressure balanced angular expansion joints, a combination of axial and lateral expansion joints. There are standards covering such systems, but the expansion joints themselves are not standardized. It is recommended to consult the manufacturer in these cases, because special constructions are sometimes technically efficient, but nevertheless the most expensive solution.

Advantages:
- small anchor point loads
- minimal space required
- technically efficient solution

Disadvantages:
- custom-built, therefore higher costs

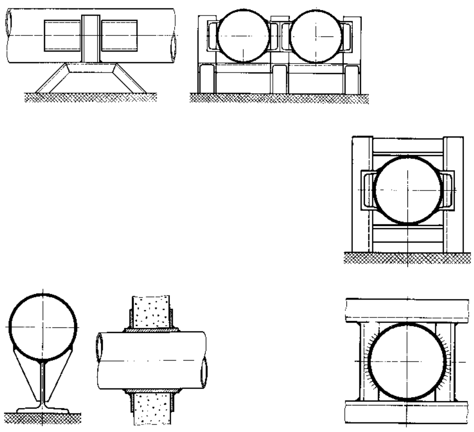
2.9 Anchor points, pipe alignment guides, suspended holding devices

Regardless of the type of expansion joint being applied, anchors shall always be provided at each end of a pipe. When axial expansion joints are used, each bend, right angle turn or considerable pipe direction change must be anchored. Pipelines whose elongation is compensated by several expansion joints, must be divided by anchor points into as many parts as expansion joints are necessary. The location of anchors is determined on the one hand by the direction of the piping, on the other hand by local conditions. However, their capacity of providing good anchorage is essential.

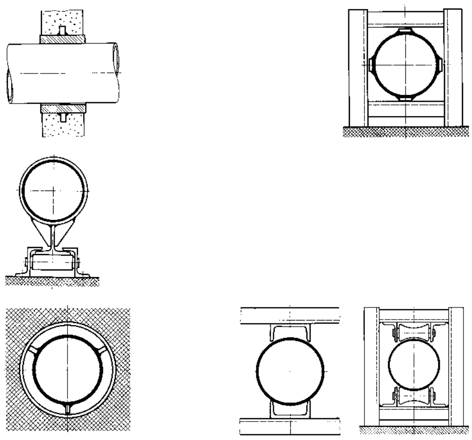
The corrugated bellow of the expansion joint tends to stretch out when subjected to internal pressure, and to contract under inner vacuum. This pressure or tensile force, the reaction force of the bellows, is transferred to the piping and has to be neutralized by the anchorage of the piping. The strength of the anchor point, and therefore basically its design, is determined by the reaction force. In this case, not the reaction force of the operating pressure, but of the test pressure is relevant, because the anchorage must absorb the reaction force of the test run, when the piping is put under pressure. However, the test pressure should not exceed 1,5 times of the operating pressure. The spring rate of the bellow must be added to the reaction force, however it usually amounts to only a small percentage of the latter. If a sufficient number of anchor points cannot be provided, restrained expansion joints such as angular, lateral or pressure balanced axial expansion joints should be used.

Anchor points within straight pipe sections may be of lighter structure, because they only have to take up the spring rate of the bellows and the friction forces of the guides. Whereas they must not take up the reaction force, acting only on points of change in pipeline direction, on its cross section variation or on its shutoff devices (valves, slides). If the pipe diameter is changed, the difference in reaction force between the larger and the smaller pipe cross section must be added to, or subtracted from the other forces. The design of an anchor point can be quite simple. Below some possible and often used anchor designs are displayed. Local conditions determine the choice of the most suitable type.

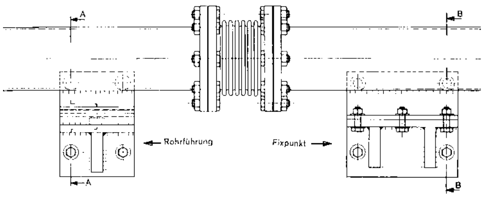
Examples of anchor points:

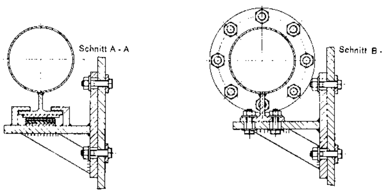


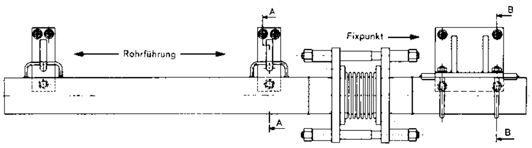
Examples of pipe guides:

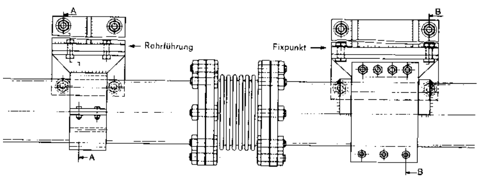


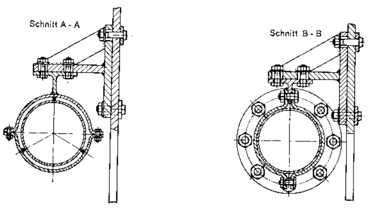
Examples of pipe guides and anchor points:

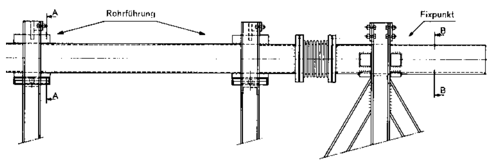


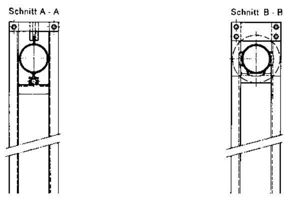












2.10 Nominal conditions

The expansion joints listed in the technical data sheets are classified by type, nominal size (DN), nominal pressure (PN) and movement capacity. Several factors must be considered for proper selection of an expansion joint.

Nominal size DN
The nominal size of the expansion joint to be selected is based on the existing flange or pipe dimensions.

The outside diameter of the expansion joint's weld ends corresponds to the ISO range. The exact connection dimensions, in particular the wall thickness, are listed in the technical data sheets.

The connection dimensions of expansion joints with flange connection are listed according to EN 1092.

Nominal pressure PN
For standard expansion joints, the nominal pressure (PN) is a ratio that indicates the admissible working pressure PS at nominal temperature (20 °C).

If the expansion joint is used at a temperature above the nominal temperature, its pressure load capacity is reduced by the derating factor K_P. For convenience, the derating factors K_P, depending on the temperature, are directly given in the technical data sheets.

The admissible working pressure PS of an expansion joint at working temperature TS is calculated as follows:

$$PS\ (TS) = PN * K_P\ (TS)\ [bar]$$

If an expansion joint must be chosen for working pressure PS and working temperature TS, then first the fictive pressure value P_e must be determined (converted to nominal temperature), which must be less than or equal to the required nominal pressure PN.

$$P_e = PS\ /\ K_P\ (TS) \leq PN\ [bar]$$

Nominal movement capacity
The nominal movement capacity given in the technical data sheets indicate the displacement, the expansion joint can take up at nominal temperature out of its neutral position. For an axial expansion joint, e.g., $\pm\Delta_{ax}$ indicates that the expansion joint is able to take up 1000 full load cycles at nominal pressure and a total expansion of $2 \cdot \Delta_{ax}$ within the neutral position, compressed or stretched by Δ_{ax}. It is irrelevant whether the load cycle starts in the compressed, neutral or stretched position.

To make usable the total expansion of $2 \cdot \Delta_{ax}$ for compensation, it is necessary to pre-restrain the expansion joint by 50 % of the total displacement, i.e. by Δ_{ax}. The same applies to the lateral or angular movement compensation ($\pm\Delta_{lat}$ or $\pm\alpha$).

Particularly easy to fit are the axial expansion joints of our standard program, which are able to take up their total expansion on compression without needing on-site pre-restraining.

For these expansion joints, the nominal axial expansion compensation Δ_{ax} corresponds to the total expansion on compression.

If an expansion joint is used at a temperature above the nominal temperature for expansion compensation, the movement capacity is reduced by the derating factor K_Δ.

The derating factors K_Δ (TS) are indicated on the technical data sheets as a function of temperature.

The admissible movement capacity $\pm\Delta_{adm}$ (TS) or $\pm\alpha_{adm}$ (TS) of an expansion joint at working temperature TS is calculated as follows:

$$\pm\Delta_{adm}\ (TS) = \pm\Delta * K_\Delta\ (TS)$$

If a certain working condition needs a movement capacity of $\pm\Delta TS$ at working temperature TS, then the necessary nominal movement capacity of the expansion joint to be chosen is to be determined as follows:

$$\pm\Delta \geq \pm\Delta TS\ /\ K_\Delta\ (TS)$$

Inherent resistance of the Bellows ± 30% (spring rate)
The inherent resistance (spring rate) of the bellows is a force (moment), the bellows withstand a movement.
The bellows' specific spring rate per ± 1 mm (1°) is indicated in the technical data sheets as spring rate. For production reasons, a tolerance of ± 30% is applicable for the values listed.

Life time
The life time (life expectancy) of an expansion joints is defined by the minimum number of full-load cycles that can be taken up until a leak caused by fatigue will appear. The maximum permissible expansion capacity is indicated on the expansion joint. It refers to 1000 full-load cycles (expansion joints conforming to EC standards: 500 full load cycles with safety factor 2).

The nominal expansion capacity given in the technical data sheets refer to a minimum life time of **1000 full-load cycles** at nominal conditions.

A load cycle means the movement cycle, the bellows is running through between the two extreme positions during the application and removal of the total expansion capacity.
For example: a pipeline is brought from ambient temperature to full operating temperature, and then cooled down again. For an expansion joint, built into the pipeline, this procedure means a full load cycle.
In normal cases, a design for 1000 full-load cycles is absolutely sufficient.

If higher load cycles are required, such as e.g. for industrial plants with several operating intervals per day, the expansion capacity must be reduced by the load cycle factor K_L (see table).

Load cycle factor K_L

Load cycles N_{adm}	Load cycle factor K_L
1'000	1.00
2'000	0.82
3'000	0.73
5'000	0.63
10'000	0.51
30'000	0.37
50'000	0.32
100'000	0.26
200'000	0.22
1'000'000	0.14
25'000'000	0.05

$$K_L = (1000 / N_{adm})^{0,29}$$

Life-reducing additional effects such as corrosion, impact stress caused by explosions, water hammer or thermal shocks, resonances due to flow-induced or mechanical influences can not be calculated and are therefore inadmissible.

If during operation, in addition to the static inner pressure, dynamic pressure variations occur, they will reduce life time. If the pressure variations are on a low level within the nominal pressure range, the influence on the life time is small and in most cases negligible. If in individual cases there is uncertainty regarding the rating of the impact, please inquire.

Load spectrum
If an expansion joint shall be designed for different load cases, the degree of fatigue (D_i) of each load spectrum must be linearly accumulated

$$D = \Sigma D_i = \Sigma (n_i/N_i) \leq 1$$

where n_i means the necessary and N_i the allowable number of cycles of each load case.

Example:
Load case 1 with n_1 = 500 load cycles at 100 % nominal expansion capacity with N_{1adm} = 1000.
Load case 2 with n_2 = 10 000 load cycles at 30 % nominal expansion capacity (K_L = 0.3) with

$$N_{2adm} = 1000 / (K_L^{3,45}) = 63670$$

resulting in an overall fatigue degree of

$$D = n_1 / N_{1adm} + n_2 / N_{2adm} = 0,66 < 1$$

which, with 66% capacity, constitutes a permissible load spectrum.

2.11 Materials

The materials used for metal bellows, whether single-ply or multi-ply must meet various conditions.
These are:

- **Weldability**
  It must be fundamentally ensured. The longitudinal weld seams must meet the same conditions as the base material.

- **Ductility**
  It is a prerequisite for the production of cold-formed bellows, however sufficient residual elongation at rupture must be ensured.

- **Mechanical strength properties**
  High mechanical strength is a prerequisite for pressure resistance. Simultaneously the elastic range is extended.

- **Technological properties**
  These include the strength properties under alternating flexural stress for expansion joints. They are not only determined by the alloying components, but also by surface conditions, by the grain size and by the metallurgic microstructure.

- **Corrosion resistance**
  There is no corrosion allowance for expansion joint bellows. It would have a negative influence on the bellows' expansion properties. Therefore, only materials being corrosion resistant against the concerned medium are possible.

- **Temperature properties**
  This means the materials' resistance to heat or cold and their long-term behavior. Almost all of austenitic chrome-nickel steels are tough down to -200°C and usually meet all requirements up to 550°C.

For applications working at temperatures above approx. 550°C, special heat resistant materials are used.

Mainly stainless steels fulfil the above mentioned criteria. The general term for these materials is "stainless steel". They generally contain more than 12% chromium (Cr) and are resistant to oxidizing agents attack.

Higher chromium contents and other alloying elements such as nickel (Ni), molybdenum (Mo) and nitrogen (N) improve the corrosion resistance.

Also the mechanical and technological properties are strongly influenced by these or other additives. Containing at least 8% nickel, the "stainless steel" becomes austenitic. These steels are therefore often referred to as, e.g., 18/8, 18/10, or as austenitic chrome-nickel steels.

With the formation of a passive layer and the presence of oxygen, "stainless steel" gets its anti-corrosive property.

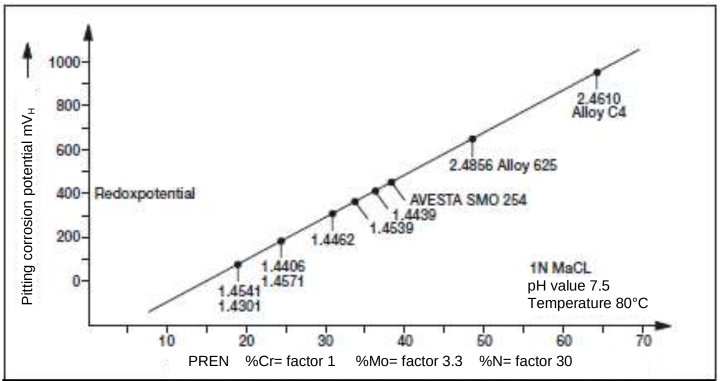
Standard materials for bellows are

Material n°	Short form DIN 17006	AISI (USA)
1.4541	X6 Cr Ni Ti 18 10	321
1.4571	X6 Cr Ni Mo Ti 17 12 2	316 Ti

These are austenitic, titanium-stabilized steels with a wide range of application areas.

For more aggressive corrosion conditions higher alloyed steels or nickel-based materials shall be used.

Pitting resistance equivalent number diagram (PREN)



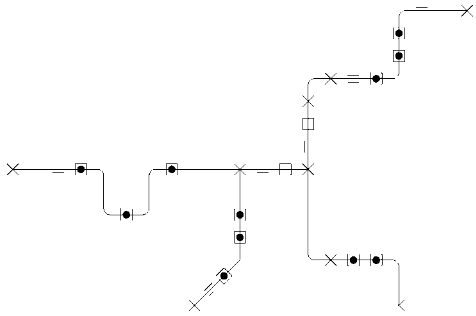
Pitting potential of austenitic steel as a function of PREN

The diagram allows estimating the increasing corrosion resistance in aqueous media. The pitting corrosion potential in this case represents a measure for the resistance of the material against pitting as a function of the alloy components' PREN, with the elements chromium, molybdenum and nitrogen having a significant effect (see pitting factors).
The material 1.4439, for example, due to its content of molybdenum and nitrogen (4-5% Mo, 0.1-0.2% N) has an about twice as high PREN relative to the material 1.4541, and is therefore much more resistant to pitting.

.

2.12 Approach in practice

For a given routing, see the example to the right, initially anchor points must be set where a movement of the line is undesirable, namely at the branch points. In the next step those line segments are to be considered, where the natural legs are able to absorb parts of the pipeline expansion. These line segments must be limited by anchor points. For the other line parts, expansion joints must be provided to take up expansion.



Two questions are crucial for the decision, **whether axial or hinged expansion joints** are to be chosen:
The line's routing and the possibility of taking up axial forces.
If it is a pipe system with **short, straight** sections and stretching movements to about 80 mm, i.e. a system with many changes of direction and junctions, an **axial** expansion joint is recommended. In **long straight** lines with stretching movements higher than 80 mm, **hinged** expansion joints are rather used. If the on-site conditions **allow strong anchor points** and placing **enough guides**, then the choice of **axial** expansion joints is correct. Otherwise, especially in pipes of **large cross-section** and at **high pressure ratios**, the **hinged** expansion joint is also a good solution, where small stretching movements occur. Artificially arranged pipe legs are not economical for space and cost reasons. It is quite possible to compensate for expansion within a piping system using various methods. To each expansion joint, however, a defined task must be assigned, i.e. the section of line to be compensated by it must be limited by two anchor points.
The economically most advantageous solution will be found, taking steps in this order when solving problems of compensation in pipelines. Early collaboration with the manufacturer however will always pay off.

2.12.1 Data requirements / Check list

Please ask for our technical advice if planning CE-marked expansion joints. You may prepare the necessary information for the expansion joint design with the help of this check list. Please add, if possible, an installation sketch and/or an isometric drawing of the pipe system. Make a copy of the following list or download it from our website www.boagroup.com.

BOA Check list: Expansion joints

Company: ____

Address: ____

Inquiry n°: ____________________ Person in charge:____________________________

Quantity ___________ **units** **DN** ______________ **mm**

Expansion joint type:

☐ axial	☐ lateral	☐ universal	☐ angular
☐ low pressure	☐ vibration absorber	☐ other	

Bellows material:

exterior ply:	☐ 1.4541	☐ 1.4404	☐ 1.4571	☐ ___________
intermediate ply:	☐ 1.4541	☐ 1.4404	☐ 1.4571	☐ ___________
interior ply:	☐ 1.4541	☐ 1.4404	☐ 1.4571	☐ ___________

Inner sleeve:	☐ yes	☐ no		
material:	☐ 1.4541	☐ 1.4404	☐ 1.4571	☐ ___________

Fittings:	**1st side**	**2nd side**
lose flange:	☐	☐
welded flange:	☐	☐
weld ends:	☐	☐

materials 1st side:	☐ 1.4541	☐ 1.4301	☐ 1.4571	☐ carbon steel	☐ ________
materials 2nd side:	☐ 1.4541	☐ 1.4301	☐ 1.4571	☐ carbon steel	☐ ________

Movement:		
	☐ axial	±_________ mm
	☐ lateral	± _________ mm
	☐ angular	± _________ °
	☐ vibrations	± _________ mm

Cycles :
☐ 1000
☐ 500 (standard products and PED 97/23/EC with CE-marking)
☐ _______

Operating conditions: ☐ PED 97/23/EC
☐ Piping ☐ Container

Piping: **Type of fluid:**______________________________
☐ group 1: dangerous gaseous / dangerous liquid
☐ group 2: innocuous gaseous / innocuous liquid

Container: required customer's indications:
container, category: ____
fluid type: ____
fluid group: ____
Inspection authority: ____

Max. operating pressure PS: ________bar
Min. operating pressure PS: ________bar (if also used in vacuum)

Max. operating temperature TS: ________°C
Min. operating temperature TS: ________°C (if also used below 0°C)

Tests: ☐ standard ☐ PED 97/23/EC
☐ special test

Inspection certificates:
☐ EN 10204-2.2 ☐ EN 10204-3.1 ☐ EN 10204-3.2
☐ Conformity declaration according to Pressure Equipment Directive 97/23/EC
☐ Conformity certificate issued by the inspection authority

Marking: ☐ standard ☐ EN 10380 ☐ customer's indication
☐ according to PED 97/23/EC

Packing: ☐ standard ☐ special ☐ customer's indication

Various:
☐ exterior protecting tube ☐ transportation fixing ☐ ____________________

Issued by: ______________________________

Place / date: ______________________________

Signature: ______________________________

Schema / sketch:

3 Quality Assurance

3.1 Approvals / Certificates

BOA expansion joints are designed, calculated, manufactured and tested following latest professional and state of the art standards. Regular inspections by accredited authorities for enterprise certification confirm the efficient and professional continuity of BOA process management.

Company approvals

EN 9100	Quality Management for Aerospace applications
ISO 9001	Quality Management
ISO 14001	Environment Management
ISO TS 16949	Quality Management
Euro-Qualiflex	Quality Management System
ISO 3834-2	Certification as welding company
DIN EN 15085-2	Welding of Railway vehicles and components

PED Conformity
Pressure Equipment Directive PED 97/23/EC (and SR 819.121)
authorized for CE marking

Swiss Association for Technical Inspections Regulation 201 and 501

Euro-Qualiflex *TUEV Sued* *KTA 1401*

Product approvals

To cover the particular market orientations, the necessary product type approvals could be organised at accredited certification authorities (examples below).

Bureau Veritas *Det Norske Veritas* *Germanischer Lloyd* *Lloyd's Register*

German Association for Gas and Water *Swiss Association for Gas and Water*

3.2 Tests / Laboratory

BOA expansion joints may be subject to various quality tests and inspections. The scope of the testing program follows the requirements and wishes of the customer or the design and production standards, as well as the inspection authority's conditions.

Product quality however is a matter of production standards and not of the subsequent tests. Those tests only confirm the rated required quality level. Therefore our production methods are generally based on a high quality level. Additional tests should be required only where the application imperatively demands it. If in a particular case design evidence is requested, the requirements must be clearly specified for a review of the permissible operating data in our factory.

Non-destructive test methods

- TP - water pressure test
- LT - leak-tightness test with air or nitrogen under water
- LT - leak-tightness test with air and foaming agents at the welds (soap bubble test)
- Differential pressure test with air
- RT – X-ray test
- MP - magnetic particle crack test
- PT - dye penetration test
- LT – helium leakage test (<1x10^{-9} mbar l/s)
- US - ultrasound test
- VT – visual test
- Hardness test

Destructive test methods

- mechanical strength test
- cupping test
- metallographic investigations
- spectroscopic test
- movement test (endurance test under pressure)
- vibration test
- burst pressure test

Our VT & PT test staff is certified according to EN473 and ASME.

Tests and laboratory

Compared with other leak test methods, the helium test permits detection of the smallest measurable leakage rate so far. Depending on the size of the specimen, it is possible to detect even a leak up to 10^{-9}mbar l/s. Using a special device, the expansion joint is sealed on both sides and then pumped out to a vacuum of 10^{-2}mbar. The weld seams are blown with helium on the outside. The mass spectrometer will instantly register any leak and the leak rate may be read from the measuring instrument. The leak will also be indicated by an acoustic signal.

Movement test to determine the stress cycles endured.

Macro cross section of an inner welding seam

Helium leak test

4 Application Fields

In almost every technical-oriented industrial area expansion joints are used to ensure the operating stability of the installations. Using flexible, metallic expansion joints in today's installation and plant construction is not only technically necessary, but also important to meet the industry's general demands for:

- improved profitability
- reduced plant size
- easy installation
- system compatibility
- smooth operating
- safety in case of incidents

BOA expansion joints meet all these requirements. Below some of the application fields are listed, where BOA expansion joints mainly are used. Nevertheless, our experienced team will be happy to develop, together with your engineers, new applications in all areas where flexible pipe elements or connections are needed. Please submit your problem – and we will suggest our solution as we have been doing for more than hundred years.

4.1 Diesel and gas engines

BOA has been supplying to leading diesel engine manufacturers expansion joints in exhaust lines between outlet valve and turbocharger. Through continuous development of our products in this area, we are now able to design and supply complete exhaust systems. BOA exhaust systems are now in use worldwide and have the following customer benefits:

- one contact person, and therefore less suppliers
- compact construction
- considerable cost savings thanks to quick mounting and 50% less weight
- optimal and interactive design thanks to state of the art engineering tools with 3D-CAD and ANSIS-FE calculation program
- 100% system tightness because of less intersections
- efficient benchmarking at BOA

Exhaust line modular assembly system 12/18/20

In addition to the complete exhaust systems, we also construct special expansion joints for diesel and gas engine manufacturers, designed according to customer's requirements:

Expansion joint with V-clamp flanges

Expansion joint with special flanges

Expansion joint with bent tubes

4.2 Aerospace

All experiences made over decades and in different areas needing sophisticated flexible elements were successfully implemented into aero-space applications by BOA. The multi-ply expansion joint in this highly demanding application field has the following advantages:

- low weight thanks to short construction length, small displacement rates and special welding connections
- BOA's high level welding competence allows using the most different materials, particularly required in this exigent sector
- effective vibration absorption

Thanks to the high quality standards, our own test laboratory and the latest calculations modules, BOA is today able to approach successfully the solution of your problem. BOA is certified according to EN 9100.

Vibration decoupling unit for helicopters

4.3 Power distribution

Through many years of collaboration with the leading manufacturers of high voltage SF6 installations, BOA has developed different types and procedures for this special market. Customers take profit from this long experience as follows:

- worldwide certification according to GIS/GIL standards
- cost reduction thanks to the connection of the austenitic bellows with aluminium flanges
- no subsequent cleaning due to manufacturing according to SF6 cleanness directives

Axial expansion joint with aluminium flanges

Pressure balanced axial expansion joint for high voltage SF6 installations

4.4 HVAC

The compensation of dilatations in central heating pipe systems is not only a problem for industrial plants and large public buildings, but also in the private construction sector. The rather long pipelines generate dilatations that can not quite simply be compensated by deviating the piping. In shorter main pipe lines axial expansion joints are used. In long linear main pipe lines hinged and angular expansion joints are needed. The BOA standard expansion joints program meets usually the requirements of the heating and ventilation sector.

Axial expansion joint Type W

Small (sanitary) expansion joint Type Za

Angular expansion joint Type AW

Vibration absorber Type Alpha-C

4.5 Hydraulic engineering

In this sector mostly BOA disassembly joints are used. Compared with standard demounting joints, BOA units have the following advantages:

- 50% installation time reduction
- quick availability of the plant by exploiting the spring rate of the bellows
- 100% tightness because no rubber elements are used (no ageing)
- economic execution using parts in contact with the medium made of non-corrosive austenitic material
- compensation of installation misalignment without tightness problems

The successful use of BOA disassembly joints during many years proves the advantages mentioned above.

Water supply, City of Zurich, Switzerland

Fresh water piping, chemical plant, Germany

4.6 Plant construction, general piping construction

Lateral and angular expansion joints

There is hardly another application field needing more expansion joints than plant construction or general piping construction. BOA expansion joints are successfully installed e.g. in chemical plants, thermal power plants, petrochemical plants and district heating power plants.

The requirements of plant construction are mostly fulfilled by the BOA standard expansion joints program. As a special service for the pipe system engineer, BOA may offer stress analysis data generated by the "Caesar II" program. This helps optimizing construction costs and trouble-free operating is ensured.

4.7 Pumps and compressors

Oscillations/vibrations caused by pumps, compressors, burners, piping equipment etc. and subsequently transmitted to the pipe system, not only make annoying noise, they also stress enormously the materials exposed to the vibrations. Therefore in this application field mostly BOA vibration absorbers (made of metal or rubber) are used. Our vast standard program of metal and rubber vibration absorbers covers almost all application fields of pumps and compressors.

Rubber and metal vibration absorbers

Pump station with vibration absorbers

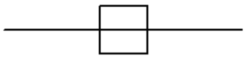
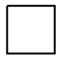
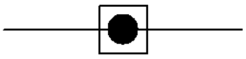
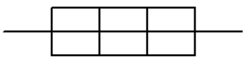
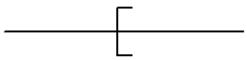
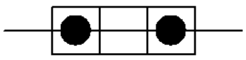
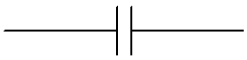
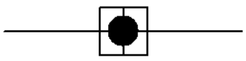
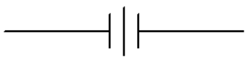
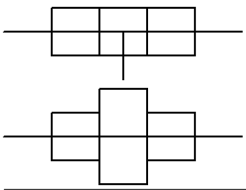
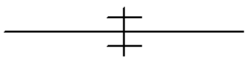
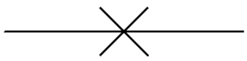
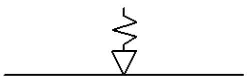
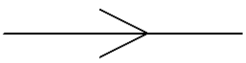
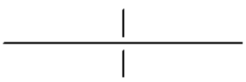
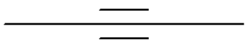
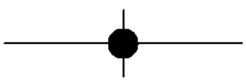
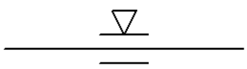
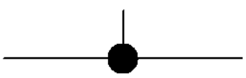
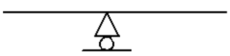
4.8 Gas turbines

For use in gas turbines, particularly pressure balanced expansion joints are used for not exceeding the allowable stresses in the transition piece between the pipeline and the aggregate. Also restrained (lateral/ angular) expansion joints are used between turbine and condenser.

Pressure balanced expansion joints

5 Annex/ Standards

5.1 Symbols used in pipe construction

	Axial expansion joint		Apparatus (without rotating parts)
	Angular expansion joint		Apparatus (with rotating parts)
	Universal expansion joint		Socket connection
	Lateral expansion joint		Flange joint
	Gimbal expansion joint		Screwed connection
	Pressure balanced expansion joint		Coupling
			Anchor
	Non-insulated pipeline		Vertical holding device (support)
	Insulated pipeline		Suspended holding device (suspension)
	Flexible pipe		Spring suspension
	Pipe with flow direction indicator		Spring support
	Pipe crossing without connection		Slideway
	Pipe crossing with connection		Suspended pipe slideway
	Pipe branch with connection		Roller guide

5.2 Table on guide analyses and characteristic strength values

* Strength values at room temperature

Material group	Material n° acc. to DIN EN 10027	Short form according to DIN EN 10027	Short form according to DIN 17006 (old)	Documentation	Upper temp. limit	Apparent yielding point min. * $R_{eH}/R_{p0.2}$	Tensile strength * R_m	Breaking elongation min. * A_5	A_{80}	Impact value min. AV (KV)
-	-	-	-	-	°C	N/mm²	N/mm²	%	%	J
Unalloyed steel	1.0254 1.0427	P235T1 C22G1	St 37.0 C 22.3	DIN EN 10217 DIN EN 10216	300 350	235 240	350-480 410-540	23 20		 31
General structural steel	1.0038 1.0050 1.0570	S235JRG2 E295 S355J2G3	St 37-2 St 50-2 St 52-3	DIN EN 10025	300	235 295 355	340-470 470-610 490-630	21-26 16-20 17-22		27 27/ -20°C
Temperature resistant unalloyed steel	1.0460	C22G2	C 22.8	VdTÜV-W 350	480	240	410-540	20		31
Temperature resistant steel	1.0305 1.0345 1.0425 1.0481 1.5415 1.7335 1.7380	P235G1TH P235GH P265GH P295GH 16Mo3 13CrMo4-5 10CrMo9-10	St 35.8 H I H II 17 Mn4 15 Mo 3 13 CrMo 4 4 10 CrMo 9 10	DIN 17175 DIN EN 10028 T1/T2	480 480 480 500 530 570 600	235 235 265 295 275 300 310	360-480 360-480 410-530 460-580 440-590 440-590 480-630	23 25 23 22 24 20 18		34 27 / 0°C 27 / 0°C 27 / 0°C 31 31 31
Stainless austenitic steel	1.4301 1.4306 1.4541 1.4571 1.4404 1.4435 1.4465 1.4539 1.4529	X5CrNi18-10 X2CrNi19-11 X6CrNiTi18-10 X6CrNiMoTi17-12-2 X2CrNiMo17-12-2 X2CrNiMo18-14-3 X1CrNiMoN25-25-2 X1NiCrMoCu25-20-5 X1NiCrMoCuN25-20-7	X 5 CrNi 18 10 X 2 CrNi 19 11 X 6 CrNiTi 18 10 X 6 CrNiMoTi 17 12 2 X 2 CrNiMo 17 12 2 X 2 CrNiMo 18 14 3 X 2 CrNiMoN 25 25 2 X 2 NiCrMoCu 25 20 5 X 2 NiCrMoCu 25 20 6	DIN EN 10088 SEW 400 VdTÜV-W 421 VdTÜV-W 502	550 550 550 550 550 550 550 400 400	230 200 220 240 240 240 255 220 300	540-750 520-670 520-720 540-690 530-680 550-700 540-740 520-720 600-800	45 45 40 40 40 40 30 40 40	45 45 40 40 40 40 40	
High temperature resistant austenitic steel	1.4948 1.4919 1.4958	X6CrNi18-11 X6CrNiMo17-13 X5NiCrAlTi31-20	X 6 CrNi 18 11 X 6 CrNiMo 17 13 X 5 NiCrAlTi 31 20	DIN 17459	600	185 205 170	500-700 490-690 500-750	40 35 35	38 33 33	60 60 80
Heat resistant steel	1.4828 1.4876 (1.4876H)	X15CrNiSi20-12 (AISI 309) X10NiCrAlTi32-21 Incoloy 800 X10NiCrAlTi32-20 Incoloy 800H	X 15 CrNiSi 20 12 UNS N 08800 ASTM B409/408/407 UNS N 08810 ASTM B409/408/407	DIN EN 10095 DIN EN 10095 VdTÜV-W 412 VdTÜV-W 434	1000 600 950	230 210 170	500-750 500-750 450-700	22 30 30		

* Strength values at room temperature (continued from Tab. 5.2)

Material group	Material n° acc. to DIN EN 10027	Short form according to DIN EN 10027	Short form according to DIN 17006 (old)	Documentation	Upper temp. limit	Apparent yielding point min. *	Tensile strength *	Breaking elongation min. *		Impact value min.
						$R_{eH}/R_{p0.2}$	R_m	A_5	A_{80}	AV (KV)
-	-	-	-	-	°C	N/mm²	N/mm²	%	%	J
Nickel-based alloys	2.4360	NiCu 30 Fe Alloy 400/ Monel	UNS N 04400 ASTM B127/164/165	DIN 17750 VdTÜV-W263	425	195	≤ 485	35		80 / 20°C
	2.4602	NiCr 21 Mo 14 W Alloy C-22	UNS N 06022 ASTM B575/622/574	- VdTÜV-W479	600	310	≥ 690	45		150 / 20°C
	2.4605	NiCr 23 Mo 16 Al Alloy 59	UNS N 06059 ASTM B575/574/622	- VdTÜV-W505	450	340	≥ 690	40		225 / 20°C
	2.4610	NiMo 16 Cr 16 Ti Alloy C-4	UNS N 06455 ASTM B575/574/622	DIN 17750 VdTÜV-W424	400	305	≥ 700	35		96 / 20°C
	2.4816	NiCr 15 Fe Alloy 600	UNS N 06600 ASTM B168/166/167	DIN EN 10095 VdTÜV-W305	450	200	550-750	30		150 / 20°C
	2.4819	NiMo 16 Cr 15 W Alloy C-276	UNS N 10276 ASTM B575/574/622	DIN 17750 VdTÜV-W400	800	310	≥ 750	30		
	2.4856	NiCr 22 Mo 9 Nb Alloy 625	UNS N 06625 ASTM B443/446/444	DIN EN 10095 VdTÜV-W499	600	410	≥ 800	30		100 / 20°C
	2.4858	NiCr 21 Mo Alloy 825	UNS N 08825 ASTM B424/425/423	DIN EN 17750 VdTÜV-W432	450	225	550-750	30		80 / 20°C
Pure nickel	2.4068	LC-Ni 99.2	UNS N 02201 ASTM B162/160/161	DIN EN 17750 VdTÜV-W345	600	80	340-450	40		
Copper	2.0090	SF-Cu		DIN 17670	250	45	≥200	42		
Copper tin alloys	2.1020 2.1030	CuSn6 (Bronze) CuSn8	UNS – C 51900 UNS C 52100	DIN 17670 DIN 17670	250 250	300 ≤300	350-410 370-450	55 60		
Copper zinc alloys	2.0250 2.0321	CuZn20 CuZn37 (Messing)	UNS C 24000 UNS C 27200	DIN 17670 DIN 17670		≤150 ≤180	270-320 300-370	48 48		
Copper beryllium alloys	2.1247	CuBe2		DIN 17670		≤250	390-520	35		
Aluminium	3.0255	Al 99.5		DIN 1712		≤55	65-95	40		
Aluminium forging alloys	3.3535 3.2315	AlMg 3 AlMgSi 1		DIN 1725 DIN 1725	150	80 ≤85	190-230 ≤150	20 18		
Titanium	3.7025	Ti		DIN 17850 VdTÜV-W230	250	180	290-410	30		62
Tantalum	-	Ta		VdTÜV-W382	250	150	> 225	35		

5.3 International standards / Comparison table

Germany		USA		Great Britain	France	Russia
Material n°	Short form	UNS / ASTM standard	Grade	Designation	Designation	Designation
1.0254 1.0427	P235T1 C22G1	~ A106 /A53 -	A	~ S360 (S;ERW) -	- -	- -
1.0038 1.0050 1.0570	S235JRG2 E295 S355J2G3	A252 /A500 /A570 ~ A714	3	En 40 B E 295 En 50 D	S235JRG2 A50-2 S355J2G3	~ St 3 ps ~ St 5 ps ~ 17GS / 17 G1S
1.0460	C22G2	-		-	-	-
1.0305 1.0345 1.0425 1.0481 1.5415 1.7335 1.7380	P235G1TH P235GH P265GH P295GH 16Mo3 13CrMo4-5 10CrMo9-10	A106/A178/A179/A53 K 02202/A285/A414 K 02402/A283/A285 A106/A414/A555/A662 A204 A182/A234/A387 A182/A217/A541/A873	A A, B, C C C, F, E, B A, B, C F F22	~ 320/ ~ 360 141 - 360 151 - 400 224 – 460 B 16 Mo 3 / ~ 243 13 CrMo 4 -5/ ~ 620 10 CrMo 9 – 10/ ~ 622	- A 37 CP A 42 CP A 48 CP 15 D 3 13 CrMo 4-5 10 CrMo 9-10	- - ~ 16K / ~ 20K 14G2 - ~ 12ChM / ~ 15 ChM 12Ch8
1.4301 1.4306 1.4404 1.4435 1.4465 1.4529 1.4539 1.4541 1.4571	X5CrNi18-10 X2CrNi19-11 X2CrNiMo17-12-2 X2CrNiMo18-14-3 X1CrNiMoN25-25-2 X1NiCrMoCuN25-20-7 X1NiCrMoCu25-20-5 X6CrNiTi18-10 X6CrNiMoTi 17-12-2	AISI 304 AISI 304 L AISI 316 L AISI 316 L N 08310 A 351 N 08904 AISI 321 AISI 316 Ti		304 S 15 304 S 11 316 S 11 316 S 13 - - 904 S 13 321 S 13 320 S 31	Z6 CN 18-09 Z2 CN 18-10 Z2 CND 17-12 Z3 CND 17-12-03 - - Z2 NCDU 25-20 Z6 CNT 18-10 Z6 CNDT 17-12	08Ch18N10 03Ch18N11 - 03Ch17N14M3 02Ch25N22AM2-PT - - 08Ch18N10T 08Ch16N11M3T
1.4948 1.4919 1.4958	X6CrNi18-11 X6CrNiMo17-13 X5NiCrAlTi31-20	AISI 304H / S30480 AISI 316 H		304 S 51 316 S 50 – 53 NA 15 H	- - Z8 NC 33-21	- - -
1.4828 1.4876 (1.4876H)	X15CrNiSi20-12 X10NiCrAlTi32-21 X10NiCrAlTi32-20	AISI 309 N 08800/B409/408/407 N 08810/B409/408/407				
2.4360 2.4602 2.4610 2.4816 2.4819 2.4856 2.4858	NiCu 30 Fe NiCr 21 Mo 14 W NiMo 16 Cr 16 Ti NiCr 15 Fe NiMo 16 Cr 15 W NiCr 22 Mo 9 Nb NiCr 21 Mo	N 04400/B127/B164/B165 N 06022/B575/B622/B574 N 06455/B575/B574/B622 N 06600/B168/B166/B167 N 10276/B575/B574/B622 N 06625/B443/B444/B446 N 08825/B424/B425/B423				

5.4 Conversion tables

5.4.1 Pressure

	Pressure units used in vacuum engineering				
	mbar	**Pa (Nm^{-2})**	**dyn cm^{-2} (µb)**	**Torr (mm Hg)**	**micron (µ)**
mbar	1	100	1000	0.75	750
Pa (Nm^{-2})	$1 \cdot 10^{-2}$	1	10	$7.5 \cdot 10^{-3}$	7.5
dyn cm^{-2} (µb)	$1 \cdot 10^{-3}$	0.1	1	$7.5 \cdot 10^{-4}$	0.75
Torr (mm Hg)	1.33	$1.33 \cdot 10^{2}$	$1.33 \cdot 10^{3}$	1	1000
micron (µ)	$1.33 \cdot 10^{-3}$	$1.33 \cdot 10^{-1}$	1.33	$1 \cdot 10^{-3}$	1
bar	$1 \cdot 10^{3}$	$1 \cdot 10^{5}$	$1 \cdot 10^{6}$	750	$7.5 \cdot 10^{5}$
atm	1013	$1.01 \cdot 10^{5}$	$1.06 \cdot 10^{6}$	760	$7.6 \cdot 10^{5}$
at (kp cm^{-2})	981	$9.81 \cdot 10^{4}$	$9.81 \cdot 10^{5}$	735.6	$7.36 \cdot 10^{5}$
mm WS (kp m^{-2})	$9.81 \cdot 10^{-2}$	9.81	98.1	$7.36 \cdot 10^{-2}$	73.6
psi	68.9	$6.89 \cdot 10^{3}$	$6.89 \cdot 10^{4}$	51.71	$5.17 \cdot 10^{4}$

	General pressure units				
	bar	**atm**	**at (kp cm^{-2})**	**mm WS (kp m^{-2})**	**psi**
mbar	$1 \cdot 10^{-3}$	$9.87 \cdot 10^{-4}$	$1.02 \cdot 10^{-3}$	10.2	$1.45 \cdot 10^{-2}$
Pa (Nm^{-2})	$1 \cdot 10^{-5}$	$9.87 \cdot 10^{-6}$	$1.02 \cdot 10^{-5}$	0.102	$1.45 \cdot 10^{-4}$
dyn cm^{-2} (µb)	$1 \cdot 10^{-6}$	$9.87 \cdot 10^{-7}$	$1.02 \cdot 10^{-6}$	$1.02 \cdot 10^{-2}$	$1.45 \cdot 10^{-5}$
Torr (mm Hg)	$1.33 \cdot 10^{-3}$	$1.32 \cdot 10^{-3}$	$1.36 \cdot 10^{-3}$	13.6	$1.93 \cdot 10^{-2}$
micron (µ)	$1.33 \cdot 10^{-6}$	$1.32 \cdot 10^{-6}$	$1.36 \cdot 10^{-6}$	$1.36 \cdot 10^{-2}$	$1.93 \cdot 10^{-5}$
bar	1	0.987	1.02	$1.02 \cdot 10^{4}$	14.5
atm	1.013	1	1.03	$1.03 \cdot 10^{4}$	14.7
at (kp cm^{-2})	0.981	0.968	1	$1 \cdot 10^{4}$	14.22
mm WS (kp m^{-2})	$9.81 \cdot 10^{-5}$	$9.68 \cdot 10^{-5}$	$1 \cdot 10^{-4}$	1	$1.42 \cdot 10^{-3}$
psi	$6.89 \cdot 10^{-2}$	$6.8 \cdot 10^{-2}$	$7.02 \cdot 10^{-2}$	702	1

1 kp	9.81 N	
1 at	0.981 bar	
1 kpm	9.81 Nm	
1 kp /mm^2	9.81 N /mm^2	
1 Mpa	$1 \cdot 10^{6}$ Pa	= 10 bar
1 bar	$1 \cdot 10^{5}$ Pa	= 100 kPA

0.1 N /mm^2	14.5038 lb /$inch^2$
1 kp / cm^2	14.2233 lb /$inch^2$
1 Pascal	$14.5038 \cdot 10^{-5}$ lb /$inch^2$
1 kPascal	$14.5038 \cdot 10^{-2}$ lb /$inch^2$
1 Millipascal	$14.5038 \cdot 10^{-8}$ lb /$inch^2$
1 bar	14.5038 lb /$inch^2$

5.4.2 Other conversion tables

Flow rate

	Conversion of flow rate units				
	mbar l s^{-1}	**Pa m^3 s^{-1}**	**Torr l s^{-1}**	**atm cm^3 s^{-1}**	**lusec**
mbar l s^{-1}	1	$1 \cdot 10^{-1}$	$7.5 \cdot 10^{-1}$	$9.87 \cdot 10^{-1}$	$7.5 \cdot 10^{2}$
Pa m^3 s^{-1}	10	1	7.5	9.87	$7.5 \cdot 10^{3}$
Torr l s^{-1}	1.33	$1.33 \cdot 10^{-1}$	1	1.32	$1 \cdot 10^{3}$
atm cm^3 s^{-1}	1.01	$1.01 \cdot 10^{-1}$	$7.6 \cdot 10^{-1}$	1	$7.6 \cdot 10^{2}$
lusec	$1.33 \cdot 10^{-3}$	$1.33 \cdot 10^{-4}$	$1 \cdot 10^{-3}$	$1.32 \cdot 10^{-3}$	1

Temperature

	° C	**° F**	**° K**
° C	1	$^5/_9$(°F-32)	K-273.15
° F	$^9/_5$°C+32	1	$^9/_5$K-459.67
° K	°C+273.15	$^5/_9$ (°F+459.67)	1

Length

	mm	**m**	**inch**	**feet**
mm	1	0.001	0.03937	0.00328
m	1000	1	39.3701	3.2808
inch	25.4	0.0254	1	0.0833
feet	304.8	0.3048	12	1

Surface

	mm^2	**m^2**	**$inch^2$**	**$feet^2$**
mm^2	1	$1 \cdot 10^{-6}$	0.00155	$1.0764 \cdot 10^{-5}$
m^2	$1 \cdot 10^{6}$	1	1550	10.7639
$inch^2$	645.16	$6.452 \cdot 10^{-4}$	1	$6.944 \cdot 10^{-3}$
$feet^2$	92903	0.092903	144	1

Volume

	mm^3	**cm^3**	**m^3**	**$inch^3$**	**$feet^3$**
mm^3	1	0.001	$1 \cdot 10^{-9}$	$6.1 \cdot 10^{-5}$	$3.531 \cdot 10^{-8}$
cm^3	1000	1	$1 \cdot 10^{-6}$	0.061	$3.531 \cdot 10^{-5}$
m^3	$1 \cdot 10^{9}$	$1 \cdot 10^{6}$	1	61023.7	35.3147
$inch^3$	16389	16.387	$1.6387 \cdot 10^{-5}$	1	$5.787 \cdot 10^{-4}$
$feet^3$	$2.832 \cdot 10^{7}$	$2.832 \cdot 10^{4}$	0.0283169	1728	1

Weight

	kg	pound
kg	1	2.20462
pound	0.453592	1

Force

	kp	N	Dyn	lbf
kp	1	9.80665	980665	2.20462
N	0.101972	1	$1 \cdot 10^{5}$	0.224809
Dyn	$1.01972 \cdot 10^{-6}$	$1 \cdot 10^{-5}$	1	$2.24809 \cdot 10^{-6}$
lbf	0.453592	4.44822	444822	1

Density

	g/m^3	kg/m^3	$lb/inch^3$	lb/ft^3
g/m^3	1	0.001	$3.61273 \cdot 10^{-8}$	$6.2428 \cdot 10^{-5}$
kg/m^3	1000	1	$3.61273 \cdot 10^{-5}$	0.062428
$lb/inch^3$	$2.76799 \cdot 10^{7}$	27679.9	1	1728
lb/ft^3	16018.5	16.0185	$578.704 \cdot 10^{-6}$	1

Moments

	Nm	kp · m	lbf · ft	lbf · inch
Nm	1	0.101972	0.737561	8.85073
kp · m	9.80665	1	7.233	86.796
lbf · ft	1.35582	0.138255	1	12
lbf · inch	0.112985	0.0115213	0.08333	1

Spring characteristics

	N/mm	kg/mm	lb/inch
N/mm	1	0.101972	5.7101
kg/mm	10.1972	1	55.991
lb/inch	0.1751	0.01786	1

Acceleration

	m/s^2	ft/s^2	$inch/s^2$
m/s^2	1	3.28084	39.3701
ft/s^2	0.3048	1	12
$inch/s^2$	0.0254	0.083333	1

5.5 Corrosion

5.5.1 Technical information

All information, data and tables are based on information and documentation provided by the raw materials manufacturer or our many years of experience in the field. They do not claim to be exhaustive and are expressly recommendations for which no liability can be accepted. The users of our products are recommended to perform their own tests in case of uncertainties for the intended use.

Among other things, it should be noted that all data concerning chemicals are based on analytically pure substances and never on mixtures of media. All relevant conditions must be observed.

Often the chemical behaviour of the metal hose or metal bellows material depends on the upstream tube material. All surfaces exposed to the medium must be taken into account, e.g. if there is corrosion tendency, but the surface likely to corrode is very small, then the corrosion attack can very quickly go into depth.

Layers, deposits, ferritic filings, etc., can both inhibit corrosion (e.g. thick layers) as well as stimulate corrosion (e.g. deposits enriched with chlorides). Ferritic filings can even act as a real corrosion trigger.

Any legal claim based on the information in this document may be derived, either express or implied.

Information on the following corrosion table
The corrosion rate is expressed as a weight loss per unit of surface and time, e.g. g/mm^2h or as a reduction in thickness per unit of time, e.g. mm/year. The corrosion rate is used for laboratory tests, whereas the thickness reduction is more useful for practical assessments.

In the tables on the following pages, the corrosion rate or corrosion behaviour of the various materials is classified into resistance levels from 0 to 3, based on an even corrosive attack. The meaning of the levels is given in the table below:

Resistance level	Thickness reduction mm/year	Resistance
0	≤ 0.11	Completely resistant under normal operating conditions.
1	>0.11 ... ≤1.1	Resistant in many cases under normal operating conditions, but should only be used if other specific material properties do not allow the use of a level 0 material.
2	>1.1 ... ≤11.0	Moderate resistance. Shall only be used in exceptional cases.
3	>11	Not resistant. Use by no means possible.

Meaning of the abbreviations used in the tables

L	=	risk of pitting corrosion
S	=	risk of stress crack corrosion
Schm	=	molten, melts
Konz	=	concentrated substance
SP	=	boiling (boiling point)
tr	=	dry (anhydrous)
fe	=	moist
wh	=	contains water
wL	=	aqueous solution
ges	=	saturated
kg	=	cold saturated
hg	=	hat saturated
> 50	=	higher than 50
≤ 50	=	smaller than or equal to 50
≤ 0.1	=	smaller than or equal to 0.1
( )	=	divergent literature information or uncertain values

Information on types of corrosion

Pitting corrosion

Pitting is a special type of corrosion in electrolytes containing halogen. The risk of pitting depends on several factors.

The pitting tendency increases with
- increasing concentration of chloride ions
- increasing temperature
- increasing electro-chemical potential of the steel in the electrolytes concerned

The pitting tendency is reduced by
- adding molybdenum (increasing contents of molybdenum in the steel reduces the risk of pitting, which means Mo contents between 2% and about 5%)
- higher chromium contents. The higher the chromium content (>20%), the more effective even a small quantity of Mo can be.

Pitting may be prevented by
- reduction of the electro-chemical potential in the electrolyte concerned, e.g. by cathodic protection.

Stress corrosion cracking

Stress corrosion cracking is one of the corrosion type needing several factors simultaneously to be triggered:
- a specific corrosion agent, e.g. chlorides or alkaline media
- critical system parameters (temperature, concentration, limit stress)
- a material susceptible to stress corrosion cracking
- static and/or dynamic mechanical tensile load

Stress corrosion cracking is one of the most unpleasant forms of corrosion, because it usually leads abruptly and very quickly to crack damage in components of any kind. Depending on alloy structure and corrosive attack, as a typical phenomenon cracks appear in intercrystalline or transcrystalline form, amorphous and usually ramified. Often there is a forced rupture of the component at the end of the crack. Stress corrosion cracking may be triggered by pitting corrosion, always starting from a locally active weak spot. Stress corrosion cracking can identically proceed in non-ferrous metals as in austenitic materials.

5.5.2 Corrosion resistance table

Medium		Concentration %	Temperature (°C)	unalloyed steels	18/8-Steel	18/8+Mo-Steel	Nickel	Monel 400 2.4360	Inconel 600 2.4816	Incoloy 825 2.4858	Hastelloy C 2.4819	Copper	Tombak	Bronce	Titaniuim	Aluminium
Acetanilide (Antifebrin)			<114													0
Acetate			20									0	0	0		0
Acetate dehydrate		100	20	1	1	0	0	0	0	0	0	1	1	1		0
		100	SP					0	0	0	0	2	3	2		0
		98	<54					0	0	0	0					
		99	<40					0	0	0	0					
Acetic anhydride		alle	20	1	0	0	0	1	1	0	0	0	3	0	0	0
		100	60	3	0	0	0					1		1	0	1
		100	100	3	0	0	0					2		2	0	
		100	SP	3	0	0	1		3	1	0				0	
Acetone		100	20	1	0	0	0	0	0	0	0	0	0	0	0	0
		100	SP	1	0L	0L	0	1	0	0	0	1	1	1	0	0
		all	<SP	1	0L	0L	0	1	0	0	0					
Acetylene	tr		20	0	0	0	0	0				3	3	3	0	0
	tr		200	2			2									0
	fe		20													1
	tr	100	<150				0		0							0
Acetylene dichloride	wL	5	20													3
	tr	100	20		1L	0L	0	0	0	0	0					0
	tr	100	SP		2L	1L	0	0	0	0	0					0
	Schm	100	700						0		0					3
	fe	100	20					0	0	0	0					3
Acetylenetetrachloride	tr	100	20	0	0	0	0				0	0			0	0
	tr	100	SP	0	0	0	0				0	1			1	3
	fe		SP	1			1					3				3
Acytelene cellulose		<100	20				1	1	1	0						0
Acytelene chlorid			20		1L	0L		1	2	2		3	3	3	0	
			SP		1L	0L		2	2	2		3	3	3	0	
Adhesive, neutral			20	(0)	0	0	0	0				0	1	0	0	0
sour			20	(1)	0	0		0								(2)
			SP		0	0										

Medium		Concentration %	Temperature (°C)	unalloyed steels	18/8-Steel	18/8+Mo-Steel	Nickel	Monel 400 2.4360	Inconel 600 2.4816	Incoloy 825 2.4858	Hastelloy C 2.4819	Copper	Tombak	Bronce	Titaniuim	Aluminium
Adipic acid		all	100		0	0										
			200		0	0										
Aethan			20		0	0										0
Aktivine		0.5	20	3	1L	0L		0								1
		0.5	SP	3	1L	0L		0								3
Alanine			20		0	0										0
Allylalkohol		100	25				0	0	0	0	1					
		100	SP								1					
Allylchloride		100	25				0	0	0	0						
Alum		100	20	2	0	0			2	0	0	2	3	3		1
	wL	10	20	2	0	0					1					1
	wL	10	<80	3	0	0					1					
	wL	10	SP	3	1	0					1					
		hg	SP	3	2	1										
Aluminuim	Schm	100	750	3	3	3	3	3				3	3	3		
Aluminuim acetate	wL	3	20	3	0	0					0					0
	wL	100	100	3	0	0					1					
	wL	all	20								1					
	wL	kg	20		0	0	0	2	2	2	1					2
	wL	kg	SP		0	0					1					
		hg	SP		0	0					1					2
Aluminuim chloride	wL	5	20	3	2L	1L	1	1	1	1	0	2	3	2	0	
		5	50	3	2L	1L	1	1	1	1	0	3	3	3	0	
		5	100	3											0	
		10	20	3	3L	2L	1	1	1	1	0	3	3	3	0	3
		10	100	3											0	
		10	150	3											0	
		20	20	3			1	1	1	1	1	3	3	3		
		20	150	3											3	
	wL	25	20	3	3L	2L	1	1	1	1	0	3	3	3	0	
		25	60	3											0	
		25	100	3											2	
		30	150	3											3	
		40	122	3											3	
		80	100	3											3	
Aluminium fluorid	wL	5	25	3	2	2		1		0		0			0	
	wL	10	25	3	3	3	1	1			1	1			0	0
Aluminiumformiate			20									2	3	3	0	0
Aluminium hydroxide		ges	20	1	0	0		1		0		0	0	0	0	0
		ges	SP	2	0	0									0	
	wL	2	20	3	0	0		1		0	0	0			0	1
	wL	10	20	3	0	0		1		0		0			0	1
Aluminium na-sulphate	wL	10	<SP								1					
Aluminium nitrate			20		0	0										
	wL	10	20		0	0										2
	wL	10	50													3
Aluminium oxyde			20	1	0	0	0	0	0	0	0	0	0	0	0	2
Aluminium sulphate	wL	10	20	3	0	0	0	0	0	0	0	2	2	1	0	3
		10	SP	3	1	0	1	2	1	1	1	3	3	3	3	3
		50	SP	3	2	1	1				0	3	3	3	3	3
Amber acid			20													0
Ammonia	tr	10	20	0	0	0	2	1	0	0	0	0	0	0	0	0
	fe		20	0	0	0	3		0	0	0	3	3	3	0	
	wL	10	20		0	0	0	0		0	0	3	3	3	0	
	wL	10	SP		0	0	3			1	1				0	
	wL	30	20		0	0				0	0					
	wL	30	SP		0	0				1	1					
	wL	50	20		0	0				0	0					
	wL	50	SP		0	0				1	1					
	wL	100	20	0	0	0				0	0					
	wL	100	SP		0	0				1	1					
Ammonium alume	wL	100	20	3	0	0										
	wL	100	SP	3	3	2										
Ammonia bicarbonate		all	20		0	0		2	2	1		3	3	3	0	0
	wL	all	hot		0	0		2	2	0		3	3	3	0	0
Ammonia bifluoride	wL	100	20	3	0	0					0					
		20	80	3	0	0					0					
Ammonia bromide	wL	5	25	3	0	0		2			0	3	3	3		2
	wL	10	SP	3	1LS	1LS										1
	wL	10	25	3	1LS	1LS					1					3

Medium		Concentration %	Temperature (°C)	unalloyed steels	18/8-Steel	18/8+Mo-Steel	Nickel	Monel 400 2.4360	Inconel 600 2.4816	Incoloy 825 2.4858	Hastelloy C 2.4819	Copper	Tombak	Bronce	Titaniuim	Aluminium
Ammonia carbonate	wL	20	20	0	0	0	0	0	0	0	0	2	2	2		
	wL	20	SP		0	0	1	0	0	0	1	3	3	3		
	wL	50	20	0	0	0	0	0	0	0						
	wL	50	SP		0	0	1	0	0	0	1					
Ammonia chloride	wL	25	20	3	1LS	0LS		0	0	0	0	3	3	3	0	2
	wL	25	SP	3	2LS	1LS		1		1	1				0	3
	wL	50	20	3	1LS	0LS	1	0	1	0	0				0	
	wL	50	SP	3	2LS	1LS		1		1	1				0	
Ammonia fluoride	wL	20	80	3	2LS	2LS					0	3	3	3		
Ammonia formate	wL	10	20													0
	wL	10	70													0
Ammonia hydroxyde		100	20		0	0	0	3	0	0	0	3	3	3		1
Ammonia nitrate	wL	100	20	3	0	0			3		0	3	3	3		0
		100	SP	3	0	0			3		0	3	3	3		0
		10	25	3	0	0			3		0	3	3	3		
Ammonia oxalate		10	20	1	0	0					0					
		10	SP	3	1	0					0					
Ammonia perchlorade	wL	10	20		0LS	0LS					1					
	wL	10	SP		0LS	0LS					1					
	wL	all	<70		0LS	0LS					1					
Ammonia persulphate	wL	5	20	3	0	0	3	3	1	0	0	2				2
		10	25	3	1	1	3	3			0	2	3	3		
		10	30	3	1	1	3	3			0	2	3	3		
		20	20	3												
		20	100	3												
Ammonia phosphate		5	25	0	1	0	1	1	0		0	2	2	2		0
		10	20	0	1	0						3	3	3		1
		10	60				1	1	0							3
Ammonia rhodanide		5	20	3	0	0			0	0	0					0
		5	70	3	0	0			0	0	0					0
Ammonia sulphate	wL	1			0	0	1	1	1	0	0	2	2	2	0	2L
	wL	5			0	0	1	1	1	0	0	2	3	2	0	2L
	wL	10	20		1	0	1	1	2	0	1	3	3	3	0	2L
	wL	10	SP		2	0	2	1	2	0	2	3	3	3	0	3L
	wL	100	20	0	0	0		1			1				0	
	wL	100	SP	1	0	0		1			2				0	
Ammonia sulphite	wL	100	20	2	0	0	3	3	3	2		3	3	3		
	wL	100	SP	3	0	0	3	3	2	2		3	3	3		
Ammoniumfluorsilikat	wL	20	40	3	1	0					0					
Ammoniummolybdat		100	100												0	
Amoniacal copper chloride	wL	1	20					1								
	wL	10	20					3								
	wL	20	20					3								
Amyl acetate		100	20	0	0	0	0	0	0	0		0	0	0		0
		100	SP	1	0	0	0	0	0	0	1					0
Amyl alcohol		100	20	0	0	0	0	0	0	0	0	0	0	0	0	0
		100	SP	1	0	0	0	0	0	0	0					1
Amyl chloride		100	20	1	0LS	0LS	1	1	1	0	0	0				2
		100	SP		1LS	0LS										
Amylmercaptan		100	20		0	0					0					0
		100	160		0	0					0					
Aniline		100	20		0	0		1	0	0		3	3	3		0
		100	180		1	1		2								3
Aniline cholours												2	2	2		
Anilinhydrochloride	wL	5	20		3	3									0	
	wL	20	100												0	
Aniline sulphite	wL	10	20						1L							
		100	20								0					
Antimony	Schm	100	650	3	3	3					0					3
Antimony chloride	tr		20	0	3	3	0									3
	wL		100	1			0									3
Apple acid	wL		20	2	0	0	2	1	1	0	0	3	2	2	0	0
	wL	<50	90	3	0	0	2	1	1	0	0	3	2	2	0	0
	wL	<50	100	3	0	0	2	1	1	0	0	3	2	2	0	0
Arsenic acid	wL		65	3	0	0										
	Schm		110	3	2	1										
Asphalt			20	0	0	0	0	0	0	0	0	0	0	0	0	0
Atmosphere	Land		-20	0	0	0	0	0	0	0	0	0	0	0	0	0
	Indust.		bis	1	0	0	0	1	0	0	0	0	1	0	0	1
	Sea		30	2	0LS	0S	0	0	0	0	0	0	1	0	0	2
Azo benzene			20		0	0	0	0	0	0	0	0		0		0

Medium		Concentration %	Temperature (°C)	unalloyed steels	18/8-Steel	18/8+Mo-Steel	Nickel	Monel 400 2.4360	Inconel 600 2.4816	Incoloy 825 2.4858	Hastelloy C 2.4819	Copper	Tombak	Bronce	Titaniuim	Aluminium
Barium carbonate			20	3	0	0		1		0	0				0	1
Barium chloride	Schm	100	1000		3L	3L			1							
	wL	10	SP		1L	0L	1	1	1	1	0	2	3	3		
	wL	25	SP		1L	0L		1			0				0	
Barium hydroxyde	solid	100	20	0	0	0	0	1	1	0	0	1	1	1		3
	wL	all	20		0	0	1	1	1	0	0	1	1	1		3
	wL	all	SP		0	0					1					
		100	815				1		1	0						
	wL	kg	20	0	0	0	0				1		1			0
	wL	hg	SP	0	0	0	0				1					3
		50	100				0	1	1	0						
Barium nitrate	wL	all	40		0	0			1	0		2			0	0
	wL	all	SP		0	0			1	0		2			0	0
	Schm		600		0	0									0	
	wL		20	0	0	0			1	1		2			0	0
	wL		>100	3	0	0			1	0		2			0	0
Barium sulphate			25	1	0	0	1	1		0	0	0		0	0	0
Barium sulphite			25	2	0	0	2					3	3	3		
Beer		100	20		0	0	0	0	0	0	0	0	1	0	0	0
		100	SP		0	0	0	0	0	0					0	0
Beer condiment		20	SP									3	1	3		1
Beet sugar syrup			20	(1)	0	0		0						0		
Benzene acid	wL	all	20		0	0					0				0	0
	wL	10	20	1	0	0	0	0	0	0	0	1	1	1	0	0
	wL	10	SP	3	0	0	0	0			0		2		0	3
	wL	ges	20		0	0					0				0	0
Benzene chloride	tr	100	20													0
	fe	100	20													3
Benzene, non-sulfureos		100	20		0	0	0	0	0	0	1				0	0
		100	SP		0	0	1	1	1	1	1	1	1	1		
Benzene sulphonal acid		91,3	140	3	3	3					1				3	
		92	200	3	3	3					0				3	
Blood (pure)			36		0S	0										
Bonder solubilzing			98			0	0									
Borax	wL	1	20		0	0	0	0	0	0						
	wL	ges	20	1	0	0	0	0	0	0			0	0	0	0
	wL	ges	SP	3	0	0	0	0	0	0						1
	Schm				3	3									0	
Boric acid	wL	1	20	3	0	0	1	1	1	0	0				0	0
	wL	4	20	3	0	0	1	1	1	0	0				0	0
	wL	5	20	3	0	0	1	1	1	0	0				0	0
	wL	5	100	3	0	0	2	1	2	0	0	1	2	1	0	0
	wL	ges	20	3	0	0	0	1	1	0	0				0	
	wL	all	20	3	0	0					0				0	
	wL	all	<SP	3	0	0		0	0		0				0	
		10	20	3	0	0	1	1	1	0	0				0	
Boron			20			0	0									
Brandy			20		0	0										1
			SP		0	0										3
Bromide water		0,03	20		0L	0L										
		0,3	20		1L	1L										
		1	20		3L	3L										
Bromine	tr	100	20	3L	3L	3L	0	0	0	1	0	0	0	0	2	3
	tr	100	<65	3L	3L	3L		0	0	1	0					3
	tr	100	<370	3L	3L	3L					2					3
	fe	100	20	3L	3L	3L	0	0	3		3	2	3	1	0	3
	fe	100	50		3L	3L	0		3		3					
Butadiene		100	30		0	0	0	0	0	0	0					
			20		0	0	0	0	0	0	0					0
Butane		100	20	0	0	0						0	0	0		
		100	120		0	0					1					
Butter			20		0	0	0	0	0	0	0	1	2	1	0	0
Butter acid		25	20	3	1		2	1	2	1	0	1				0
		25	60	3	1		2				0					0
		50	20	3			2				0					0
Butter acid		50	60	3			2				0					1
		ges	20	3	0	0	2				0					0
		ges	SP	3	2	0	2				0					1
Buttermilk			20		0	0		0	0	0	0				0	0
Butyl alcohol		100	20	0	0	0	1	1	1	0	0	0	0	0	0	0
		100	SP	0	0	0		2	2		0				0	0
Butyl acetate			20	0		0		1				0	0			0

Medium		Concentration %	Temperature (°C)	unalloyed steels	18/8-Steel	18/8+Mo-Steel	Nickel	Monel 400 2.4360	Inconel 600 2.4816	Incoloy 825 2.4858	Hastelloy C 2.4819	Copper	Tombak	Bronce	Titaniuim	Aluminium
			SP					1								
Cadmium	Schm	100	350	1	2	2										
	Schm	100	400		2	2										
Calcium	Schm	100	800	3	3	3										
Calciumbisulphite	wL	ges	20	3	0	0						0	3	1	0	
		ges	SP	3	2	0									0	
		20	20		0	0									0	
		20	SP		1	0									0	
Calcium carbonate			20		0	0	0	0	0	0	0					
Calium chlorate		100	20	0	0LS	0LS	1	1	1	0	1	1				
	wL	10	20		0LS	0LS	1	1	1	0	1	1				
	wL	10	100		2LS	1LS	1	1	1	0	1	1				
	wL	100	100		2LS	1LS	1	1	1	0	1	1				
Calcium Chloride	wL	10	20	3	0S	0S	0	0	0	0	0	1	3	1	0	3
	wL	25	20	3	0L	0L	0		0	0	0	1	3	2	0	3
	wL	25	SP	3	0LS	0LS			0	0	0		3		0	3
		ges	20	3	0L	0L	1	1	0	0	0		3		0	3
		ges	SP	3	1L	0L		2	0	0	0		3		1L	3
Calcium hydroxyde		<50	20	0		0	1	1	1	1	0	1	0	0	0	3
		<50	<SP	0		0	1	1	1	1	0	1			0	3
		ges	20	0		0	0	0	1	1					0	3
		ges	SP	0		0	0	0	2	2					0	3
Calcium hypochloride	wL	10	25	3	3LS	0LS		3			1	1	3	1	0	3
		15	50	3	3LS	0LS					1				0	3
		20	25	3	3LS	0LS					0	1	3	1	0	3
		20	50	3	3LS	0LS					1				0	3
		ges	<40	3	2LS	1LS					0				0	3
Calcium nitrate		20	100		0	0		0	0							
		50	100		0	0		0	0							
	Schm	100	148		0	0		0	0							
Calcium sulphate	fe		20	1	0	0	0	0	0	0	0					0
(Gypsum)			SP	3	0	0					1					1
Calcium sulphite	wL	ges	20	0	0	0										1
		ges	SP	0	0	0										1
Camphor		20	(0)	0	0	0	0	0	0	0	0					0
Carbon dioxide	tr	100	20	0	0	0	0	0	0	0	0	0		0	0	0
	tr	100	<540	0	0	0	0	0	0	0	0	3	0			
	tr	100	700	3					1							
	tr	100	1000	3					3							
	tr	all	<760													
	fe	15	25		0	0	1	1	1	0	0	0			0	3
Carbon dioxide	fe	20	25	1	0	0					0	1	2	1		3
	fe	100	25	2	0	0	1	1	1	0	0	0			0	3
Carbon oxide, 100 atü		100	20	0	0	0	0	0	0	0	0					
		100	<540	3	(0)		3	(1)	(3)		0	2				1
Carbon tetrachloride	tr	100	20	0	0L	0L	0	0	0	0	0	0	0		0	0
	tr	100	75		0L	0L										0
	tr	100	SP	1	0L	0L	0				0	0	0		0	2
	fe		20	0	0L	0L	0	0				1	2	1	0	1
	fe		SP	1	1L	1L	3	3				2	2	3	1	3
Carnallite	wL	kg	20	3	0L	0L				0	0					
		kg	SP	3	2LS	1LS				0	0					
Castor oil		100	20	(0)	0	0	0	0	0	0	0	0	0	0	0	0
		100	100	(2)	0	0	0	0	0	0	0	0	0	0	0	0
Cement	fe		20													3
Cheese			20		0	0										
Chloramin			20	3	1L	0L		0								0
		0,5	SP	3	1L	0L		0								0
Chlorine	tr	100	20	0	0L	0L	0	0	0	0	0	0		0	3	0
	tr	100	100	0	0L	0L	0	0	0	0	0	0			3	0
	tr	100	<250	3	0L	0L	0	0	0		1	3			3	3
	tr	100	<400	3	2L	1L	0	0	0		1				3	3
	tr	100	500	3L	3L	2L	1	1	0	2	1				3	3
	fe	99	20	3L	3L	3L	0	2	1		0	3	3	2	0	3
	fe	99	100	3L	3LS	3LS					1	3	3	3	1	3
Chlorine benzene		100	20	0	0LS	0LS	1	1	1	1	0	1				1
		100	SP		0LS	0LS	1	1	1	1	0					2
Chlorine calcium	fe		20	3	1LS	1LS		1				1	3	1		3
	wL	1	20	3	2LS	0LS									0	3
	wL	5	20	3	1LS	0LS	0					3			0	3
	wL	5	100	3	3LS	3LS	0								1	3
Chlorine dioxide	tr		70	2	2	0					0		3	3		
	wL	0,5	20	3	3	3					1		3	3		

Medium		Concentration %	Temperature (°C)	unalloyed steels	18/8-Steel	18/8+Mo-Steel	Nickel	Monel 400 2.4360	Inconel 600 2.4816	Incoloy 825 2.4858	Hastelloy C 2.4819	Copper	Tombak	Bronce	Titaniuim	Aluminium
	wL	1	65	3	3	3					2		3	3		
Chlorine sulphinated acid	tr	100	20		1LS	0LS	0	0	0	0	0	0			3	0
	fe	99	20	3	2LS	0LS	3		1	1					3	3
	wL	10	20	3	3	3	3		0	0					3	3
Chlorine vinegar acid	Mono-	50	20	3	3	3	1		1			2	3	3		3
		Konz	20	3	3	3	1		1							
		<70	SP	3					2		1					
	Di-	100	100	3												
	Tri-	>10	20	3	0L	0L			0		0					
			SP	3					3		1					
Chlorine water		ges	20	3	1LS	1LS					0				0	3
		ges	90	3	2LS	2LS					1					3
Chloroform	fe	99	20	3	0LS	0LS	0	0	0	0	0	0			0	3
	fe	99	SP	3	0LS	0LS	0	0	0	0	0	1			1	3
Chocolate			20	0	0	0	0	0	0	0	0	(0)	(0)	(0)	0	0
			120	0	0	0	0	0	0	0	0	(0)	(0)	(0)	0	0
Chromic alum	wL	ges	20	3	1	0	1	0	0				3			3
	wL	ges	SP	3	3	3	2						3			3
	wL	10	20	3	0	0	0						3			1
Chromium acid	wL	5	20	3	0	0	3	3	3	1	0	3	3	3	0	1
		5	90	3	3	3	3	3		1	1	3	3	3	0	
		10	20	3	0	0	2	2	2	1	0	3	3	3	0	1
		10	SP	3	3	3	3	3	3	1	0	3	3	3	0	3
		50	20	3	3	3	2	2	2	1		3	3	3	0	2
		50	SP	3	3	3	3	3	3	1		3	3	3	0	3
Chromium sulphate		ges	20	2	0	0	0	0	0	0	0					
			90	3	3	2	0	0	1	0	0					
Cider			20		0	0										1
Cinammon acid		100	20													3
Cocoa			SP	2	0	0	0	0	0	0	0	0	0	0	0	0
Coffee	wL		20	0	0	0	0	0	0	0	0	0	0	0	0	0
			SP	2	0	0	0	0	0	0	0	0	0	0	0	0
Copper acetate	wL		20	(3)	0	0	(1)	(1)	(1)					3		3
			SP	(3)	0	0								3		3
Copper-II-chloride	wL	1	20	3	1LS	0LS				0	1				0	
	wL	1	SP	3	3LS	3LS									0	
	wL	5	20	3	2LS	1LS	3				1	2	3	2	0	3
	wL	40	20	3	3	3	3				1					
	wL	40	SP	3	3	3	3		3	3					0	
	wL	ges	20	3	3	3	3									
Copper-II-cyanide	wL	10	20	2	0	0					0					
	wL	10	SP	3	0	0					1					
	wL	hg	SP	3	0	0	3	3	3		1	3				3
Copper-II-nitrate	wL	50	20		0	0	3	3	3	0	1	(2)	(3)	(2)	0	3
	wL	50	SP		0	0		3	3		1				0	
	wL	ges	20		0	0	3	3	3	0	1	3			0	3
Copper-II-sulphate		all	20	3	0	0	2	2	2		0	(1)	(3)	(1)	0	3
(copper vitriol)		all	<SP	3	0	0	3	3	3	0	0	3			0	3
Cotton seed oil			25	0	0	0				0		0	1	0		
Creosote			20	0	0	0						0				1
			SP													3
Creosote		100	20		0	0						0	1	0		
		100	SP		0	0										
Crude oil		100	20	1	0	0	0	0	0	0						0
		100	100	1	0	0	1	0	0							1
		100	400	3				3				3	3			
Developer (Photo)			20		0L	0L										
Dichlorethene		100	<50	3	2L	1L					1			0		
		100	SP											0		
Dichlorethylene	tr	<100	<30	0	0L	0L	0	0	0	0					0	0
	tr	100	SP		0L	0L									0	1
		<100	<700													3
	wh		105													3
	wh	1:1	<SP													
Dichlorethylene		100	20	0	0L	0L						0			0	
		100	SP		0L	0L	2					0			1	
Diesel oil			20	0	0	0	0	0	0	0	0	0	0	0	0	0
Diesel oil, S <1%		100	20		0L	0L	0	0	0	0	0	0	1	0	0	0
		100	100	0	0L	0L	2	0	0	0	0	1	1	1	0	1
Diphenyl		100	20	0	0S	0S	0	0	0	0	0	0	0	0	0	0
		100	400	0	0S	0S	0					0				
Dripping			20		0	0										

Medium		Concentration %	Temperature (°C)	unalloyed steels	18/8-Steel	18/8+Mo-Steel	Nickel	Monel 400 2.4360	Inconel 600 2.4816	Incoloy 825 2.4858	Hastelloy C 2.4819	Copper	Tombak	Bronce	Titaniuim	Aluminium
Dye liquor																
alkaline or neutral			20		0	0		0								0
			SP		0	0		0								0
organic sour			20		0	0		0								1
			SP		0	0		0								1
heavily sulphuric			20	3	1	0		0	0							
			SP	3	3	1		0								
slightly sulphuric			20		0	0		0	0							
			SP	3		0		0								
Ether		100	20		0	0		0			1	0	0			0
		100	SP		0	0		0				0	0			
		all	SP		0	0		0				0	0			
Etherial oil																
Citrus oil			20		0	0	0	0	0	0						0
Eucalyptus oil			SP		0	0	0	0	0	0						0
Caraway seed oil			20		0	0	0	0	0	0						0
Ethyl acetate			20	1	0	0	2	1			1	0		0	0	1
		all	<SP	1	0	0	2	1			1	2	2	2		
		35	120	1	0	0		1			0	2	2	2		
		100	20	1	0	0	2	1			1	0	1	0		1
		100	SP	1	0	0	2	1			1	2	2	2		
Ethyl alcohol		100	20	0	0	0	0	0	0	0	0	0	0	0	0	0
denaturalized		96	20	1	0	0	0	0	0	0	0	0	0	0	0	0
		96	SP	2	0	0	0	0	0	0	0				0	0
Ethyl benzene			115		0	0			0	0	0					0
Ethyl chloride			20	0	0L	0L	0	0	0	0	1	2	2	2	0	1
			SP		0L	0L					1	3	3	3	0	
	tr		20	0	0L	0L	0	0	0	0	1				0	0
	tr		SP		0L	0L					1				0	1
	fe		SP								1				0	3
	wL	25	20				0	0	0	0	1				0	
	wL	50	25				0	0	0	0	1				0	
	wL	70	25				0	0	0	0	1				0	
	wL	100	25		0L	0L	0	0	0	0	1				0	
	wL	5	25		0L	0L	0	0	0	0	0				0	2
Ethylene			20		0	0										0
Ethylene bromide			20		0L	0L										0
			SP		0L	0L										3
Ehtylene diamide Hydrochloride		100	SP	3						2						
Ethylene chloride	tr	100	20	0	0L	0L		0	2	0		2	3	2	0	0
	wL	100	50	3	1L	1L					1				0	3
	tr	100	SP		0L	0L									0	0
	fe	100	20													3
	wL	100	SP													3
			20	1	0	0										
Ethylene glycol		100	20	0	0	0	1	1	1	0		1	2	2		0
		100	120													0
Ethylene oxyde			20		0	0										0
Exhaust gas																
Exhaust gas (diesel)	tr		600	3	0L	0L	0	0	0	0	0					1
(Flue gas)	tr		600	3	0L	0L			0	0	0					3
			900	3					0	0	0					
			1100	3					0		0					
Fatty acid, high technology		100	60	3	0	0	0	0	0	0	0	0	2	1	0	1
		100	150	3	0	0	0	1	0	0	0	0			0	3
		100	235	3	2	0	0	1	0	0	0	3	3	3	0	3
		100	300	3	3	0	0	1	0	0	0	3	3	3	0	3
Ferro-gallic-ink			20	0	0L	0L		1								
Fluorbor ether		100	50								0					
Fluorine	tr	100	20	0	0	0	0	0		0	0	0	0	0	0	3
	tr	100	200	0	1LS	1LS	0	0			0	3				3
	tr	100	500	3			0				0	3				3
	fe	100	20	3	3	2	0	0			0	3	3	3		3
Formic acid		10	20	3	0	0	0		0	0	0					0
		10	SP	3	1	0	2		0	0	0					3
		50	20	3	0	0				0	0					
		50	SP	3	3	1				0	0					
		80	20	3	0	0		2	0	0	0	1				0
		80	SP	3	3	2		2	1	0	0	0				2
		100	20	3	0	0		3			0	1	1	1		0
		100	SP	3	1	1		3			0					
Formic aldehyde		10	20	3							0	0	2	0	0	1
		10	70	3							1				0	2

Medium		Concentration %	Temperature (°C)	unalloyed steels	18/8-Steel	18/8+Mo-Steel	Nickel	Monel 400 2.4360	Inconel 600 2.4816	Incoloy 825 2.4858	Hastelloy C 2.4819	Copper	Tombak	Bronce	Titaniuim	Aluminium
		40	20	3	0	0		0			0	0		0	0	1
		40	SP	3	0	0					1				0	
Freon		100	-40		0	0	0	0	0	0	0	0	0	0	0	
			100		0	0	0	0	0	0	0	0	0	0	0	
Fruit acid			20	(1)	0	0	0	0	0	0	0	(0)				0
			SP	(2)	0	0	(0)	(0)				1	3	1		
Fruit juce			20	1	0	0		0				1	3	1		0
			SP	1	0	0		0								
Fuel, benzene	tr		20	0	0	0	0	0	0	0	0	0	0	0	0	0
	tr		SP	0	0	0	0	0	0	0	0	0	0	0	0	0
	wh		20	0	0	0	0	0	0	0	0	0	0	0	0	3
	wh		SP	0	0	0	0	0	0	0	0	0	0	0	0	3
Fural		100	25	2	0	0							2	0		
		100	SP	3								2				
Furaldehyde			20	2	0	0						1	3	1		0
			SP	3	0	0										3
Gallic acid	wL	1	20					0								0
	wL	<50	100	2												0
		100	20	2	0	0										0
		100	SP	3	0	0			3							
Gelatine	wL		80	1	0	0	0	0	0	0	0	0	1	0	0	0
		<40	50				1	1	0	0	0					0
Glas	Schm	100	1200	1	1	1										
Glucose			20		0	0						0	1	0		
Glutamine acid			20	1					0	0	0					
			80	3					1	1	1					
Glycerin		100	20	0	0	0	0	0	0	0	0	0	0	0	0	0
		100	SP	1	0	0	0	0	0	0	0	1	0	0	0	0
Glykol acid			20	3	1	1					0				0	1
			SP	3	3	3					0				0	1
Gum (raw)			20	1	0	0	0	0	0	0	0	0	0	0	0	0
Heavy fuel		100	20		0L	0L	2	0	0	0	0	0	0	0	0	0
Hexamethylenetetramine	wL	20	60	1	0	0					0					
	wL	80	60	2							0					
Hydrobromic acid			20	3	3	3	3	3	2	3		2	3	2		3
Hydrocarbon, pure			20	0	0	0							0	0	0	
Hydrochloric acid		0.2	20	3	1LS	1LS	(1)				0				0	
		0.2	50	3	2LS	3LS					0				0	
		1	50	3	3	3					0				0	
		1	100	3	3	3					3				(1)	
		10	20	3	3	3	(2)				1				1	
Hydrofluosilic acid		5	40	3	1L	1L					1		(1)			3
		100	20	3	1L	2L					1	1	3	1		3
		100	100	3	2L	2L					1				2	3
Hydrocyanic acid		20	20	3	0	0	2	1	1	0	0	3	3	3	0	0
Hydrogen		100	20	0	0	0					0	0	0			0
		100	300	1	0	0					0	0	0			0
		100	500	3	0	0					0		3			0
Hydrogen fluoride		5	20	1	3	3	0	0	0	0	0	3			3	3
		100	500	3	3	3	1	2	2	3	1	3	3		3	3
Hydrogen fluoride acid		all	20	3	3L	3L	1	1	1	1	1	3	3	3	3	3
HF-Alkylation		10	20	3	3L	3L	1	1	1	1	0	2	3	2	3	3
		80	20	1			1	1	1	1	1	1			3	3
		90	30				1	0	1	1					3	3
Hydrogen superoxide		all	20		0	0	1	1	1	0	0	2			1	0
		30	20		0	0					0	1	2	1		
		30	70		0	0					0	1	2	1		
		85	<70		0	0					0					
		all	SP	2	2	0					0	3			1	
Hydroquinone			20				1	1	0	0						0
Hydroxylamine sulphate	wL	10	20		0	0										
	wL		SP		0	0										
Hypochlorous acid			20			0										3
Illuminating gas			20	(1)	0	0		0								0
Inert gas	tr		20	0	0	0	0	0	0	0	0	0	0	0	0	0
	fe		20	0	0	0	0	0	0	0	0	0	0	0	0	0
Ink		100	20	1	0L	0L		0								3
		100	SP		1L	1L										3
Insulin		100	<40					0	0	0	0					
Iod	tr	100	20	0	0L	0L		0	0	0		3	3	3	3	0
		100	300	1	0L	0L	3			0	0				2	3
	fe	100	20	3	3L	2L	3	3			1					3

Medium		Concentration %	Temperature (°C)	unalloyed steels	18/8-Steel	18/8+Mo-Steel	Nickel	Monel 400 2.4360	Inconel 600 2.4816	Incoloy 825 2.4858	Hastelloy C 2.4819	Copper	Tombak	Bronce	Titaniuim	Aluminium
Iod, alcohol 7%			20	3	1L	0L	3					3	3	3		
Iod hydrogene acid	wL		20		3	3							3			3
Iodoform, steam	tr		60	0	0	0										0
	fe		20	3	0L	0L										0
Iod tincture			20		2L	0L										3
Iron-II-chloride	tr	100	20	0			3	3	3	2	0				0	
	wL	10	20	3	3	3	3	3			1	1	3	1	0	3
Iron-III-chloride	tr	100	20	0	0L	0L	2	2	2	1	0	3	3	3	0	3
	wL	10	Sp	3	3L	3L				2					0	
	wL	50	20	3	3L	3L			2		1				0	
	wL	50	<SP	3	3L	3L			3						0	
Iron-III-nitrate	wL	10	20	3	0	0					0					
	wL	all	20	3	0	0										
	wL	all	SP	3	0	0										
Iron phosphate (Bonder)			98		0	0										
Iron-II-sulphate	wL	all	20	0	0	0		1			1	1	3	1		1
	wL		SP		0	0	3	1			1					3
Iron-III-sulphate	wL	<30	20	3	0	0					0	3	3	3		3
		<30	<65	3	0	0					0					
		<30	80	3	1	0						3	3	3		3
		<30	SP	3	1	0										
Isopropyl nitrate			20										0			
Kerosene		100	20	(0)	0	0	0	0	0	0	0	(0)	(0)	(0)		
Lactic acid	wL	1	20	1	0	0						0	2	1	0	0
		1	SP		0	0									0	3
		10	20		0	0	(1)	0	0			1	2	1	0	0
		10	SP		3	2	3	3	(2)			1			0	3
		50	20		0	0	1		0		0				0	0
		50	SP		2	1			(1)		(0)				0	3
		80	20		0	0									0	0
		80	SP		2	1									0	3
		100	SP		2	1									0	3
Laquer (also varnish)			20	(1)	0	0	0	0				0	0	0	0	0
			100					0								(1)
Lead		100	360	(0)	(2)	(1)	(2)	2	0							0
			600	(0)	(2)	(1)	(3)		0							
Lead acetate	wL	10	20		0	0										0
	wL	all	SP		0	0										
Lead nitrate	wL		20		0	0										
	wL		100		0	0										0
	wL	50	20		0	0										3
Lead suggar		all	20		0	0	1	1	2	0		2			0	3
		all	SP		0	0	1	1	2	0		2			0	3
Lead vinegar, basic	wL	all	20		0	0	1	1	2	0		2	3	2		3
	wL	all	SP		0	0	1	1	2	0		2	3	2		3
Lime-milk			20	0	0	0	0	0	0	0	0	0	0			
			SP	(0)	0	0	0	0	0	0	0	0	0			
Lemon acid	wL	5	20	2	1	0			0	0	0	0	0	0	0	
		konz.	SP		3	2	2	2	2	1	0	2			0	3
Lemonade			20		(1)	0			0	0	0					
Linseed oil			20	0	0	0		0	0	0	0	0	1	1	0	0
			200	(0)	0	0		0	0	0	0	(0)			0	
+ 3% H_2SO_4			200	(3)	1	0			0	0	0				0	
Lithium	Schm		400	(0)	0	0			0	0	0					
Lithium chloride	wL	kg		3	3	1LS	0	1	0	0	0				0	
Lysoform			20		0	0			0	0	0					
			SP		0	0			0	0	0					
Lysol		5	20	(2)	0	0		0	0	0	0					0
		5	SP	(3)	0	0			0	0	0					0
Magnesium	Schm		650		3	3	3	3	3	3	3	3	3	3	0	3
Magnesium carbonate		10	SP	(0)							1	0			0	1
		ges	20	(0)	0	0									0	1
Magnesium chloride	tr	100	20	0	0L	0L					0				0	3
	wL	5	20	3	0LS	0LS			0	0	0	2			0	2
	wL	5	SP	3	2LS	2LS			0	0	0	2			0	3
	wL	50	20	3	2LS	1LS			0	0	0				0	3
	wL	50	SP	3	2LS	2LS			0	0	0				0	3
Magnesium hydroxyde			20	0	0	0	0	0	0	0	0	0	(0)	0	0	3
Magnesium sulphate		0.10	20	(0)	0	0										3
		5	20	2	0	0	1	1	1	0	0	0	3	0	0	0

Medium		Concentration %	Temperature (°C)	unalloyed steels	18/8-Steel	18/8+Mo-Steel	Nickel	Monel 400 2.4360	Inconel 600 2.4816	Incoloy 825 2.4858	Hastelloy C 2.4819	Copper	Tombak	Bronce	Titaniuim	Aluminium
		10	SP	3	0	0					1				0	0
		25	SP	3	0	0				1	1					
		50	SP	3	0	0					1				0	0
Malonate acid			20		1	1	1	1	1	1	1				1	1
			50				1	1	1	1	1				1	
			100				3	3	3	3	3				3	
Manganese dichloride		5	100	3	0LS	0LS	1	1	1	0		3			0	0
		10	SP	3	0LS	0LS	1	1	1	0		3			0	
		50	20	3	0LS	0LS			0			3			0	
		50	SP	3	0LS	0LS			0			3			0	
Meat			20		0	0										
Methyl acetate		60	SP	(0)							0					
Methyl alcohol		<100	20	(1)	0	0	0	0	0	0	0	0	0	0	0	0
		100	SP	(1)	1	1	0	0	0	0	0	0	0	0	0	1
Methyl chloride	tr	100	20	0	0	0	0	0	0	0	0	0	0	0	0	0
	fe		20	2	0LS	0LS			0	0	0				0	3
Milk	fresh		20	(0)	0	0	0	1	0	0	0	(0)	(2)	0		0
			70	(1)	0	0	2	2	0	0	0					(0)
	sour		20	(1)	0	0										
	sour		SP	(3)	0	0										
Mercury		100	20	0	0	0	0	(3)	0	0	0	3	3	3		(1)
		100	50	0	0	0	0	3		0	0					3
		100	370				(0)	3		0	0					3
Mercury chloride		0.1	20	3	0S	0S	0	3	0	0	0	3	3	3		3
		0.1	SP	3	1S	0S	1	3	1	0	0	3	3	3		3
		0.74	SP	3	2S	2S	1				0					3
		10	<80								1					3
Mercury cyanide	wL		20	(3)	0	0	3	(3)	3	2	0	3	3	3		
Mercury nitrate			20	(3)	0	0		(3)				3	3	3		3
Molybdenum acid	wL	10	25								1					
Monochloracetic acid	wL	all	20	3	3	3	(1)	2	(1)	3	1	3				3
		30	80	3	3	3	(1)		(2)			3	3	3	3	3
Mustard			20	2	0L	0L										
Natural gas		100	20		0	0		0		0	0	0	0	0		
Naphtene		100	20	0	0	0	0	0	0	0	0					0
Nickel chloride		10	20	3	1LS	1LS	1	1	1	0	0	3	3	1		
		10	<60	3	1LS	1LS			0	0	0					
		80	<95								0					
Nickel nitrate	wL	<10	20	3	0	0	3	3	0	0	0	3			0	3
		10	25	3	0	0	3	3	0	0	1	3			0	3
		<100	30	3	0	0	3	3	3	0	1	3			0	3
Nickel sulfate	wL		20	3	0	0	(3)	(1)	(1)	0	(1)	0	2	1		
		<60	SP	3	0	0	(3)	(1)	0		1					
		10	25	3	0	0	2	2	2	0	0	0				3
Nitric acid		1	20	3	0	0	0	0				3	3	3	0	
		1	SP	3	0	0	2	2				3	3	3	0	
		10	20	3	0	0	2	1	2	1	0	3	3	3	0	2
		10	65	3	0	0	3	2			0	3	3	3	0	
		10	SP	3	0	0	3	3			1	3	3	3	0	
		15	20	3	0	0					(1)				0	
		15	SP	3	0	0					3				0	
		25	20	3	0	0					0				0	
		25	65	3	0	0					0				0	
		25	SP	3	0	0					3				0	
		40	20	3	0	0					0				0	
		40	65	3	0	0					1				0	
		40	SP	3	0	0					3				0	
		50	20	3	0	0					0				0	
		50	65	3							1				0	
		50	SP	3	1	1					3				0	
		65	20	3	0	0					0				0	
		65	SP	3	(0)	2					3				0	
Nitric acid		90	20	3	0	0					1				0	
		90	SP	3	2	2					3				0	
		99	20	(1)	1	2					3				0	
		99	SP		3	3					3				0	
		Konz														
		.	20	3	0	0										0
		5	25	3	0	0			1	0		2			0	2
Nitro acid		5	20		0	0										
		5	75			1										
Nitro benzene		100	100				1	1	1	1	1					0
Nitro gas	tr	alle	540								0	3	3			

Medium		Concentration %	Temperature (°C)	unalloyed steels	18/8-Steel	18/8+Mo-Steel	Nickel	Monel 400 2.4360	Inconel 600 2.4816	Incoloy 825 2.4858	Hastelloy C 2.4819	Copper	Tombak	Bronce	Titaniuim	Aluminium
Nitrogen		100	20	0	0	0	0	0	0		0	0	0	0	0	0
		100	200	0	0	0	0					0			0	0
		100	500	0	1	1	3									
		100	900	1			3									
Nitrogen oxide NOx	tr	100	20		0	0	3	3	3	0	0	0			0	0
	fe	100	20													3
Nitrohydrochlorid acid			20	3	3	3L	3L	3	3	3	3	3	3	3	2	3
Novocaine			20		0	0										
Oil			20	0	0	0						0		0		0
			SP	(0)	0	0						(0)		(0)		(1)
Oil acid, tech.			20	(1)	0	0		0	0		0	0	1	(0)		0
			150	(2)	0	0		0	0		(0)	(2)	1	1		0
			180	3	1	0		1	0		(0)	3	(1)	3		
			235	3	2	0			(0)		(0)	3		3		
Oxalic acid	wL	2	20	3	0	0	2	1	1	1	0	0	2	1	0	0
		2	80	3	0	0		1	1	1	0				3	1
		5	20	3	0	0	2	1	1	1	0				0	1
		5	80	3	1	0					0				3	2
		10	20	3	1	0	2	1	1	1	0	(0)	2	1	2	3
		10	SP	3	3	2	2	1	1	0	0	1			3	(3)
		30	20	3	3	3	2	1	1	1	0					
		30	SP	3	3	3		1	1	1	1				3	
		50	20	3	3	3	2	1	1	1	0					
		50	SP	3	3	3	2	1	1	1	1				3	
Oxygen		100	-185	(0)	0	0		0				0	0	0		
		100	20	0	0	0		0				0	0	0		
		100	500	(1)	0	0		0				3		3		
Palmitic acid		100	20		0	0	0	0	0	0	0	1	2	1	0	0
Paraffin	Schm		120	(0)	0	0	0	0	0	0	0	0	0	0	0	0
Perchloroethylene	wL	100	20	0	0L	0L	0	0	0	0	0	0	1	1	0	3
		100	SP	(3)	0L	0L	0	0	0	0	0	(0)	(0)	(0)	0	3
Petrol	tr		20	0	0	0	0	0	0	0	0	0	0	0	0	0
	tr		SP	0	0	0	0	0	0	0	0	0	0	0	0	0
Petroleum (kerosine)			20	0	0	0	0	0	0	0	0	0	1	0	0	0
			100	0	0	0	(2)	0	0	0	0	(0)	(1)	(0)	0	
Petroleum ether		100	20		0	0										
		100	SP		0	0										
Petrolium / fuel		100	20	0	0	0					0	0	0	0		
		100	SP		0	0					0					
Phenic acid	pure	100	SP	3	1	0	0	0		1	1				0	3
(Phenol)	wL	90	SP	3	1	0	0	(0)			1				0	3
	raw	90	20	(1)	0	0	0	0			0	1	1	1	0	
		90	SP	3	1	0		(0)			1					3
		50	20	(1)			(1)	0		0	0					0
		50	70	3	1		(1)	0			1					1
Phenolsulphonic acid		30	20	(0)	0	0				0	0					
		30	120							0	0					
Phosphor	tr		20	0	0	0										0
phosphor penta chloride	tr	100	20				(0)	(0)							1	
		100	60				(0)	(0)							1	
Phosphorous acid	wL	1	20	3	0	0	0	1	0	0	0	2	3	3	0	3
chem. pure		5	20	3	0	0	0	1	1	0	0	2	3	3	0	3
		10	20	3	0	0	2	1	1	0	0	2	3	3	0	3
		10	80	3	0	0					0				1	
		30	20	3	0	0	0	1			0	1	1	1	0	
		30	SP	3	1	1	(2)	(1)			1	2	2	(1)	3	
		50	20	3	0	0	0	0	0		0		(0)		1	
		50	SP	3	2	1	(2)	3	3	2	1		(0)		3	
		80	SP	3	3	3	3		(0)	1	2			1	3	1
Phosphorous acid		<30	25	3	0	0					0				1	
technical		<30	SP	3	0	0					1				3	
		50	25	3	0	0					0				1	
		50	SP	3	3	2					2				3	
		85	25	3	0	0					0				3	
		85	SP	3	3	3					1				3	
Pineapple juice			25		0	0	0	0	0	0	0					
			85				1	1	0	0						
Pit water (sour)			20	3	0	0						3	2	1		2
Potassium	Schm	100	100	0	0	0				0						0
			600		(0)					0						0
			800		(0)					0						0
Potassium acetate	Schm	100	292	3	0	0						3				

Medium		Concentration %	Temperature (°C)	unalloyed steels	18/8-Steel	18/8+Mo-Steel	Nickel	Monel 400 2.4360	Inconel 600 2.4816	Incoloy 825 2.4858	Hastelloy C 2.4819	Copper	Tombak	Bronce	Titaniuim	Aluminium
	wL		20	(1)			0	0	0	0	0	1		1		
Potassium bi-chromate	wL	25 25	40 SP	3 3	0 0	0 0	1	1	1	1	1 1	3 3	3 3	3 3		0 (0)
Potassium bi-fluoride	wL	ges	20		0L	0L										
Potassium bi-tartrate (Cream of tartar)	wL wL	kg hg		3 3	0 3	0 1	0 1									0 1
Potassium bromide	wL	5 5	20 30	3 3	0L 0L	0L 0L	0 0	0 0	 1	 1	 0	0 0	0 0	0 0		1 2
Potassium carbonate	Schm wL wL	100 50 50	1000 20 SP	3 2 3	3LS 0 3	3LS 0 3	 0	0 0 0	 0 0	 0 0	 0 1	 1	 3 3	 1	 0	3 3
Potassium chlorate	wL	5 ges	20 SP	(2) 3	0L 0L	0 0	1 3	1 3	1 3	0 0	 0	(1) 1	(1)	(1)	0 0	0 1
Potassium chloride	wL	5 30 30	85 20 SP	(2) (1) 2	0L 0L 1L	0L 0L 0L	1 0	1 0 0	2 0 0	0 0 0	1 1 1	1 1 (2)	2 2 (2)	1 1 (1)	0 0 0	3 3 3
Potassium chromate	wL	10 10 <30	20 SP 30	0 (1)	0 0 0	0 0 0	0 0 0	1 1	0 0	0 0	0	0	0			0 0
Potassium chrom. sulph.	wL	ges ges	20 SP	3 3	1 3	0 3	1 2	0 (1)	0				3 3			3 3
Potassium cyanate	Schm wL	100 10	750 20	3 (0)	 0	 0		3 (1)				 3	 3	 (0)		 1
Potassium cyanide	wL	10	SP	3	0	0						3	3	3		3
Potassium hydroxide	wL	20 20	20 SP	0 0S	0 0S	0 0S	0 0	0 0	 1	0 1	0 1	1 3	2	1	0 0	3 3
Potassium hydroxide	 Schm	50 50 hg 100	20 SP 360	0S 0S 0S 3	0S 3 0S 3	0S 3 0S 3	0 0 0	0 0	1 3 3	1 1	0 1 1 3	 3			 3 3	3 3 3 3
Potassium hypochloride	wL	all all	20 SP	3	2L 3L	0L 3L	3 3	3 3	3 3	3 3	0 1				0 0	3 3
Potassium iodide	wL		20 SP	(0) (0)	0L 0L	0L 0L	3 3	3 3	1 1	0 0	0 0					3 3
Potassium nitrate (Saltpetre)	wL	25 25 ges ges	20 SP 20 SP	0 0 2	0 0 0 0	0 0 0 0	1 1	1 1 1	1 1 1	0 0	1 1 1 1	0 0	0 (0)	0		(0) 0
Potassium nitrite		all	SP	1	0	0	1	0	0	1	0	1	1	1		
Potassium oxalate		all all	20 SP		0 0	0 0	0 0		0 0	0 0	0 0					
Potassium perchlorade	wL	25 75	20 50								1 1					
Potassium permanganate	wL	10 all	20 SP	0 3	0 1	0 1	0 0	(1) 1	 1	 0	0 1	 0			 0	 0
Potassium persulphate	wL	10	25	(3)	0	0	(3)	(3)	0		0	(3)	(3)			(3)
Potassium sulphate	 wL wL	10 all 5 5	25 SP 20 90	 3 3	0 0 2 3	0 0 0 3		(1)			1	0	1	0 0	0 0 3	(1)
Propane		100	20	(0)	0	0	0	0	0	0	0	0	0	0	0	0
Pyrogallol		all all	20 100	(0) 3	0 (0)	0 0					0 1			(0) (0)		0 0
Quinine-bi-sulphate	tr		20	3	3	1		1		0	0	0			0	
Quinine sulphate	tr		20	3	0	0		1		0	0	0			0	
Resina (natural)		100 100	20 300	 3	0 0L	0 0L		0				0 1	1	0 1		
Salycilic acid	tr wL	100 1 ges	20 80 20	1 (3) (3)	0 0 0	0 0 0	0 0 0	0 0 0				 (1)		 (1)		0 0 1
Sea water			20 50 SP	(1) (1) (2)	0LS 1LS 2LS	0LS 0LS 1	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 (0) (1)	(0) (1) (1)	0 0 (0)	0 0 0	(0) (0) (1)
Sewages (w.o.H_2SO_4) (with H_2SO_4)			<40 <40		0 0	0 0	0	0	0	0	0	2 3	3 3	2 3	0 0	3 3
Silver bromide	 wL	100 10	20 25	3 3	2LS 0LS	2LS 0LS	1			0	0 0	3	3	3	0 0	3
Silver chloride	wL	10	20	3	3LS	3LS				0	1	3	3	3	0	3
Silver nitrate	wL wL wL	10 10 20	20 SP 20	3 3 3	0 0 0	0 0 0	3 3	3	1	0	1 1	3	3	3	0 0 0	3

Medium		Concentration %	Temperature (°C)	unalloyed steels	18/8-Steel	18/8+Mo-Steel	Nickel	Monel 400 2.4360	Inconel 600 2.4816	Incoloy 825 2.4858	Hastelloy C 2.4819	Copper	Tombak	Bronce	Titaniuim	Aluminium
	Schm	100	250	2	0	0										
Sodium		100	20	0	0	0										0
		100	200	0	0	0										(1)
		100	600	(3)	0	0										
Sodium acetate	wL	10	20	0	0	0	0	0	0	0	0				0	0
		ges	SP	(2)	0	0					(1)				0	
Sodium aluminate	wL		20	0	0	0										
Sodium bi-carbonate	wL	10	20	0	0	0	1	1	1	0	0	1	2	1	0	0
		10	SP	(1)	0	0					1					
		20	SP								1					
Sodium bi-sulphite		10	20	3	0	0	0				1	3	1			(0)
		10	SP	3	2	0										3
		50	20	3	0	0	0		0		1	3	1	(0)		
		50	SP	3	0	0			(0)							
Sodium bromide	wL	all	20	3	3LS	2LS					0					3
		all	SP	3	3LS	2LS					1					3
Sodium carbonate	wL	1	20		0	0					0					
		1	75	1L	0	0	0	0			0	1	2	1	0	
		kg	20		0	0										3
		kg	SP	3	0	0										3
	Schm		900	3	3	3		(0)								
Sodium chlorate		30	20	2	0LS	0LS									0	
		30	SP	3	0LS	0LS									(0)	
Sodium chloride	wL	3	20	(1)	0LS	0LS	1	0	1		0				(0)	3
		3	SP	(2)	0LS	0LS	1	0	1		1				(0)	
		10	20	(2)	0LS	0LS	1	0	1		0	1	2	1	0	1
		10	SP	(3)	0LS	0LS	1	0	1		1				1	
		kg	20	(2)	0LS	0LS	1	0	1		0				0	2
		kg	SP	(2)	2LS	0LS	1	0	1		1				(0)	2
Soap	wL	1	20				0	0	0			0	1	0		0
	wL	1	75				0	0				0	1	0		
	wL	10	20				0									0
	wL	100		0	0	0	0					3				
Sodium citrate	wL	3.5	20		0	0	1		1	0	0	0			0	3
Sodium cyanide	Schm	100	600	(1)				3				3	3	3		3
	wL	ges	20	3		0	0	3				3	3	3	0	3
Sodium dichromate	wL	ges	20			0	0					3	3	3	0	
Sodium fluoride		10	20	(0)	0LS	0LS	0		0	0	0		(3)			
		10	SP	(0)	0LS	0LS				0	0					
		kg	20		0LS	0LS				0	0					
Sodium hydroxide	fest	100	320	(3)	3	3	0	1	0						0	3
	wL	5	20	0	0	0	0	0	0	0	0	0	1	(0)	0	3
		5	SP				0	0	0	0	0	1	2	1	0	3
		25	20	0	0S	0S	0	0	0	0	0				0	3
		25	SP	2	1S	1S	0	0	0	1	1				0	3
		50	20	0	1S	1S	0	0	0	0	0				0	3
		50	SP	2	2S	2S	0	0	0	1	1				0	3
Sodium hyposulfite		all	20	2	0	0	1	1	1	0	0	2			0	
		all	SP	2	0	0	1	1	1	0	1	2			0	
Sodium nitrate	Schm	100	320	3	0	0	1				3					0
	wL	5	20	(2)	0	0	1	1	0	0	0					0
	wL	10	20	1	0	0	1	1	0	0	1	1	2	1	0	0
	wL	30	20	1	0	0	1	1	0	0	1					0
	wL	30	SP	(1)	0	0	1	1	0							0
Sodium nitrite	wL	100	20		0	0	2	2	2	1		0			0	0
Sodium perborate	wL	ges	20	(1)	0	0					1				1	
Sodium perchlorate	wL	10	20	(2)	0LS	0LS					0					
		10	SP	(3)	0LS	0LS					0					
Sodium peroxide	wL	10	20	3	0	0	0	0	1	1	1	3			3	3
	wL	10	SP	3	0	0	1	0	1	1	1	3			3	3
Sodium phosphate	wL	10	20		0	0	0	0				1	2	1	0	(0)
		10	50		0	0	(0)									(0)
		10	SP		0	0						3				(1)
Sodium pochloride		10	25	(1)	1LS	0LS			(0)	(0)	(0)	2	3	(1)	0	3
(javel water)		10	50	(3)	1LS	0LS			(0)	1	1				0	3
Sodium salicylate (Aspirin)	wL	ges	20		0	0										
Sodium silicate		ges	20		0	0	0	0	0	0	0	0	1	0	0	(2)
Sodium sulfate	wL	10	20	3	0	0	0	0	0	0	0	0	0	0	0	0
		10	SP	3	0	0					1					
		30	20	3	0	0					1					0
		30	SP	3	0	0					1					
		kg		3	0	0		1	1	0	0				0	

Medium		Concentration %	Temperature (°C)	unalloyed steels	18/8-Steel	18/8+Mo-Steel	Nickel	Monel 400 2.4360	Inconel 600 2.4816	Incoloy 825 2.4858	Hastelloy C 2.4819	Copper	Tombak	Bronce	Titaniuim	Aluminium
		hg		3	0	0		0	0	0	0				0	1
Sodium sulfide	wL	20	20	3	0	0	1	3	0	0		2	1	2	0	3
		20	SP	3	0	0			(0)		1				0	3
		50	SP	3	0	0		3	(0)		1				0	
	wL	kg	20	3	(0)	(0)	1		1			3			0	
		hg		3	3	1									0	3
Sodium sulfite	wL	10	20	(3)	0	0		0				(1)	(3)	(1)		0
		50	20	(3)	0	0		0								
		50	SP		0	0										
Sodium thiosulfate	wL	1	20	1	0	0	0	0								0
		25	20	3	0	0	0	0								0
		25	SP	3	0L	0L	0									1
		100	20	3	0	0	1	1	1			2				
Sodium triphosphate	wL	10	20								1					
		10	SP								1					
		25	50								1					
Soft soap			20		0	0										
Spinning bath		<10	80	3	2	1					0					3
		<10	80	3	3	3					0					3
Steam	fe		100	2	0	0	0	0	0	0	0	0	0	0	0	1
	fe		200	2	0	0	0	0	0	0	0	0	2	0	0	1
	tr		150	0	0	0	0	0	0	0	0	0	0	0	0	1
	tr		600	2	0	0	2									1
Stearic acid		100	20	1	0	0	0	0	0	0	0	1	2	1	0	0
		100	80	3	0	0		0	0	0	0					3
		100	130	3	0	0		1		0	0					0
Suggar	wL		20	1	0	0			0	0	0	0	0	0	0	0
	wL		SP	1	0	0			0	0	0	1		0	0	0
Sulphite lye			20		0	0										
			80		2	0										
			140		3	0										
Sulphur	tr	100	20	0	0	0				0	0	1	0	1	0	0
	Schm	100	130	(1)	0	0	3	3	(0)	0	0	3	3	3	0	
	Schm	100	445	3	2	2					0				(0)	
	fe		20	3	1	0	3	3				3	3	3	0	
Sulphur chlorine	tr	100	30	0	0LS	0LS	0	0				(0)	(0)	(0)	0	3
	tr	100	SP		0LS	0LS	0									
Sulphur dioxide	tr	100	20	0	0	0		1				0	0	0	0	0
	tr	100	400	1	2	0							3			
	tr	100	800	3	3	2	3									
	fe		20	2	0	0						1	3	1	0	1
			400	3	1	1	3									0
Sulphur acid		1	20	3	1	0	0	1	1	0	0	1			0	1
		1	70	3	1	0			2	1	0				(0)	
		1	SP	3	1	1					1				3	
		10	20	3	2	1	1	1			0	2	1			1
		10	20	3	2	1	1	1			0	2	1			1
		10	70	3	2	2	2	2			0				(3)	
		40	20	3	1	1		1			0	2	3	2	1	1
		80	20	3	3	3		1			0	(1)	3	1	3	2
		96	20	1	0	0	1	2		0	0	1			3	2
		96	SP	3	3	3	3	3	3	3	3	3	3	3	3	3
Sulphur hydrogen H_2S	tr	100	20	1	0	0	0	1	1	0	0	0	0	0	0	0
	tr	100	100	3	0	0						0				0
	tr	100	>200	3	0	0										0
	tr	100	500													0
	tr		20	3	0	0	1	0	0		0	3	2	3	0	0
Sulphur monoxyde		100	20	1	0	0	(0)	(0)				1	0	1	1	0
		100	SP	2	0	0	(0)	(0)								0
Sulphur trioxide SO_3	fe	100	20													
	tr	100	20				3	3	3	2	0	0	0	0	3	0
Sulphurous acid SO_2 (Gas)	fe		200	3	2	0	3	3	0	0	0	3	3	3	0	2
	fe		300	3	2	0										
	fe		500	3	2	0										
	fe		900	3	3	2										
Sulphurous acid H_2SO_3	wL	1	20	3	0	0	2	2	1		0					1
	wL	5	20	3	0	0			1		0	1	1	1	0	1
	wL	10	20	3	0	0					0					0
	wL	ges	20	2	0	0		2			0				1	3
Tannic acid	wL	5	20	2	0	0	0	0	0			0	1	0	0	0

Medium		Concentration %	Temperature (°C)	unalloyed steels	18/8-Steel	18/8+Mo-Steel	Nickel	Monel 400 2.4360	Inconel 600 2.4816	Incoloy 825 2.4858	Hastelloy C 2.4819	Copper	Tombak	Bronce	Titaniuim	Aluminium
		5	SP	3	0	0										
		10	20	2	0	0	1	1	1	0	0	0	1	0	0	0
		10	SP	3	0	0										
		50	20	3	0	0		0	0			0	1	0		
		50	SP	3	0	0										
Tar			20	0	0	0			0	0	0	0	1	0	0	1
			SP	2	0	0						0	1	0	0	1
Tin	Schm	100	300	2	0	0	3	3					3		0	3
	Schm	100	400	3	1	1										
	Schm	100	500	3	3	3										
	Schm	100	600		3	3									1	
Tin chloride			20	3	1LS	1LS	3	3			0					3
			SP	3	3LS	3LS					1					3
Titaniuim sulphate		10	20								1					
		10	SP								1					
Toluene		100	20	0	0	0		0				0	0	0		0
		100	SP	0	0	0		0				0	0	0		0
Tri-chloro acetic acid		>10	20		3	3					0					
		50	20		3	3			0	0	0					
		50	100		3	3					1					
Trilene	tr	100	20	0	0L	0L	0				0	0	0	0		0
	tr	100	70		0L	0L					0					3
	tr	100	SP		0L	0L	0				0	1	1	1		3
	fe		20	2	0L	0L	0				0	1	2	1		3
	fe		SP	3	1L	0L	0				0	1	2	1		3
Trinitrophenol			20	(0)	0	0	0	0	0	0	0	(0)	(0)	(0)	0	0
			200	3			0	0	0	0	0					
Trinitrophenol	Schm	100	150	3												3
	wL	3	20	3	0	0										1
		25	20	3	0	0	3	(1)				3	3	3		
		ges	20	3	0	0	3	3	3	2	0	3	3	3		
Turpentine oil		100	20	0	0	0						0	1	0	0	0
		100	SP	1	0	0						0	1	0	0	0
Tyoglykolacid			20			1										
			SP			1										
Urea		100	20	0	0	0	0	0			0				0	0
		100	150	3	1	0		1	3		1				0	3
Uric acid	wL	konz	20		0	0		0	1	0	0	0			0	3
	wL	konz	100		0	0		0	1	0	0	0			0	3
Urine			20		0L	0L	0	0								1
			40		0L	0L	0									
Vaseline		100	≤SP	0	0	0										0
Vegetable soup		SP			0	0										
Vinegar			20		0	0						1	3	1		0
			SP		0	0						3	3	3		3
Vinegar acid		10	20	3	0	0	2	1	1	0	0	1	3	1	0	0
		10	SP	3	2	0		1	1	0	0				0	2
		20	20	3	0	0	2	1	1	0	0				0	0
		20	SP	3	0	0		1	1	0	0				0	2
		50	20	3	0	0	2	1	1	0	0			0	1	0
		50	SP	3	3	0	2	1	1	0	0	3			0	2
		80	20	3	0L	0L		1	1	0	0				1	0
		80	SP	3	3L	0L		1	2	1	0				0	2
		99	20	3	0L	0L	2	1	2	0	0				0	0
		99	SP	3	1L	1L	2	1	1	0	0				0	
Vinyl chloride			20	0	0	0					0			0		
			400		1	1					1					
Water																
H_2O dest.			20		0	0	0		0	0	0					0
dest.			SP	1	0	0	0	0	0	0	0	0	0			1
River water			20		0	0	0		0	0	0					0
River water			SP		0	0	0									1
Tap water hard			≤SP	1	0	0						0				1
Tap water soft			≤SP	0	0	0						0	1	0		1
Tap water alkaline			≤SP	2	0	0						0				3
Pit water sour			20	1	0	0	1					1	2			2
Pit water sour			20	1	0	0	2					2	3			3
Mineral water			20	1	0	0										3
Rainwater flowing			20	2	0	0	0					0				1
Rainwater still			20													3
Sweat			20	1	0	0										3

Medium		Concentration %	Temperature (°C)	unalloyed steels	18/8-Steel	18/8+Mo-Steel	Nickel	Monel 400 2.4360	Inconel 600 2.4816	Incoloy 825 2.4858	Hastelloy C 2.4819	Copper	Tombak	Bronce	Titaniuim	Aluminium
Sea water			20	1	0LS	0LS	0	0	0	0	0	0	0	0	0	1
			SP	2	2LS	1LS	0	0	0	0	0	1	1	0	0	3
Water condensate, pure			<200	0	0	0	0	0	0	0	0	0	0	0	0	
plus CO_2			<200	2				1			1	0	1	0		
plus O_2			<200	2			1	0			1	0		0		
plus C_1			<200	2	2LS	2LS						2				
plus NH_3			<200	2				0					3	2	0	
Wattle	wL		20	2	0	0		0	0	0						0
			SP	3	0	0		0	0	0						
Whiskey			20													3
Wine acidity	wL	3	20		0	0					0				0	0
	wL	10	20	1	0	0	1	1	1	0	0	0	2	0	0	2
	wL	10	SP	3	0	0	2	2	2	0	1	3	3		0	2
	wL	25	20		0	0		0	0		0				0	2
	wL	25	SP		1	0		1	0		1				0	3
	wL	50	20		0	0					0				0	2
	wL	50	SP		1	0					1				0	3
	wL	75	20		0	0					0				0	2
	wL	75	SP		2	2					1				0	3
	wL	all									1				0	3
Wine vinegar	wL	5	20	0	0	0			0	0	0	1	1	1		0
Wine, white & red			20	2	0	0	2		0	0	0		3	3		3
			SP	3	0	0	3		0	0	0		3	3		3
Xylene			20	0	0	0										0
			SP	0	0	0										0
Yoghurt					0											3
Zinc	Schm	100	500	3	3	3	3	3								3
Zinc chloride	wL	5	20	3	3LS	2LS	1	1	1	0	0	2	3	2	0	3
	wL	5	SP	3	3LS	2LS	1	2	2	0	1	2	3	2	0	3
Zinc silicone sulfide	wL	30	20								0					
	wL	30	65								2					
	wL	40	20								0					
	wL	50	65								3					
Zinc sulphate	wL	10	20	2	0	0	1	1	1	0	0	1	3	1	0	1
	wL	25	SP	3	0	0	1	1	1	0	1	2			0	3
	wL	hg	20		0	0	1	1	1	0	1	1			0	1
	wL	hg	SP		0	0					1					3
Zyanide baths			25												0	