INDEX

BUSINESS DIVISION AND PRODUCTION

Ayvaz deals with the development and production of high quality products for HVAC industry, gas and steam supply applications, power and electricity generation sectors and many others for over six decades.

Our production experience in manufacturing the special designed products and the success in providing the technical support and infrastructure for all sized projects are our biggest strengths. From the first day of establishment we have been aiming to manufacture and supply superior quality products which provide value added performance to our customers.

We will keep producing with focused quality control, comprehensive training programs and innovative technology. We are dedicated to a professional sales force with technical support and continuous improvement of our people, products and service.

Challenge of doing extraordinary works with the respect to the human and nature is the main purpose of our organization.

EXPANSION JOINT PRODUCTION

Ayvaz is the first metal bellowed expansion joint manufacturer of Turkey and one of the biggest ones in Europe. The company has started expansion joint production in 1975 and been developing the product range of expansion joints for all industrial requirements since then. We keep up with the state of art technology production techniques and train our employees as to use and control these techniques individually.

CAPACITY

• Ayvaz increases its production capacity from the first day of establishment. Our main production is carried out at Hadimkoy Factory which has 15000 m^2 total available space and 30000 m^2 closed production area based on the land of 7500 m^2 with 4 floors .Additionally 7500 m^2 of Logistic Center. 1500 m^2 based with 5 floors.

• We are also expanding our production abroad in parallel with this, we opened new production plants in Russia and Bulgaria, we aim to reach our clients faster and provide better services in different areas.

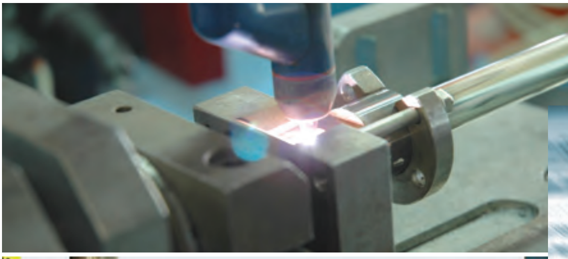
• We are able to produce metal bellowed expansion joints at the sizes from DN25 up to DN3000.

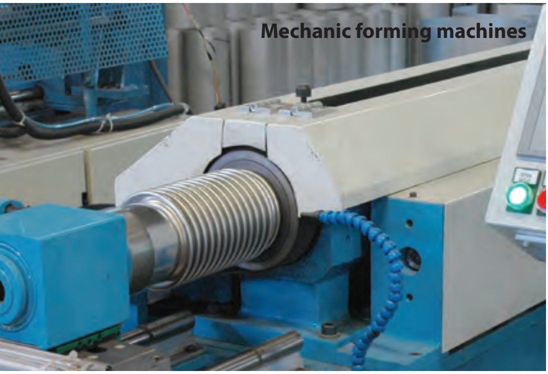
ABOUT AYVAZ

EQUIPMENT

Ayvaz uses modern production techniques and equipment in order to maintain high quality production.

Automated welding machines





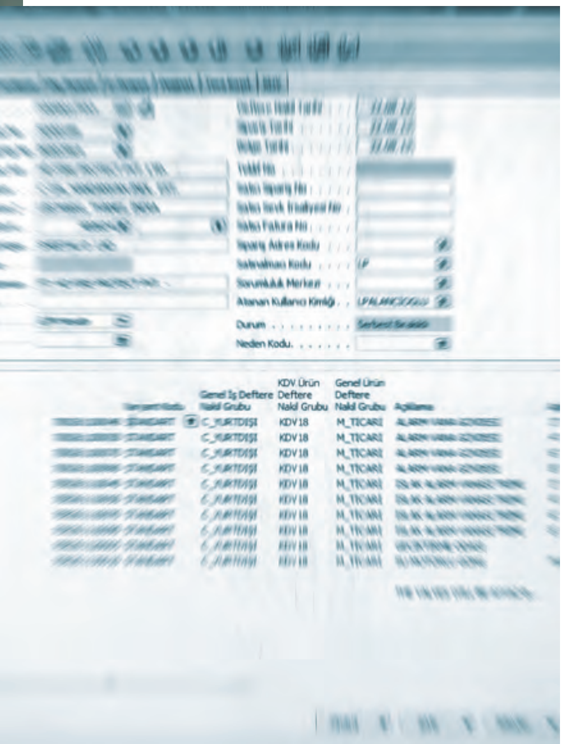
Mechanic forming machines

Hydraulic forming machines

WPS certificated welding process

SOFTWARE

We believe the success comes with correct resource planning and operate our ERP with Microsoft Navision. We monitor our production with SCADA and operate controlling and planning activities accordingly.



EXPERIENCE

Ayvaz is celebrating its 65th establishment anniversary this year. The company holds the production experience of different type and designed products for over six decades.

We provide engineering activities from product specification to project estimation and work on to provide the most specific solution for each case.

QUALITY MANAGEMENT SYSTEM

We constantly work on developing our quality management techniques that are used to communicate to employees what is required to produce the desired quality of products and services and to influence employee actions to complete tasks according to the quality specifications. We see the product quality is the key factor of our company's success. Ayvaz's quality management system allows us to keep up with and meet current quality levels, meet the consumer's requirement for quality, retain employees through competitive compensation programs, and keep up with the latest technology.

• AYVAZ's Quality Management System based on the internationally recognized ISO 9001:2008 standard and certificated by TÜV.

• AYVAZ is continually monitoring global development of technology and learning about areas of activity.

• AYVAZ is educating, training, choosing and motivating workers capable of flawless performance and constantly improving work processes.

• AYVAZ is working in compliance with adopted standards and specifications and any regulatory requirements.

• AYVAZ is permanently monitoring and improving the quality management system.

OUR VISION

• AYVAZ's priority is to provide the best quality products for both domestic and international markets.

• World class production and providing before and after sales services with highly experienced personnel.

• Another objective of the company, and the responsibility of each employee, is to continually exceed industry standards for Health, Safety, Environment and Quality and to continually improve Efficiency and Profitability.

OUR MISSION

• Promoting creativity, flexibility and innovation

• Satisfying and exceeding our client's requirements, demands and expectations

• Keep growing our international activities and meet the demands of the Turkish market

• Aiming continual improvements in Health, Safety, Environment and Quality

• Employing highly trained, experienced and motivated employees

• Working for improvements in efficiency and profitability

HUMAN RESOURCES

• AYVAZ employs over 600 employees.

• Workforce and know-how present key values to our business success.

• Care for employees and their development is our continuous strategic priority.

• We continuously invest in the education and training of our employees.

• We develop and promote good team relations and efficient communication among employees.

• We promote acknowledgements and awards for employee commitment and achievements.

CUSTOMER RELATIONS

Communication:

• Pre-sales operations enable our sales team to identify and analyse customer needs and problems. We very much value gathering the feedbacks and suggestions of the customers in order to develop ourselves and our communication skills.

Engineering:

• The data gathered from the customers by the sales team is analysed carefully by our expert engineering team.

• We provide engineering activities from product specification to project estimation and work on to provide the most specific solution for each case.

Consulting:

• We delightfully share our expertise with the potential clients who experience problems caused by wrong product selection, improper working conditions etc… with the products that are not even manufactured by our brand.

BUSINESS DIVISION WHOLE SALE AND RETAIL SERVICES

The main business activity of Ayvaz's whole sale is providing products for large scale projects and customized goods for business partners. Retail sale of core products is fulfilled by 8 domestic sales offices and over 250 distributors globally.

AYVAZ ACTIVITIES

• Apart from being the biggest manufacturer of its sector in Turkey. Ayvaz operates exportation to 83 countries all around the world.

• Ayvaz has seven international sales offices located in Italy, Russia, Ukraine, Bulgaria, Brazil, Saudi Arabia and Dubai.

AYVAZ

DESIGN, GENERAL APPROVALS AND CERTIFICATIONS

DESIGN

	EJMA	We design our expansion joints complying with the requirements of EJMA by using BM2 EJMA 9 software.

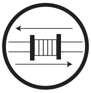
GENERAL APPROVALS

	TÜV	Quality Managemet system to DIN ISO 9001:2008
	CE	Production in accordance with EU legislations
	OHSAS	18001 Occupational Health & Safety Management System

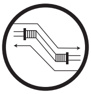
CERTIFICATIONS

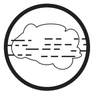
	GOST-R	All-Union State Standard	Russia
	FM	FM Global	USA
	BV	Bureau Veritas	France
	RINA	Italian Naval Register	Italy

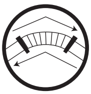
SYMBOLS FOR PRODUCT FEATURES AND QUICK SELECTION

 Axial Expansion Joint

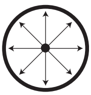
 Seismic Expansion Joint

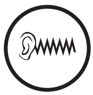
 Lateral Expansion Joint

 Suitable for gaseous media

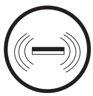
 Angular Expansion Joint

 Resistant to hot water

 3D Movement

 Suitable for noise absorption

Threaded Connection

 Suitable for vibration absorption

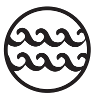
Max. Product Pressure

 Suitable for Oil media

Flange Standards

 Suitable for drinking water

Max Product Temperature

 Suitable for seawater

 Flame-proof

AYVAZ

THE QR CODES IN THE BOOK

THE QR CODES

New generation barcoding system called Quick Response Code (QR Code) is the **easiest way to reach** the most detailed information of our products.

We have prepared unique QR codes for each product in "The White Book". All you need to do is to let your mobile device read the code.

For more information:

ayvaz.com/qrcode

AEQ MEMBERSHIP OF AYVAZ

The quality of Ayvaz production has been approved by the most respected European association of Expansion Joint and Flexible Metal Hose manufacturers (AEQ). This membership represents the ability of Ayvaz to use its knowledge and experience to manufacture reliable products guarantee the health and safety of the users.

As the only Turkish member of the association, Ayvaz starts representing Turkey in AEQ which has 19 members from Europe.

What is Euro-Qualiflex (AEQ)

AEQ is the association which was established by the leader manufacturers of Expansion Joints and flexible metal hoses in France in 1956. The main purpose of the association is improving the quality and the reliability standards of related products. AEQ had studied on European Standards (CEN and ISO) between 1981 and 1997 and started issuing official requests on the high quality and approved products to enter the market between 1997 and 2007.

Euro-qualiflex has currently 19 members and Ayvaz is the only Turkish member of the association. Each year the association organizes an assembly in one of the member countries for a week and review the problems of the sector also discuss the international standards and unfair competition in manufacturing.

AYVAZ

EXPANSION JOINTS

CHAPTER I

METAL BELLOWED EXPANSION JOINTS

I. 1 A brief idea and general knowledge about expansion joints:

One of the basic rules of physics is materials to expand and compress caused by the temperature changes. Expansion joints are the elements that absorb all those expansions, compressions and also vibrations and let the industrial systems work continuously and efficiently.

An expansion joint is a flexible element. The bellows of expansion joints are designed to absorb the movements become as the result of thermal changes and vibration. Number of bellows is depended on the amount of expansion movement. For different industrial needs there must be some factors of designing expansion joints to meet all those different needs. The bellows must provide the required flexibility and resistance against the peripheral pressure.

Different problems depending on the direction and the form of pressure may be solved by using different expansion joint types in various ways. The main usage area of expansion joints are the pipeline applications. Strains may happen in the shape of pipelines caused by many factors, we may count some of those factors as follows.

a-Internal or external pressure at working temperature
b-The weight of the pipeline and transportation materials
c-The forced movement of the pipeline because of the external restrictions
d-Thermal expansion

Because of its importance, the stress of thermal expansion must be reviewed individually. The thermal stress between two fixed ends of a pipeline may be as concerning as the stress with one moving end. In order to understand the effects of last two factors (c, d), we need to study the expansion movements.

The stress becomes in pipelines is depended on,

-The force directed from the external restrictions
-The movement directed from the external restrictions
-The flexibility of the pipe material

In case, the stress level or the force and amount of the movement exceed the limitations, the flexibility of the pipeline must be increased.

This may be possible by,

-Changing the overall design of the pipeline
-Application of the elements which have high flexibility

That is because the first way will result the loss of temperature, pressure and isolation and increase the costs, application of expansion joints is a more meaningful solution.

1.2 Types of expansion joints:

Expansion joints can be classified under three groups according to the types of movement to be absorbed.

1) AXIAL
2) LATERAL
3) ANGULAR

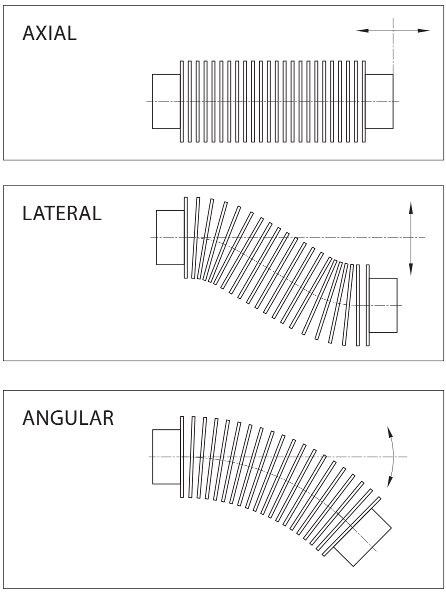


Figure 1

I .2 a) Axial expansion joints:

Axial expansion joints aim to absorb the axial expansions.

-They do not change the direction of the flow
-Additional assemblage distance is not necessary
-Dividing the pipeline helps to prevent stress of lateral forces

By using expansion joints in pipeline applications, it will be possible to build up well structured and freely moving straight pipelines. Axial expansion absorption can only be possible with applying appropriate guides which are strong enough to meet the pressure at both ends.

Applying pipe guides are very tough for following situations.

-High pressured pipelines.
-Medium pressured, large sectioned pipelines.
-Self-boosted pipelines and bridges

The pressure force mentioned above can be calculated as working pressure multiply by effective surface.

Advantages of axial expansion joints:

- Easy to absorb the expansion movements
- No direction changes of the flow
- Minimum application area
- Possible lateral and angular expansion absorption by the additional bellows.
- To provide a non-stressed area where the pressure level is not too high such as pump and compressor applications.
- Low application costs.

Disadvantages of axial expansion joint applications:

- Using pipe guides is compulsory, this may cause some technical and economical issues.
- For the straight and long pipelines, it may be required to use a high numbered expansion joints.
- All the divided pipeline parts must be leveled individually, that may be difficult and costly.
- Axial expansion joints have very limited 3D movement abilities.
- Where the pressure and dimension are high, they cannot guarantee non-stressed areas for sensitive applications.

Axial expansion joints

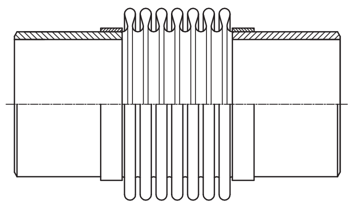


Figure 1-2

Working simulation of axial expansion joints

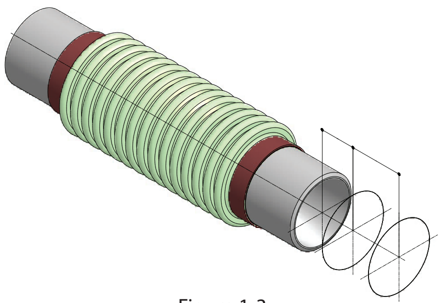


Figure 1-3

Movement of axial expansion joints

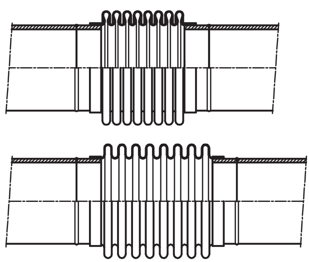


Figure 1-4

1.2.b. Lateral expansion joints:

At the pipelines where expansion movements exist in two directions, these movements can be absorbed by using Lateral Expansion Joints.

The expansion happens in two dimensions on the same plate can be taken by applying a lateral expansion joint on one dimension. This kind of expansion joints are also able to absorb axial movements at the same time.

The usage of lateral expansion joints may provide cheaper solutions where the direction changes are unavoidable.

At very long pipeline applications, movement may not be absorbed by a single lateral expansion joint, inch waterch cases using angular expansion joints which will be explained later can be a better solution.

Advantages:

• They require less pipeline guides compared with axial expansion joints
• Movements in three dimensions can be absorbed by using two lateral expansion joints
• They may provide a solution understood more easily then angular expansion joints
• They supply a non-stressed area for the sensitive units such as Pumps, compressors and turbines where the pressure stress is high.

Disadvantages:

• They can only be used for the turning points at pipelines.
• They require more assemblage distance in comparison with axial expansion joints
• When they expand in one dimension that may cause a compression in the other dimension and force the pipeline to be twisted. As a result of that angular expansion joints must be used in following sections of the pipelines

Lateral expansion joints (Movement in all directions)

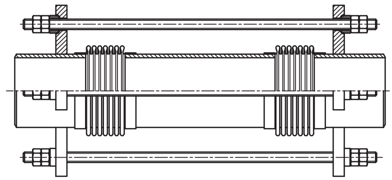


Figure 1-5

Movement of lateral expansion joints (Movement in all directions)

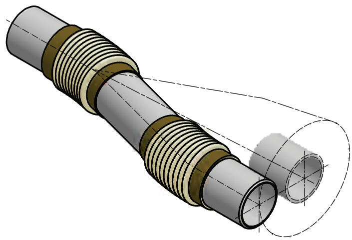


Figure 1-6

Movement of lateral expansion joints (Movement in two directions)

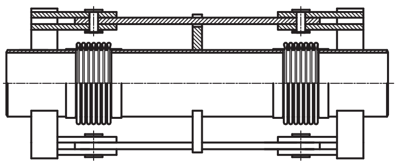


Figure 1-7

Working simulation of lateral expansion joints (Movement in two directions)

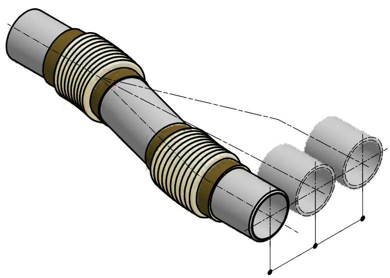


Figure 1-8

Movement of a lateral expansion joints

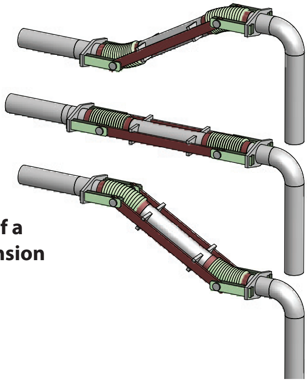


Figure 1-9

1.2.c. Angular expansion joints:

Angular expansion joints are the absorption elements where the movements happen in turning points similarly the lateral expansion joints. They are appropriate elements to absorb the movements in two or three dimensions. They also require minimum pipeline guiding while taking all the lateral and axial movements.

As it has been mentioned above, two angular expansion joints can work as a lateral expansion joint.
Angular Expansion Joints can be classified in two groups,
• Movement in two dimensions
• Movement in all dimensions

Advantages

• No pipeline guiding necessary unless the length of pipe that absorbs the movement is extremely long.
• Absorption of all movements and expansion is possible not related to the length of pipeline.
• As long as the system is designed properly, they guarantee to absorb both expansions and movements in all dimensions on all plates.

Disadvantages

• They require more assemblage distance in comparison with axial expansion joints.
• They can only be used for the turning points at pipelines.

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Movement of angular expansion joints (Movement in two directions)

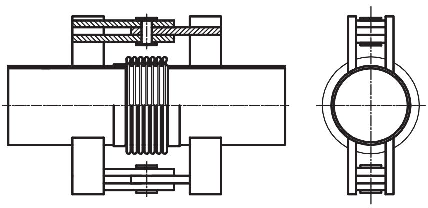


Figure 1-10

Working simulation of angular expansion joints (Movement in two directions)

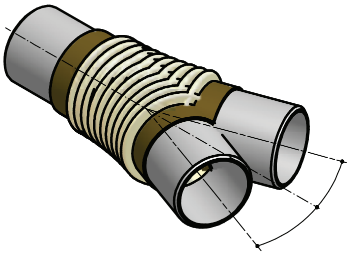


Figure 1-11

Angular expansion joints (Movement in all directions)

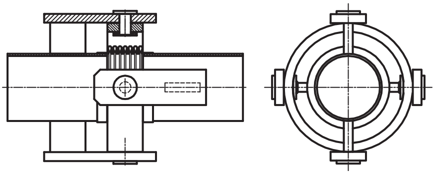


Figure 1-12

Working simulation of angular expansion joints (Movement in all directions)

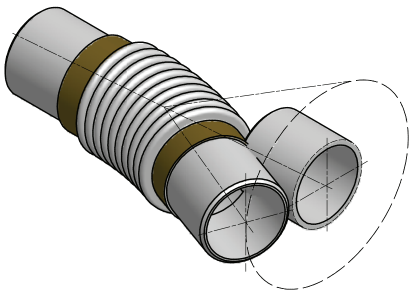


Figure 1-13

Movement of a lateral expansion joints

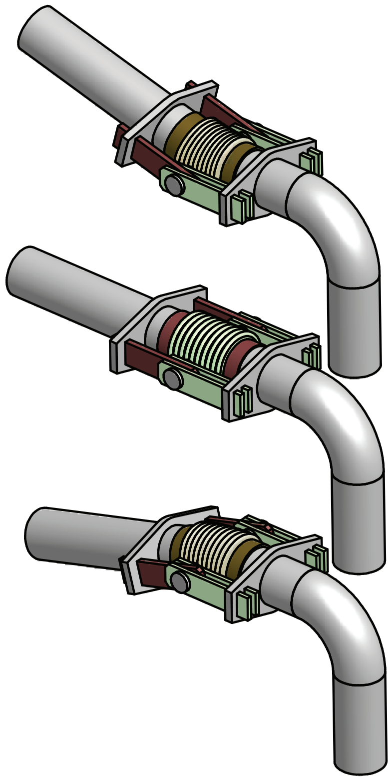


Figure 1-14

I.3 Expansion joint applications:

Expansion joints have a really large application range. As a result of that, expansion joint applications can be seen in almost all industries.

The main usage areas are pressured vessels, pipelines, transportation and carriage systems.

Especially, in the high pressured pipelines at big diameters, expansion joints can meet all the requirements with their flexible structures and special designs.

Each expansion joint type has different advantage according its usage area and design.

Ayvaz is able to manufacture all types of expansion joints for every pressure and temperature levels in order to transport every kind of fluids and absorb movements in all dimensions.

The movements mentioned can be listed as follows.

- Axial Movements
- Lateral Movements
- Angular Movements
- Combined Movements
- Vibrations

Expansion joints that are selected and installed properly, provide reliable connections with following features.

- Resistant against pressure and vacuum.
- Resistant against temperature
- Rustfroof
- Maintenance free
- Long service life
- Economic

At this stage, defining the application areas of the expansion joints would be beneficial in order to determine the most distinctive features of these elements.

*Ax: Axial Movement, L: Lateral Movement, An: Angular Movement, V: Vibrations

Using Area	**Purpose**	**A**	**L**	**A**	**V**
Pipelines	To absorb the expansion at pielines used to transport heating or cooling fluids.	X	X	X	X
	To prevent the danger of collapsing where the pipelines are the subject of structural movements	X	X	X	X
	As a tool of disassembly	X			
	As a protective jacket for the pipelines that nested each other. Chemical, Plastic, Glass Petro chemical processing ind. Rafineries, nuclear and thermic stations.	X	X	X	
Industrial Manufacture	As an assemblying tool for the pressured vessels machine and pipeline installations	X			
	To absorb the differantial expansions	X	X	X	
	To provide a non-stressed area for the sensitive tools such as pumps, compensators and turbines				X
	As a flexible bumper element	X			
	As a piston	X			
	As a mechanical plug for the rotating equipment	X			
Diesel Equipment	Pumps (Medium level of Pressure) Pumps (High Pressure)				X
	Turbines	X	X	X	X
	Diesel Engines	X	X	X	X
Pressured Vessels	Vacuum sealing	X			
	As sealing tool for the valves of pipelines transport acits	X			

Using Area	Purpose	A	L	A	V
Heating and Ventilisation	Rubber, metallurgy, oil processing. Maritime inds. and nuclear energy stations	X	X	X	X
High Pressure and Tempereture Ap-plication	Glass, Aerospace, Rubber, Chemical, Metallurgy, Oil processing, Maritime ind. Nuclear and thermic stations	X	X	X	
Noise Insulation	Aerospaces, Locomotives, Industrial Egines, Pumps. Chemical Processing Industries				X
Cooling Fluid Transport	Glass, Aerospace, Rubber, Chemical ,Metallurgy, Oil processing, Maritime ind. Nuclear and thermic stations	X	X	X	
	Pumps				X
Coolin Gas Transport	Aircrafts, Chemical and Oil Processing Ind.	X	X	X	
Engine Exhausts	Heavy machine egzaust lines	X	X	X	X

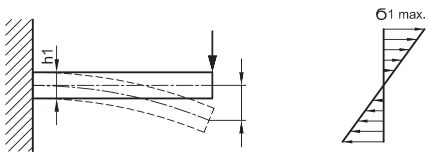
I . 4 Bellow Types:

As it was mentioned before, expansion joint is a flexible and sealed element. The main part of the expansion joints are bellows and bellows must be strong enough to resist the system pressure and provide the required flexibility to the connections.

Bellow design and material choice are extremely important issues in order to manufacture the most appropriate expansion joints that meet the pressure of the system and have maximum life cycle.

For the low and medium pressure levels, bellows may be manufactured as single layered and for the high temperature applications, double layered.

That is because flexible section divides the stress into the layers, the stress amount of multi layered bellows is much less than single layered bellows.

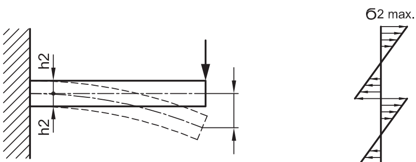


Single Layer

Wall thickness of the bellows is the result of long calculations. Material resistance, corrugation's type and diameter as well as the wall thickness of the bellows are determined according to the length of the bellow.

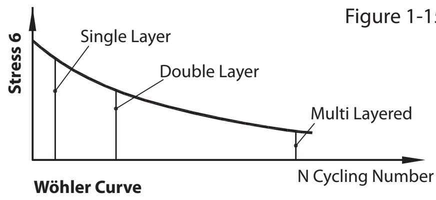
As the expansion amount goes up the resistance of flexible part decreases and bending intention increases like a straight stick under compression pressure.

Working life of the metal bellows falls in different working conditions likewise high temperature and high pressure applications. Even under such circumstances it is very unlikely, the bellows to explode in order to avoid this, we manufacture our bellows to resist against ten times of nominal pressure.



Double Layers

Figure 1-15

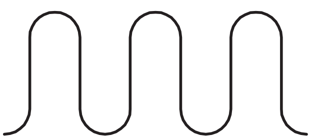


I . 5 Effects of Design on The Dynamics of The Bellows:

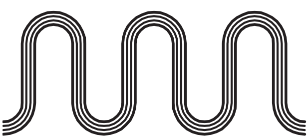
Figure 1-16

DESIGN	Perhipheral Tension	Convulation Tension	Bending Tension	Twist Tension	External Restiraint	Service Life	mm/angle Axial Movement	mm/angle Lateral Movement	mm/angle Angular Movement	KG/mm - KG mm/angle Axial Yield	KG/mm - KG mm/angle Lateral Yield	KG/mm - KG mm/angle Angular Yield	Pressure Strain	Max. Corrugation Number
Difference	–	–	+	+	+	–	–	–	–	+	+	+	S	S
Thick Material	+	+	–	–	–	+	+	+	+	–	–	–	S	S
Thin Material	–	+	–	–	+	+	+	+	+	–	–	–	+	–
Wide Convulation	+	–	+	+	–	–	–	–	–	+	+	+	–	+
Narrow Convulation	+	–	+	+	–	–	–	–	–	+	+	+	–	+
Little Ridge	–	+	–	–	+	+	+	+	+	–	–	–	S	+
Large Ridge	+	–	+	+	–	–	–	–	–	+	+	+	S	–
Multi Layer	–	–	S	+	+	S	S	S	S	+	+	+	S	–
Single Layer	+	+	S	–	–	S	S	S	S	–	–	–	S	+
Long	+	S	S	+	–	S	S	–	–	+	+	+	+	D
Short	–	S	S	–	+	S	S	+	+	–	–	–	–	D

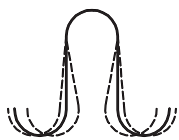
+ = INCREATION **- = DECREATION** **S = SAME** **D = DEPENDS ON THE DIMENSIONS**



Single Layered Corrugation



Double or Multi Layered Corrugation



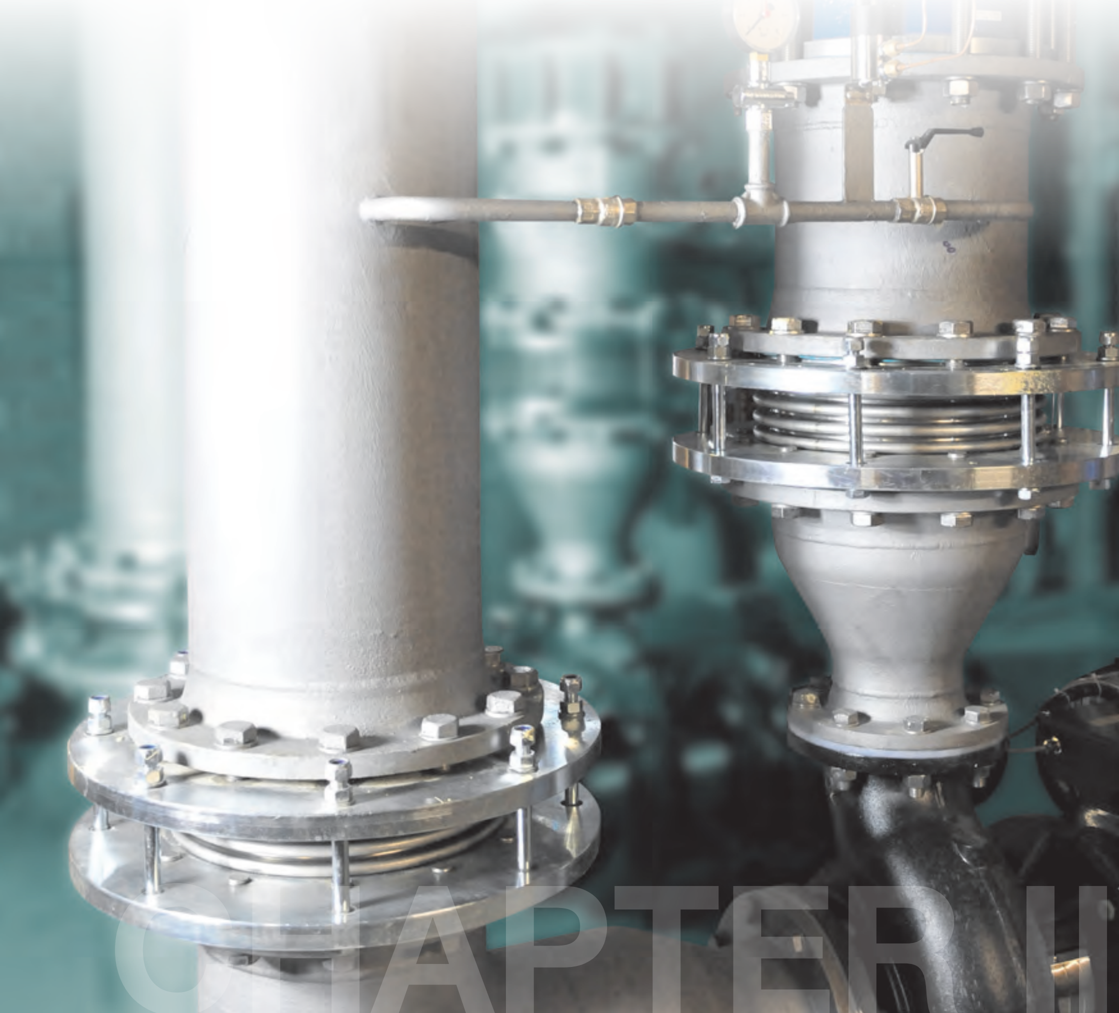
Working Simulation of Corrugation

AYVAZ

EXPANSION JOINTS

CHAPTER II

EFFECTIVE PARAMETERS & CALCULATIONS



II . 1 Life Cycle:

Expansion Joint bellows have 5000 cycling life as long as they work under the appropriate movement amounts. The table below show how the life cycle is effected when the movement limits are exceeded. Additional factors resulted of wrong assemblage are not illustrated in the tables. The working conditions must also be considered by the users to review the life cycle of the expansion joints.

Because of those reasons, the factors that have influence on life cycle must be investigated individually during the selection of the right expansion joint. We can summarize these factors as follows.

- a Temperature
- b Movement amount
- c Working Pressure
- d Pre-loading
- e Stress cycling life
- f Pressure shock and increasing pressure
- g Thermal shock
- h Corrosition
- i Assembly by nonexperts

II . 1 A: Temperature:

Working temperature is one of the most important factors that effects the life cycle. As the temperature increase, the resistance of the materials changes inversely. Nominal pressure must be detected by considering this condition. Following example is to explain how the reducing factor (C) is taken into account of calculating the nominal working pressure.

$$\text{Nominal Pressure} = \frac{\text{Working Pressure}}{C'}$$

Example: An expansion joint made by 304L material and is intended to use at 12bar and 150 C°. What should the nominal pressure be?

NP= 12/0,82=14,6 bar

In this case the expansion joint should be choisen from the class of 16 bar.

Working Temp. °C	C' Factor			
	304L	316-321	Monel 400	Inconel 400
20	0.94	1.0	0.94	1.0
100	0.87	0.98	0.93	1.0
150	0.82	0.92	0.92	1.0
200	0.77	0.87	0.91	1.0
250	0.74	0.82	0.90	1.0
300	0.70	0.80	0.88	1.0
350	0.67	0.76	0.86	1.0
400	0.66	0.74	0.85	1.0
450	0.65	0.71	-	1.0
500	-	0.69	-	1.0
550	-	0.67	-	0.98
600	-	0.65	-	0.96

Table II-1 Table of C' Faktor

B: Amount of Movement

Another important factor as important as the temperature is the amount of movement. All the expansion joints are produced to complete 5000 cycling at working full stroke, if bellows work under the full stroke, it may mean that the expansion joint works more than 5000 cycling life.

During the designing process, if greater cycling life is requested, permissible amount of movement should be higher. This could be possible by selecting an expansion joint from the upper pressure class or the one with more corrugation number than standard.

C: Working Pressure

Less working pressure that nominal pressure has a positive effect on life cycle. As the working pressure decreases, life cycle increases. Another important issue that may exist at the heat transferring long pipelines is the little defiances of the pressure.

These defiances may cause the strikes repeat regularly and serve the system on a positive manner. These little strikes help the expansion joints to be prepared for the bigger tensions and movements.

D: Pre-loading

The expansion joints are assembled as preloaded to the pipelines. This method makes it possible the expansion joint to work in the movement limits most efficiently.

For example, an expansion joint, selected from the dimensions table with 20mm + 10mm = 30mm expansion capacity may be delivered as 150mm length from the manufacturer. This expansion joint should be assembled in 160mm gap to meet the 30mm expansion amount. The difference of 10mm can be tighten by screwing the flanges at the small expansion joints. If the expansion joint has a large expansion capacity and welded ends, the expansion joint can easily be tighten by puller bars attached to the welding ends.

The manufacturer can deliver the expansion joints as pre-loaded on request. The most important factors of Preloading;

- Detection of the exact amount of movement that should be absorbed.
- Detection of the temperature of assemblage and working conditions.

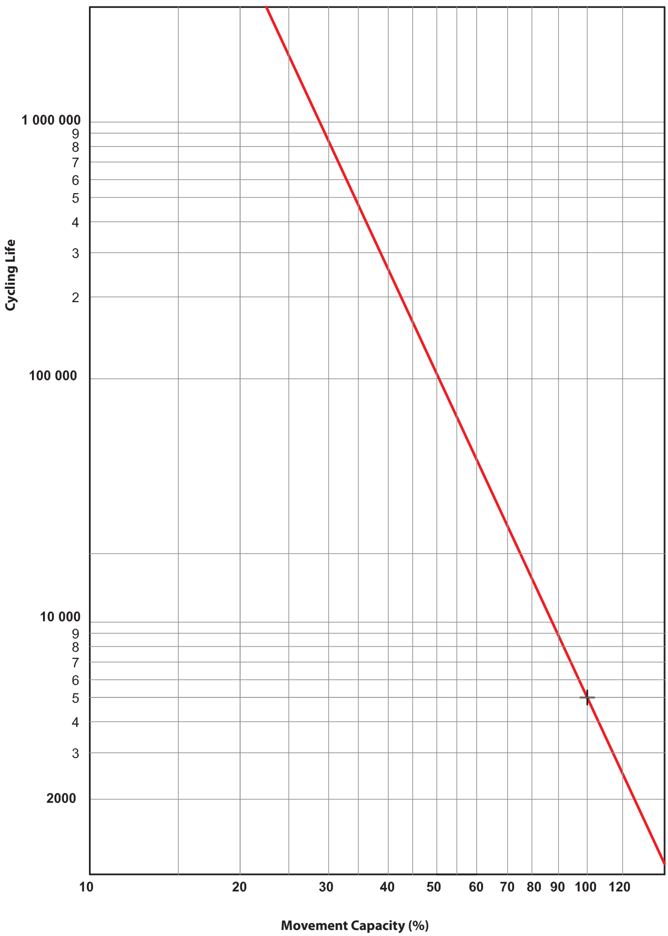
The most important factors of Preloading:

I. Detection of the exact amount of movement that should be absorbed.
II. Detection of the temperature of assemblage and working conditions.

Life Cycle: The predicted life cycle of the expansion joints is 5000 cycles while they work with %100 expansion capacity. This type of design usually meets the requirements.

he Figure below may help to detect how the life cycle changes when the expansion joint works with different capacities.

It is seen that the expansion joint reaches 8800 cycling life when it works with 50% expansion capacity on the other hand if the movement capacity is exceeded by 20% (120%), life cycle drops to the 2350 cycling life.



E: Stress Cycling Frequency

As long as the stress load occurs in the permissible values, the stress cycling frequency does not state an important change for the systems apart from some special situations.

In case the expansion joint is used to prevent vibration, the movement does not reach the maximum value and no limitation on the cycling life is subject for the systems.

F: Pressure Shock and Increasing Pressure

Working pressure of an expansion joint must be detected according to the maximum pressure that occurs while the system in on operation. If it is not possible to define the maximum pressure, it is advised to select the expansion joint from an upper pressure class.

Pumps may cause pressure surges and valves closed quickly may cause rapid pressure lifts. The water that is condensated in the pipelines may cause strokes at restarting. Inch waterch cases using multi layered expansion joints are suggested in order to prevent potential damages in the systems.

G: Thermal Shock

Flash thermal changes and especially excessive temperature rise and falls make the material fatigue quicker than usual. Sometimes a protective jacket may provide the solution. Featured methods are also available for the systems that transport solid and gas materials.

H: Corrosition

Materials of the expansion joints must be choisen according to the fluid flows through the pipelines. Otherwise corrosition may happen in time. Even the corrosive effects of the cleaning materials should be considered to prevent damages.

I: Assembly by Nonexperts

Expansion joints must be assemblied by experts very carefully, otherwise some mechanical damages may happen and these damages reduce the life cycle of the expansion joints in time.

II.2 Testing and Quality Check

Expansion joints are the products of high level of engineering and fulfill very important tasks in pipelines. That is why they are needed to be tested and checked regularly.

Pressured pipelines used in extremely important and hazardous applications to the environment likewise nuclear stations or oil processing plants must be controlled by independent inspection bodies and quality checks must be done in every levels of manufacturing

The following conditions must be abided when doing testing and checking procedures.

a-The material that is used should be pure and the exact composition of it should be detected.

b-The material and the dimensional sensitivity of the products should be cared.

c-Testing pressure is usually set as the 1.5 times of working pressure of expansion joint. This test does not aim to define the maximum pressure resistance of the bellows, because the bellows are designed to resist against the 10 times of working pressure. It is only applied to check the sealing of the bellows.

d-To check the welding seams of the pipes, X-ray test may be applied .In cases that bellows are welded with automated tools, that man not be necessary.

The checks mentioned above are done to define the dimensional sensitivity, sealing, pressure resistance of the bellows. If the material choice and the pressure class is selected properly, only issue left to be checked is the life cycle.

However, the life cycle can not be checked during the tests, it may be defined by the fatigue tests that applied to the similar expansion joints.

Detecting the optimum bellow length and corrugation number is more important than applying all those expensive tests in order to reduce the pressure tension around the corrugations and provide the required cycling life to the expansion joints.

II. 3 Calculation:

The product tables given in section VI illustrate the specifications of the expansion joints grouped towards the nominal diameter and pressure values. After defining the working conditions of required expansion joint, choosing the most appropriate product could be easy if it is done in the way of the example given below.

As we have mentioned before expansion joints are designed to absorb three kinds of movements and each movement should be reviewed in three sections.

a-Assemblage stage
b-Start and shut down stages
c-Operating stage

For a correct calculation, users must provide following data.

DATA:

D-1 Nominal Diameter
D-2 Fittings type
D-3 Max Operating Pressure
D-4 Operating Pressure
D-5 Assembly temperature

D-6 Predicted movements and cycling
6a-Assemblage Stage
Total axial movement (mm)
Total lateral movement (mm)
Total angular movement (degree)

*For this stage the cycling life should be assumed.

6b-Start and shut down Stages: All the movement amounts and a cycling value approximately.

6c-Operation Stage: All the movement amounts and exact cycling value of this stage.

V-7 Max. permissible spring rate.

7a- Axial (kg/mm)
7b- Lateral (kg/mm)
7c- Angular (kg/mm/degree)

V-8 Operating temperature.
**Should be referred by the manufacturer.

V-9 If cover or liner is required it should be indicated in the order sheet.

Selection:

Right after collecting the required data, selection stage can be passed on.

S-1 The product tables in chapter VI should be reviewed according to the nominal diameter.
S-2 Fittings types should be indicated in the order sheet.
S-3 The reducing factor (C) related to maximum operating temperature is identified from the table II-1 or figure II-2.
S-4 Nominal pressure is calculated by dividing the operating pressure by factor (C). Testing pressure should be 1.5 times of the nominal pressure.
S-5 Maximum temperature and spring rates should be controlled.
S-6 The curve of factor (C) and cycling life Figure giving in II-3 is used as follows.

6a-At the assemblage stage, cycling life is assumed to be 1 C1 = 0.40
6b-The C_2 factor for the start and shut down stage is determined for the cycling life.
6c-The C_3 factor for the operating stage is determined for the cycling life.

S-7 A_1, L_1 and An_1 values are calculated by multiplying C_1 value by axial, lateral and angular movements. For the other stages, A_2, L_2, An_2 and A_3, L_3, An_3 values are calculated with the same way.

S-8 Each movement can be calculated as the total of the movement amount of each stage.

$$E_e = E_1 + E_2 + E_3$$
$$Y_e = Y_1 + Y_2 + Y_3$$
$$A_e = A_1 + A_2 + A_3$$

S-9 From the product table in chapter VI. Nominal pressure class is determined and the corrugation number is assumed. According to this corrugation number standard values of Axial, Lateral and Angular movements are stated. (As, Ls, Ans)
S-10 The selection is checked with the formula seen below.

$$\frac{E_e}{E_k} + \frac{Y_y}{Y_k} + \frac{A_e}{A_k} = \leq 1.00$$

S-11 If the results can't meet the formula above, corrugation number is increased and checked again. This transaction should be repeated until the required value is reached.

Example:

DATA:

Diameter: 250mm
Fittings type: Fixed flanged
Operating Pressure: 8.28 atü
Installation temperature: 20°C
Designed movement and cycling amounts:

Installation:	Total 12 mm axial
	1.5 mm lateral
	0 angular
Expansion/Compression:	Total 40mm axial
	5 mm lateral
	3 mm angular
Required cycling:	200
Operating:	Total 6 mm lateral
	0.7 mm lateral
	0.2 mm axial
Required cycling:	15000

Permissible max spring rate:

Axial :	20 kg/mm
Lateral:	15 kg/mm
Angular:	10 kg/mm

Operating Temperature: Less than + 427°C
Liner and cover are required.

Selection**:**
S-1 From the product table, chapter VI, DN 250
S-2 Fixed flanged connection.
S-3 From the Figure II.2, C′=0.77
S-4 Nominal Pressure: 8.28/0.77 = 10.75 atü (Test pressure: 16.13 atü)
Pressure class: 16 atü
S-5 Corrugation number is assumed 12 that provides the required spring limitations
S-6 C_1 = 0.40 (single cycle)
C_2 = 0.47 (200 cycles)
C_3 = 1.26 (15000 cycles)

S-7 $E_1 = 0.40x12 = 4.80$ $Y_1 = 0.40x1.5 = 0.60$
$A_1 = 0.40x0 = 0$
$E_2 = 0.47x40 = 18.80$ $Y_2 = 0.47x5 = 2.35$
$A_2 = 0.47x3 = 1.41$
$A_3 = 1.26x6 = 7.56$ $Y_3 = 1.26x0.7 = 0.88$
$A_3 = 1.26x0.2 = 0.25$

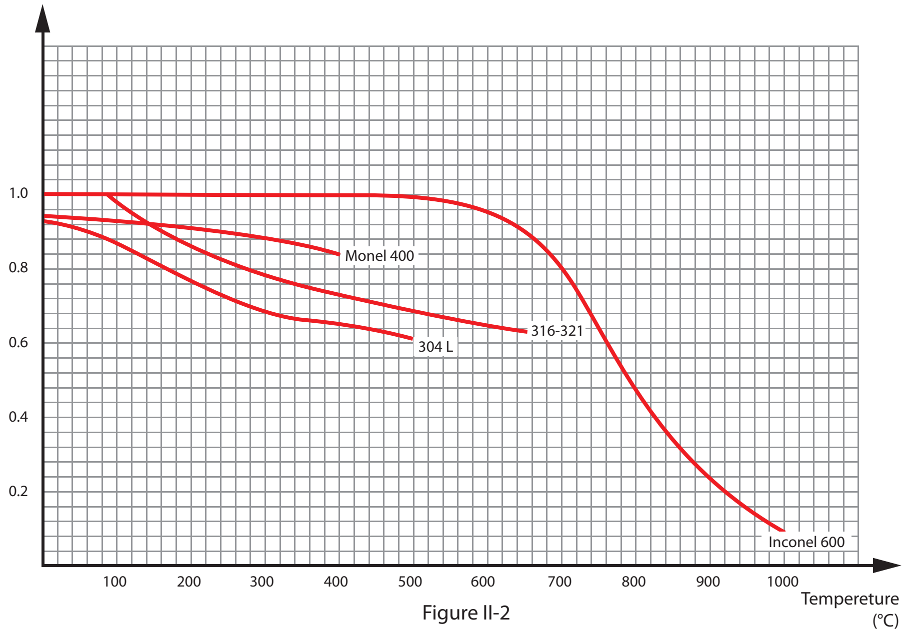


Figure II-2

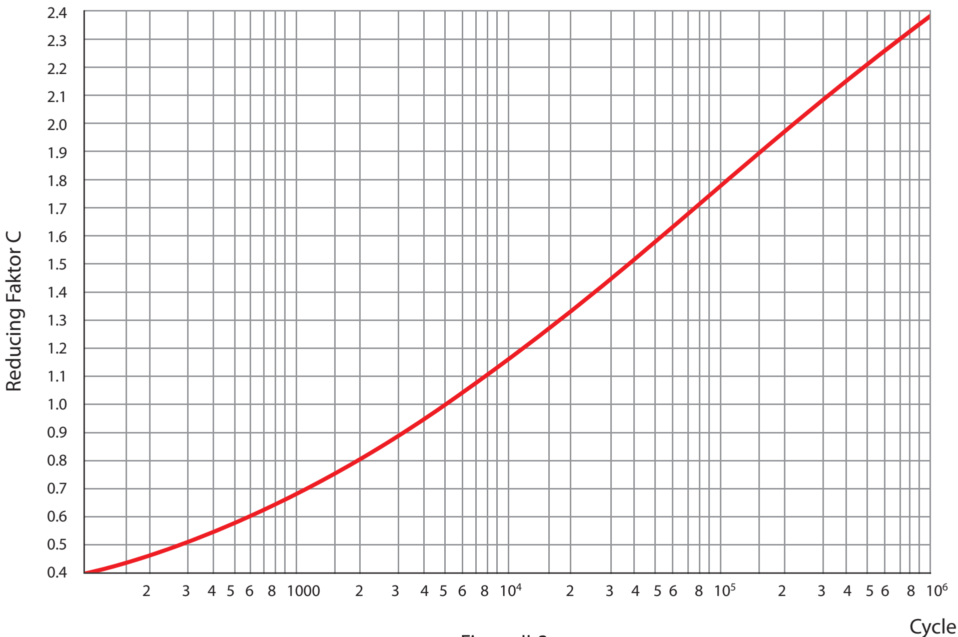


Figure II-3

S-8 $E_e = 4.80 + 18.80 + 7.56 = 31.16$
$Y_e = 0.60 + 2.35 + 0.88 = 3.83$
$A_a = 1.41 + 0.25 = 1.66$

S-9 With the assumption of 12 corrugations existence:

$E_k = 47$ $Y_k = 14$ $A_k = 15$

S-10

$$\frac{31.16}{47} + \frac{3.83}{14} + \frac{1.66}{15} = 1.05$$

Because of the calculated value is higher than 1.00, above corrugation level is selected.

$E_k = 55$ $Y_k = 21$ A_k 15

If the above calculation is re-applied with the new values,

0.86 is held as the result.

The number of the corrugations is calculated as 16 and selection is done accordingly.

As a sum of that, the selected expansion joint should have the following features;

1. Diameter: 250mm
2. Pressure:16atü
3. Number of corrugations:16
4. Fixed flanged and with cover.

II.4 Fix Points and Guide Bearings:

Expansion joints are the elements that are used to absorb the expansion and compression occurred in the systems. Especially for the axial expansion joint applications, some assisting tools are required in order to maintain the efficiency of the systems and make them work uninterruptedly. Lock plates are used to compensate the internal pressure of the pipes and the pipelines must be supported by pipe guides to keep them in the required shape.

The forces, compensated by Lock Plates:

- Pressure
- Pire friction
- Centrifugal force
- Force caused by spring rate

Calculation of each of these forces will be explained in detail in following three sections. The types of the required lock plates for these forces are given below:

a-Terminal Lock Plates
b-Elbow Lock Plates
c-Intermediate Lock Plates
d-Roller Bearings

a-Terminal Lock Plates:

Terminal lock plates are used on the dead ends of the pipelines, in cases that the machines and the equipment are needed to be supported also when the pipelines are balanced with axial and lateral expansion joints.

Calculation of the force compensated by terminal lock plates will explained in following sections.

b-Elbow Lock Plates:

Turns in the pipelines make using elbow lock plates essential in these places. Pressure force increases in line with the turning angle. If a diameter change happens right after an elbow turn, the effective forces must be taken according to the bigger diameter.

c-3. Intermediate Lock Plates

Intermediate lock plates are not designed to compensate forces initially. In very long pipelines, the expansions may not be taken by just one expansion joint. In cases that more than one expansion joints are required to be used, the pipeline must be divided in sections by using intermediate lock plates. For each section, only one expansion joint must be used.

The intermediate lock plates must not be confused with the pipe guides. The pipe guides located in certain distances are used to keep the expansion on the same plate with the pipeline direction. In addition, the friction force caused by the pipe guides are also be compensated.

Temperature of the some parts of the pipelines may rise up, because of that calculation of the force which is affected on the intermediate lock plates may not be possible. As a result of that it is required to determine an average resistance value and the pipelines must be fixed according this value.

d-4. Roller Bearings:

In cases that the expansion joints are expected to compensate lateral movements only or additionally to the axial movements, roller bearings must be used. This type of lock plates may be seen as supporting elements for the pipelines.

The forces which must be compensated are calculated as the other lock plates, but the pipe friction is not taken into account. If a high flow rate is subjected, centrifugal force is also taken into the calculation.

Generally, lock plates are fixed elements, they must not be taken into flexibility calculations with assuming they stretch with the affected forces.

Guides:

Pipe guides are essential elements in expansion joint applications such as lock plates.

For example, if we review an expansion joints assembly in the middle of an pipeline which is fixed on both ends by lock plates. (fig II-4) in case the required guiding is not provided, a very dangerous compression occurs.Calculation of the guiding distances with the assistance of Euler formula;

$I=\pi .\sqrt{EI/F}$
I: Guide Distance
E: Resistance Rate
I: Moment of inertia
F:Max Axial strain

Actual guiding distance is held by dividing this calculated value by a certain safety factor. According to EJMA specifications (Expansion Joint Manufacturers Association), first guide must be located in the distance which is maximum 4 times of the pipe diameter from the expansion joint.

Figure II.5 illustrates the Figure how to calculate the distance between guides dependent on pipe diameter and maximum pressure. This Figure is consisted by EJMA by taking the safety factor into account in calculations.

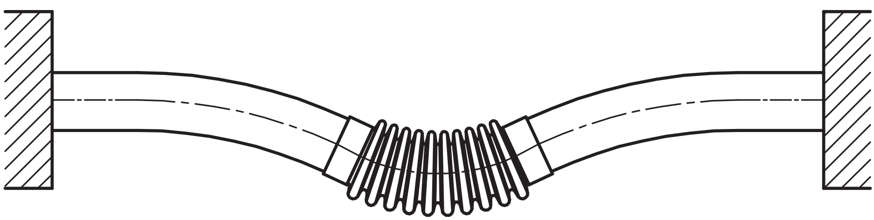
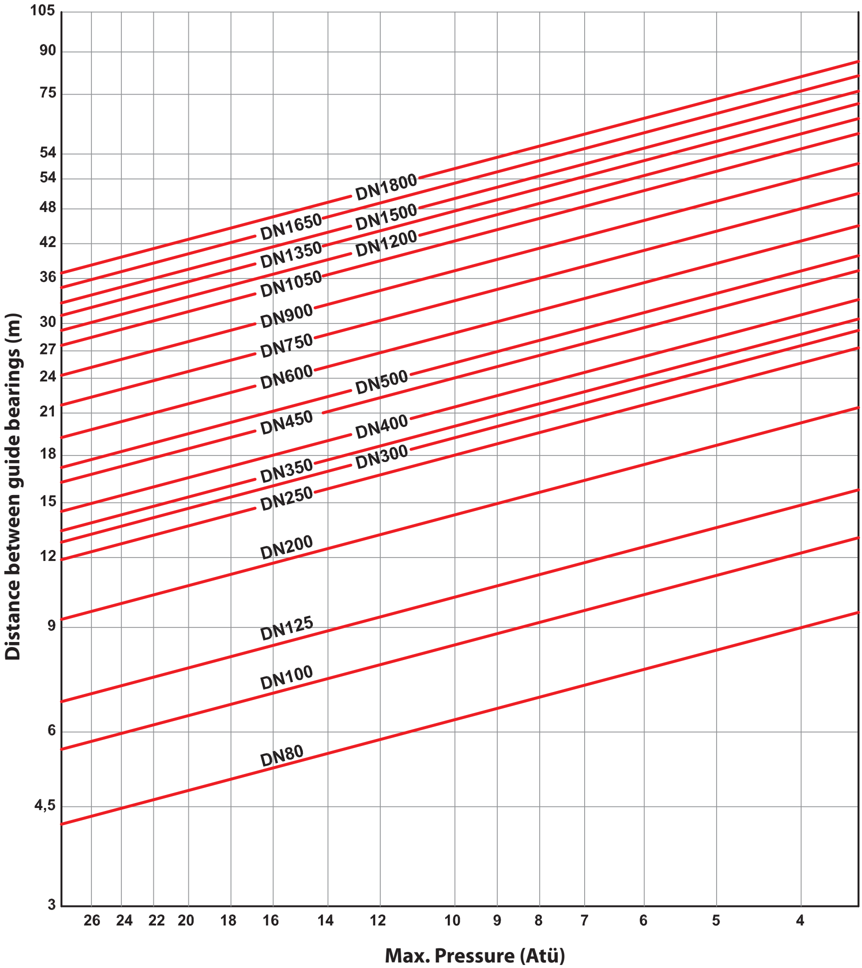


Figure II-4

For example, if we review an expansion joints assembly in the middle of an pipeline which is fixed on both ends by lock plates. (fig II-4) in case the required guiding is not provided, a very dangerous compression occurs.Calculation of the guiding distances with the assistance of Euler formula;

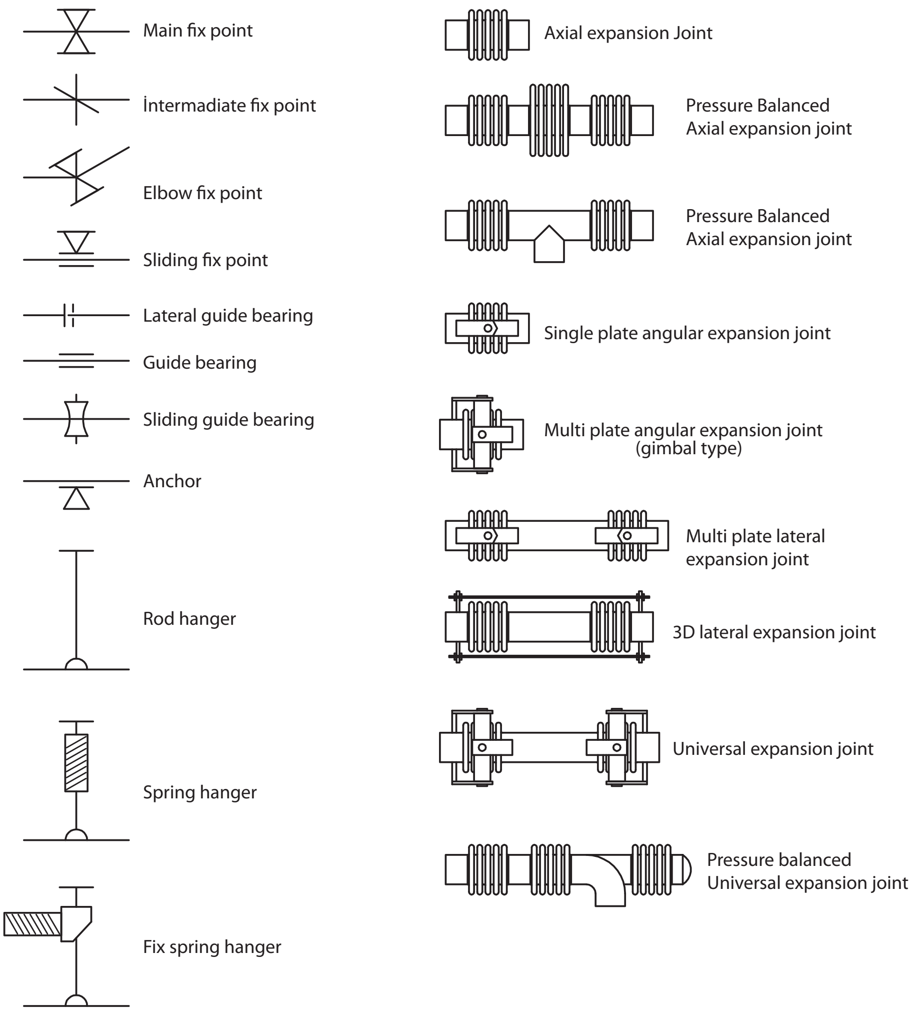
l=π .√EI/F
l: Guide Distance
E: Resistance Rate
I: Moment of inertia
F:Max Axial strain

Actual guiding distance is held by dividing this calculated value by a certain safety factor. According to EJMA specifications (Expansion Joint Manufacturers Association), first guide must be located in the distance which is maximum 4 times of the pipe diameter from the expansion joint. Figure II.5 illustrates the Figure how to calculate the distance between guides dependent on pipe diameter and maximum pressure. This Figure is consisted by EJMA by taking the safety factor into account in calculations.



Calculations of the selected lock plates and guides are given in next three selections.

Symbols related the lock plates and guiding applications are shown below.



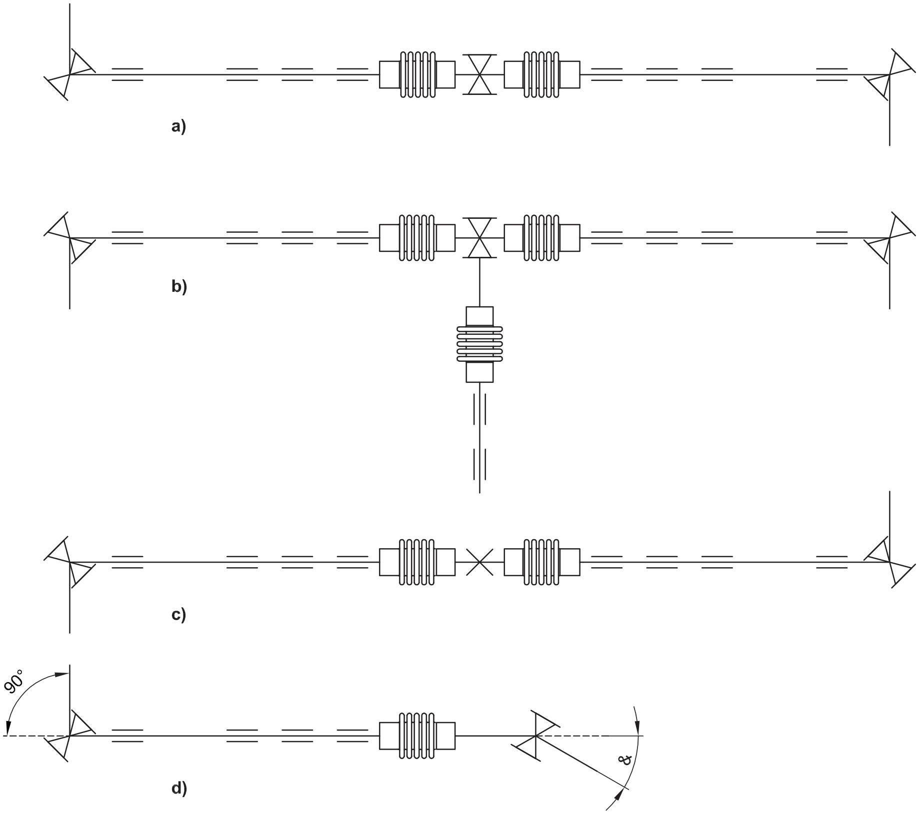


Figure II-6

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EXPANSION JOINTS

CHAPTER III

AXIAL EXPANSION JOINTS

CHAPTER III

Axial Expansion Joints

III. 1 Definition:

As it was indicated in the first chapter(1.2a), axial expansion joints are the first option to absorb the expansion with no need an additional working space. In axial expansion joint applications, the direction of the flow is not changed.

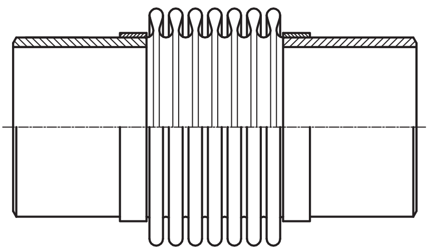
The most important feature of axial expansion joints is to absorb movements with covering lowest area possible. During the assembly of the axial expansion joints, it is not necessary to change the direction of the pipelines so the pressure loss is minimized. Also the liners placed into the axial expansion joints are very useful to reduce the pressure loss and to prevent the turbulence.

The pipe guides and locking plates which are used to absorb movements caused by the internal pipe pressure and various flow movements will be explained in following chapters.

Various connections exist for axial expansion joint applications and they can be reviewed as follows:

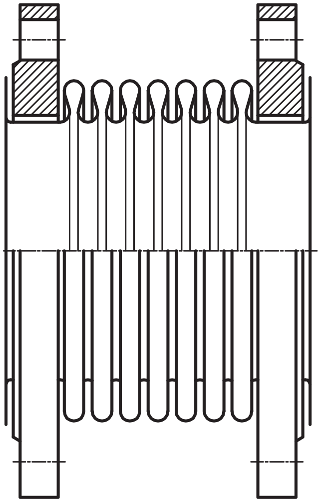
-Welding End (fig III.1)
-Floating Flanged (fig III.2)
-Fixed Flanged (fig III.3)

Also customized connection types are possible to designed and manufactured upon request.



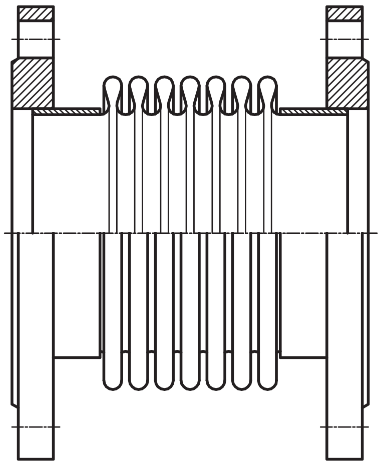
Welding End

Figure III-1



Floating Flanged

Figure III-2



Fixed Flanged

Figure III-3

In some cases, Axial expansion joints are used with additional elements if it is required according to the environmental and operational conditions. These elements could be classified as follows;

-Internal protective sleeve (liner) (fig. III-5)
-External protective cover (fig. III-4)

Internal protective sleeve (liner)

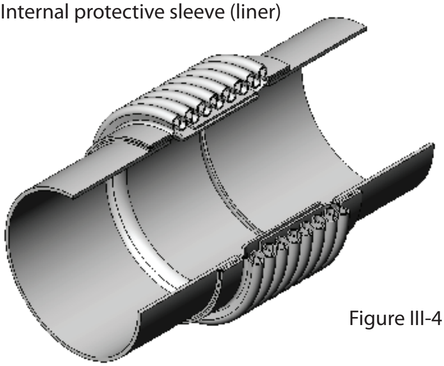


Figure III-4

External protective cover

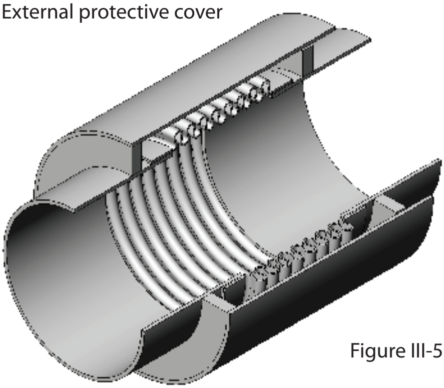


Figure III-5

a-External Protective Covers are applied externally and provide protection to the expansion joints against the outer mechanical damages.
b-Liners reduce the resistance against the flow inside the expansion joint. They prevent the accumulation of the residues contained in the dirty flow. Liners also protect the bellows from the sudden temperature shocks caused by the rapid and big temperature changes.

If the expansion joint is insulated, covers prevent the insulation material to get through the corrugations of the bellows and enable them to work properly. Despite the existence of liner, especially the bellows of very tall expansion joints can be twisted, in order to avoid such cases it is suggested to manufacture the expansion joints in the way of direct the pressure to the expansion joint externally. (Chapter VIII).

However these protective covers and liners provide the advanta-ges mentioned above, they shall never be used as the pipe guides or fixing points.

III. 2 Diverting the Pipeline Route into Sections:

It may not be possible to absorb the expansion by only one expansion joint in very long piping applications. For example; a pipe which is 150 meters long and made in St 35 material means an expansion that exceeds 242mm at 160 C° temperature difference. This example given is a very common and frequently seen situation. Especially, in larger pipeline applications which are forced to larger temperature changes, it can be foreseen that the expansion amount to be absorbed can not be taken by only expansion joint. Inch waterch cases, the pipeline route can be diverted by fixed points and the expansion amount between two fixing points can be reduced to the level that one expansion joint would be enough for absorption.

Diverting process is done by taking technical and economic issues into account, this optimization is necessary for the best results.

An example related this issue will be reviewed in chapter III.3

It is seen, how to calculate nominal pressure in the example given in chapter II.3. In following chapters, technical matters will be reviewed detailed and more practical solutions will be offered for those problems. Diverting the pipeline route in to sections, maximum axial movement, pre-loading, design of fixing points, guiding and design can be seen as some of those problems.

III. 3 Pre-Loading:

In chapter II.1 a, preloading has been defined briefly and its effect on service life was discussed. Now we will explain pre-loading by two practical examples and numeric calculations.

As it was indicated before, in principal, expansion joints are installed as they are pre-loaded. The amount of the pre-loading is calculated according to the environmental conditions.

Pipelines are expected to compress with the fall of outer temperature and to expand with the rise of the temperature.

While the pipeline is compressing, expansion joint is expanded, in opposite while the pipeline is expanded, expansion joint is compressed.

In order to maintain un-interrupted working for pipelines, expansion joint has to absorb all the expansion. In order to provide this, correct amount of pre-loading should be applied. The tables given in Chapter V illustrate, the compression and expansion amounts of each expansion joint at 5000 cycles.

The example below is to explain this situation.

Example 1:

Pipe Diameter:	150mm
Pipe Length:	25m
Operating Pressure:	7.5 atü
Pipe Material:	A St35
Installation Temperature:	+21C°
Average Temperature:	-10C°
Max Temperature:	+180C°

Please note that, It will be assumed that all the movement is axial.

Thermal expansion table given in Chapter IX will be used as follows:

The corresponding expansion values for the given temperatures are read from the material column of Carbon Steel. If there is not an exact value for these temperatures, required expansion amounts are calculated by linear inter-polarization technique. The symbols below will be helpful to determine the expansion value.

δ= represents the expansion amount for pipe 100 meters long at average temperature.
δ0 =represents the expansion amount for pipe 100 meters long at installation temperature.
δ+ =represents the expansion amount for pipe 100 meters long at maximum temperature.
Δ+ =represents the total expansion amount of pipeline
Δ+ =represents the total compression amount of pipeline
Δ= total movement

Temp.	Expansion
-10°C	= - 33 mm/100 m (Linear Inter-Polarization)
+21°C	= 0 mm/100 m (Table value)
+180°C	= 192.4 mm/100 m (Linear Inter-Polarization)

These values are given for 100m, to gather the values for 25 meters of pipeline. Each value should be multiplied by 25/100 (0.25)

$\delta_- = -33 \times 0.25$	$= -8.25$ mm
$\delta_o = 0$	
$\delta_+ = 192.4 \times 0.25$	$= 48.10$ mm
$\Delta_+ = 48.10 - 0$	$= 48.10$ mm pipe expansion
$\Delta_- = 0 - (-8.25)$	$= 8.25$ mm pipe compression
$\Delta = \Delta_+ + \Delta_-$	$= 48.10 + 8.25 = 56.35$ mm Total movement

By the assumption of the expansion joint is made in stainless steel, C factor can be determined as 0.78

Nominal Pressure = 7.5 / 0.78 = 9.62 atü

As the conclusion, we can say that an expansion joint from 10 atü pressure class and 150mm diameter and with more than 56.35mm axial movement capacity is the right choice because of its movement ability which is 44+0.5x44 =66mm.

By the formula given below, the expansion of the expansion joint will be divided in to the permissible and total expansion amount will be calculated. The parameters used in the formula are explained below.

P: Pre-Loading
L: Length of the expansion joint
L_m: Installation length of the expansion joint (after pre-loading)
E: Permissible compression amount of expansion joint

$$P = \frac{1}{2} \left(\Delta_+ - - \frac{E}{2}\right) \quad (3.1)$$

$$L_m = L + P \quad (3.2)$$

Table values in Chapter VI (150 mm diameter, 10atü pressure, 12 corrugations)

L = 240 mm
E = 44 mm

Calculated values before;
$\Delta_+ = 48.10$
$\Delta_- = 8.25$ mm

From the formula (3.1)

$$P = \frac{1}{2} (48.10 - 8.25 - 0.5 \times 44)$$

P = 8.93 mm pre-loading should be applied. The installation length is calculated from the formula (3.2)

L = 240.00 + 8.93 = 248.93 mm

Example 2:
See the fig. III-6 for this application.

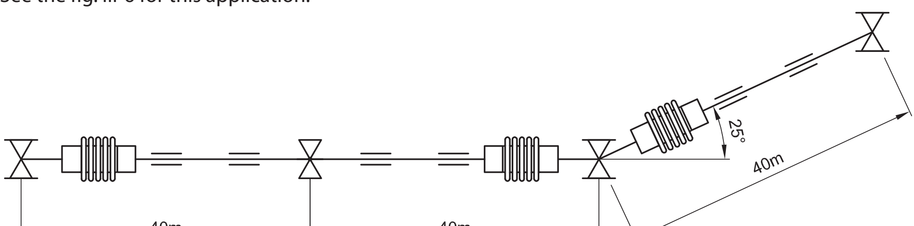


Figure III-6

Pipe Diameter:	125mm
Pipe Length:	120m
Operating Pressure:	7 atü
Pipe Material:	5 CrMo
Media:	Hydrofloric Acid
Installation Temperature:	+10 C°
Average Temperature:	-15 C°
Max. Temperature:	+120 C°
Swiveling Flanged Installation	

Please note that, the movement will be assumed as totally axial. The thermal expansion table given in chapter IX will be used as in the previous example.

Temperature	Expansion
-15°C	$\delta_- = -35.2$ mm/100 m (Linear Inter-Polarization)
+10°C	$\delta_o = -11.0$ mm/100 m (Table Value)
+120°C	$\delta_+ = +109.8$ mm/100 m (Linear Inter-Polarization)

These values are given for 100m, to gather the values for 120 meters of pipeline. Each value should be multiplied by 120/100 (1.2)

$\delta_- = -35.2 \times 1.2 = -42.2$ mm
$\delta_o = -11.10 \times 1.2 = -13.2$ mm
$\delta_+ = +109.8 \times 1.2 = +131.8$ mm
$\Delta_- = \delta_+ - \delta_o = -13.2 - (-42.2) = 29.0$ mm
$\Delta_+ = \delta_o - \delta_- = 131.8 - (-13.2) = 145.0$ mm

Total expansion joint movement reaches to 174mm, it is impossible to absorb such massive expansion by only expansion joint.

On the other hand, because the fluid is hydrofluoric acid, the most resistant material to acidic corrosion should be selected from the material table given in chapter IX.

According to the features of most appropriate material selected for this expansion joint, at the maximum temperature C factor is calculated as 0.93. Nominal pressure is calculated 7.0/0.93=7.53 atü accordingly.

In the review of the expansion joint features with 125mm diameter, 10 atü pressure class and 24 corrugations given in chapter VI. It is seen that total maximum permissible movement is 63mm.

Three of this type expansion joints can deal with total 189mm of expansion and compression. That is because the lower corrugation class is not enough, selection should be done that way.

Because of the reasons explained above, the pipeline should be divided in three sections as per 40m. Each pipe section is freed from the others and the values are calculated as follows.

$\Delta_+ = 145:3 = 48.3$ mm
$\Delta_- = 29:3 = 9.7$ mm
E = 42 mm
L = 240 mm (Total expansion joint length with flanges)
By using the formula (3.1)

$$P = \frac{1}{2}(48.3 - 9.7 - 21.0)$$

P = 8.8 mm
Installation length
L = 240.0 + 8.8 = 248.8 mm

III.4 Design of Fixed Points:

Design of fixed points defined in chapter III-4 will be reviewed by the previous example.

As it was explained before, the forces needed to be absorbed by elbows, terminal pieces and moving parts are listed below.

F1: Pressure Force
F2: Structural Resistance
F3: Friction of The Pipe
F4: Centrifugal force

The required parameters in order to calculate those forces are;

A: Effective bellow surface area (cm2)
k_E: Axial Spring Rate (kg/mm)
k_Y: Lateral Spring Rate (kg/mm) (kg/mm)
k_A: Angular Spring Rate (kg/mm) (kg/mm)
p: Operating Pressure (atü)
α: Defiance angle of pipeline
Y: Density of the fluid (g/cm3)
v: Velocity of the fluid (m/s)
ɥ: Friction rate min 0.3 - max0.5
w: Total weight of the pipe and the fluid per meter (kg/m)
l: Distance between the expansion joint and the fixed point (m)

The parameters that were not given in the example 2 before are given below:

$\alpha = 25°$
$v = 10$ m/s
$p = 7$ atü
$Y = 1 g/cm^3$
$\Delta = 48.3 + 9.7 = 58$ mm
ɥ = 0.25
w = 60 kg/mm

By using the table given in chapter VI (Diameter :125mm, pressure:10 atü, number of corrugations:24)

A = 183 cm
$k_E = 8.4$ kg/mm
$k_Y = 5.7$ kg/mm
$k_A = 3.2$ kg/mm/derece

"l" could be calculated in two ways;

a) If the expansion joint is near the fixed point l=0. Friction force is zero.

b) If there is some distance between the expansion joint and the fixed point l is calculated as follows.

Frictional Force
$f_3 = ɥ . w . l$ (3.3)

This is an additional force shoul be absorbed by the fixed point.

The distance named 1 will be assumed as zero for the design of fixed point for Example 2. Other forces are calculated with the formulas given below.

$f_1 = A.p$ (3 . 4 . a) Terminal Fixed Points.
$f_1 = 2 . A . p . \sin \alpha/2$ (3.4.b) Elbows

$$f_2 = \frac{1}{2} k_E . \Delta$$ (3.5a) Terminal Fixed Points

$f_2 = k_E . \Delta . \sin \alpha/2$ (3.5 b) Elbows

$$f_4 = \frac{1}{50} A . Y . v^2 \sin \alpha/2$$ (3.6) Elbows

That is because, no circular movement exist, F4 centrifugal force is not subjected for terminal fixed points. Fixed points can be placed as shown in fig. III-6.

The forces should be taken by the terminal fixed points are;

$f_1 = 183 . 7 = 1281$ kg

$$f_2 = \frac{1}{2} 8.4 . 58 = 243.6 \text{ kg}$$

(Note: It is assumed that only axial movement exists, k value is not taken into account)

Total f = <u>1524.6 kg</u>
For elbow F.P

$$f = 2 . 183 . 7 \sin \frac{25}{2} = 554.5 \text{ kg}$$

$$f = 8.4 . 58 . \sin \frac{25}{2} = 105.4 \text{ kg}$$

$$f = \frac{1}{50} . 183 . 1 . 100 \sin \frac{25}{2} = 79.2 \text{ kg}$$

Total f = 739.1 kg

The forces effect at intermediate fixed points are structural resistance forces (f2) and frictional forces (f3). However, structural resistance force come out theoretically, this force can be assumed at the minimum level. This value can be equaled with the structural resistance of the terminal fixed point.

f2 = 105.4 kg

Frictional force is calculated with formula (3.3). The important point that we should pay attention here is the (l) value which is taken as 40m.

f3 = 0.25.60.40 = 600 kg
Total force = 705.4 kg

Design of the fixed points for Example 2 is completed as shown above. The conclusion is;

2 nominal fixed points > 1524.6 kg
1intermediate fixed points > 705.4 kg
1 elbow fixed point > 739.1 kg

III.5 Axial Guiding:

It was defined that the guiding enables the use of expansion joints in II.4. The guiding of Example 2 can be completed as follows.

First guide is located in the distance which is 4 times of the diameter after the expansion joint (500mm), second guide after 14 diameters distance (1750mm).

Fig II-5 illustrates that a guiding which is 12m approximately is needed for 125mm diameter and 7 atü pressure for the expansion joint.

III.6 Insulation:

The insulation of the expansion joints that are used in the transportation of cold or hot fluids are done as the simple pipeline systems are done.

Choosing an expansion joint with an external sleeve will provide better results. If the expansion joints are insulated without an external protection, the insulation material can fill up the corrugation spaces and reduce the flexibility of the bellows.

Another important subject is the corrosive effects of some insulation materials in case of warming up for some reason.

III.7 Manufacturing Process of Axial Expansion Joints:

a-Planning Stage:

- Collecting the data
- Determining the Nominal Pressure
- Calculating the expansion and the compression amount of the pipeline.
- Dividing the pipeline in to sections.
- Selecting the Expansion Joint
- Determining the preloading amount.
- Designing the fixed points and guidings.
- Designing the insulation.

b-Installation Stage:

- Collecting the data
- Determining the Nominal Pressure
- Calculating the expansion and the compression amount of the pipeline.
- Dividing the pipeline in to sections.
- Selecting the Expansion Joint
- Determining the preloading amount.
- Designing the fixed points and guidings.
- Designing the insulation.

c-Operating Tips:

- Preventing the over-shocks caused by the improper installation, water hammer etc.
- Purifying the expansion joints internally from the corrosive materials as much as possible.

III.8 Axial Expansion Joint Applications

The figures shown below (III.7/8/9/10) illustrate the multi plated and multi dimensioned applications.

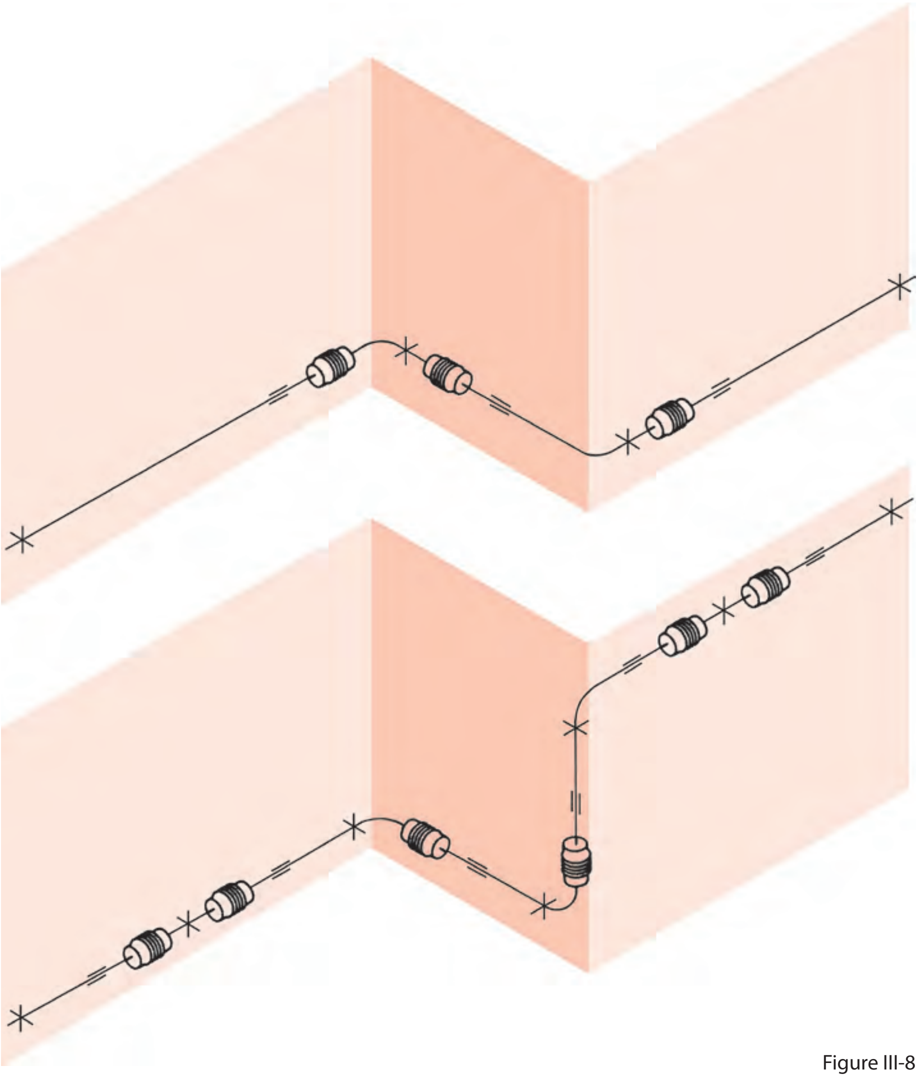


Figure III-8

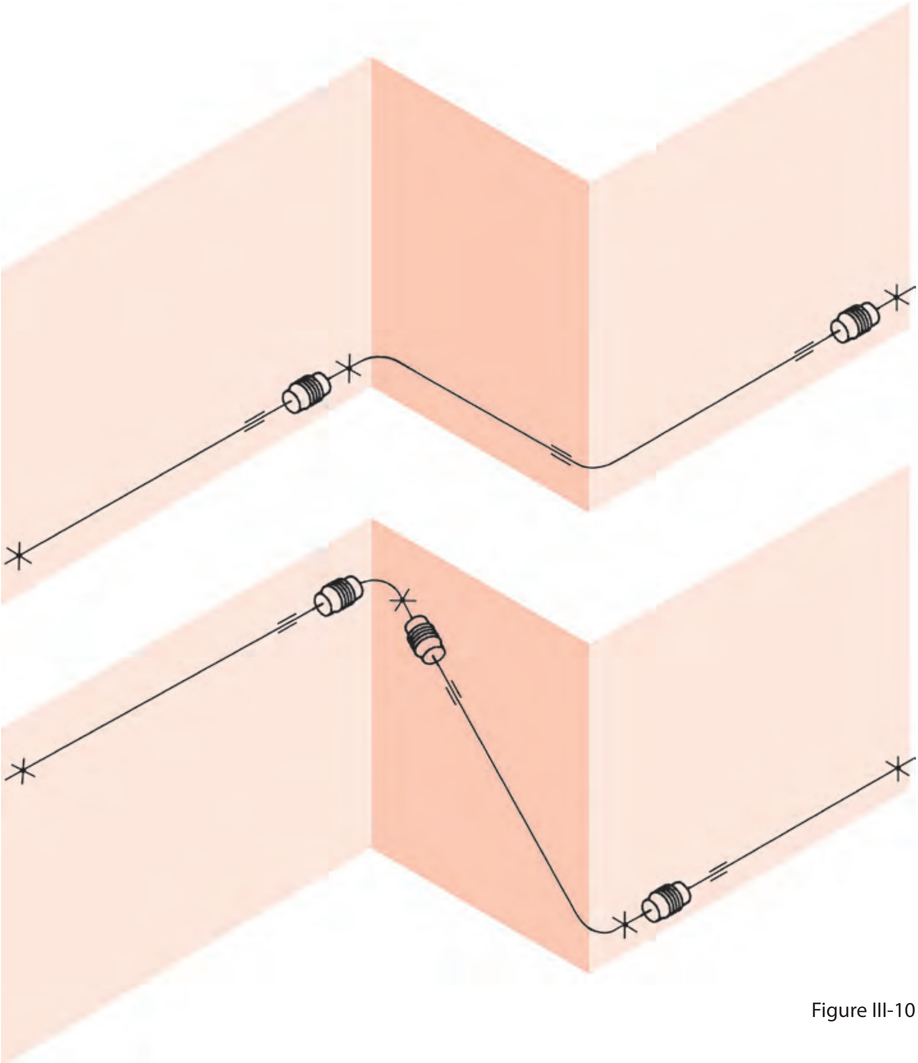


Figure III-10

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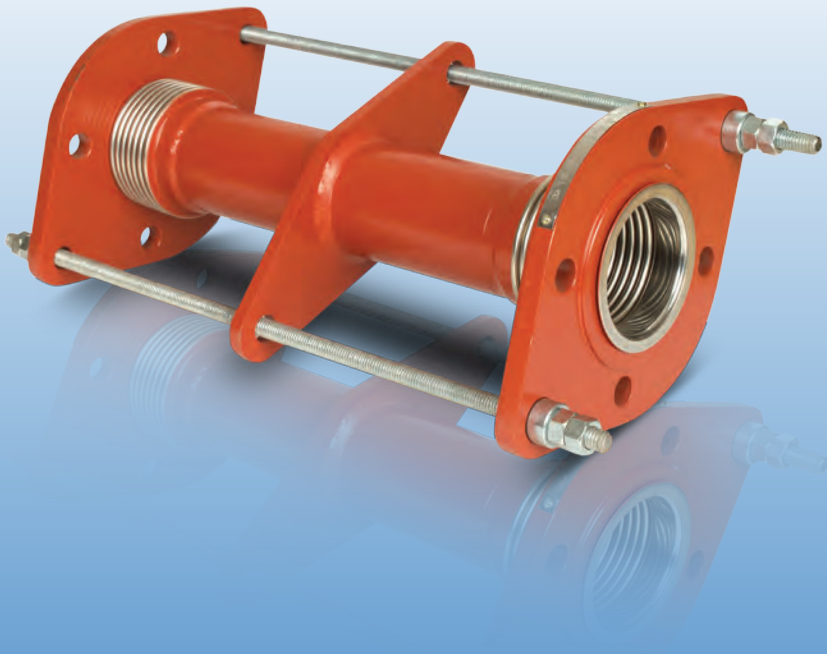
EXPANSION JOINTS

CHAPTER IV

LATERAL EXPANSION JOINTS



CHAPTER IV

Lateral Expansion Joints

IV.1 Definition:

As it was indicated in chapter I.2, Lateral expansion joints are the second option to absorb the expansion. One lateral expansion joint can absorb double dimensioned movement in one plane.

The main purpose of the lateral expansion joints is to prevent bending stresses. These stresses are caused by pressure tension. For example: the effective crossing area of an expansion joint with 500mm nominal diameter is 2291 cm2'dir.If the operating pressure is assumed as 20 kg/cm2, The pressure tension is calculated 229 x 20 = 45820 kg. If the expansion joint is designed with hinges , the hinges must also take this force. Because of this, the hinges or other supporting parts are designed with an appropriate safety factor in order to absorb all these tensions.

Lateral expansion joints are maintenance free elements just like axial expansion joints.

The main types of lateral expansion joints are;

Lateral expansion joints are maintenance free elements just like axial expansion joints.

The main types of lateral expansion joints are;

a- Tied Universal Expansion Joints
b- Heavy Duty Expansion Joints

a-Tied Universal Expansion Joints:

Design of Tied Lateral Expansion joint is especially done for the economical reasons. Limit rods are able to move in all directions. This type of expansion joints are only recommended for limited pressure and temperature applications. (fig I.5)

Three different types of connection are possible for tied lateral expansion joints;

- Welded End (fig III-1)
- Floating Flanged (fig III-2)
- Fixed Flanged (fig III-3)

Welded ends can be prepared in any customized norm. On the other hand, expansion joints can be manufactured with special connections.

Floating flanged designs offers very economical solutions in cases them to be used below the determined pressure level. For this type of connections, transported media is only connected with the bellows, no special material is required for the flanges. The applications that the floating flanged connections are not recommended are as follows.

- Vacuumed pipeline systems.
- The connections that the flange surfaces to rise and fall.
- Grooved flange surfaces

Flanges are manufactured in various norms, Special flange designs are available on request.

b-Heavy Duty Lateral Expansion Joints:

Tied expansion joints can not be used in the applications at higher pressure levels and temperatures exceeding +400 °C. Cardanic Type Lateral Expansion Joints can offer the solutions inch waterch cases.

Fig IV-1 illustrates the heavy duty lateral expansion joint which is movable in one direction because of the hinges. A Cardanic type of lateral expansion is shown in fig IV-2, this type of hinges enable the expansion joint to move in all directions.The amount of the lateral movement can be varied for the different using areas. In cases that the amount of these movements are not too high, use of a single bellowed expansion joint may be enough. But, in order to absorb big movement amounts, a double bellowed expansion joint with an extension pipe is recommended. Various extension pipes can be seen in Fig I-5 and III-3.

Amount of the lateral movement is the function of the factors below.
- Flexibility of the bellows
- Length of the bellows
- Length of the intermediate pipe between the bellows

Welded end, Single plate lateral expansion joint

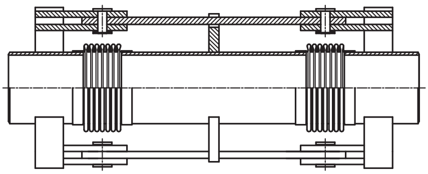


Figure IV-1

Welded end, gimbal type, 3D lateral expansion joint

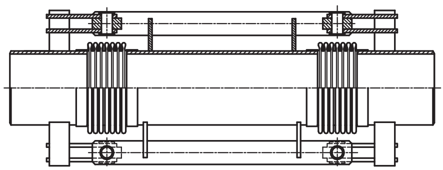


Figure IV-2

Extending the movement of lateral expansion joints by intermediate pipe.

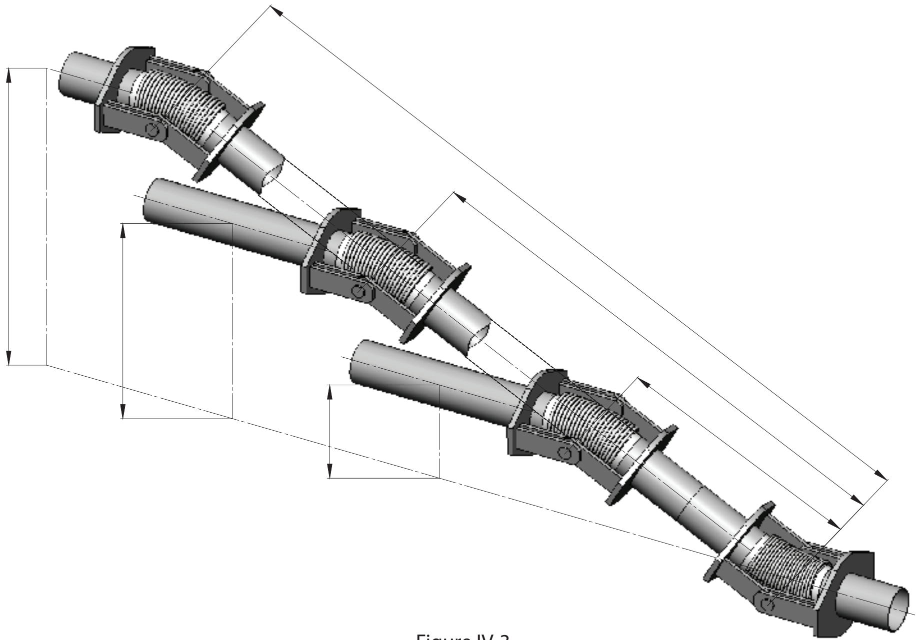


Figure IV-3

Required lateral movement may be provided by a single bellowed or a double bellowed expansion joint and the manufacturer decides the design of the expansion joint accordingly.

As it is indicated above, lateral movement ability of the expansion joint may be increased by using intermediate extension pipes. It is shown how this kind of movements occur in fig. IV-3.

As the length of the extension increases, the absorbed lateral movement amount is increases as well. In some cases, lateral movement amount may exceeds the expected amount, inch waterch cases expansion joint must be protected from permanent deforming. The limit rods shown in fig I-5 protect expansion joint against the movements that are not taken into account during the design stage. Heavy duty lateral expansion joints in fig IV-1 and fig. IV-2 provide lateral movement as well as pipe loads.

IV.2 Determining The Nominal Pressure:

After collecting the data about, operating pressure, operating temperature and the expansion joint material, the nominal pressure is determined as in Chapter II.1.

IV.3 Dividing The Pipeline into Sections:

Dividing the pipeline into sections is subjected for Lateral Expansion Joints as it was defined for axial expansion joints in chapter III-2. Inch waterch applications, elbows for multi planed installation and some other limitations besides high temperature must be taken into account.

- If the length of the pipe before the turn is too long, one expansion joint is not enough to absorb the expansion amount.
- Too many elbows are used in the pipeline.
- If the expansion exist more than two planes.
- The placing difficulties of the supports that carry the weight of the pipeline.

Pre-sectioning the pipelines is done by this way. Final sectioning is completed after calculating the thermal stresses and the permissible movement per expansion joint. In case that the pipeline movements and diagonal expansions occur in two plates, the movement is summed as vector.

IV.4 Determining The Pipeline Movement:

Determining the pipeline movement for lateral expansion joint applications is different from axial expansion joint applications.

The thermal expansion caused by the temperature differences at axial expansion joint applications is determined like the examples given in chapter III-3. The example given below is helpful for a better conclusion.

EXAMPLE: (See Figure IV-4)

A very long pipeline which is turning with 90° on one plane is shown in the figure. Expansion amount in the first dimension is shown with Δ2, the compression amount in the first dimension is shown with Δ3 and the expansion amount in the second dimension is shown with Δ4.

Total Expansion:

$$\Delta\text{+Y} = \sqrt{\Delta 21 + \Delta 22} \qquad (4.1a)$$

Total Compression:

$$\Delta\text{-Y} = \sqrt{\Delta 23 + \Delta 24} \qquad (4.1b)$$

If the required diameter and pressure are given, Lateral movement amount (Y) is determined from chapter VI. If the figure shown below is met, the corrugation number of the expansion joint is selected accordingly.

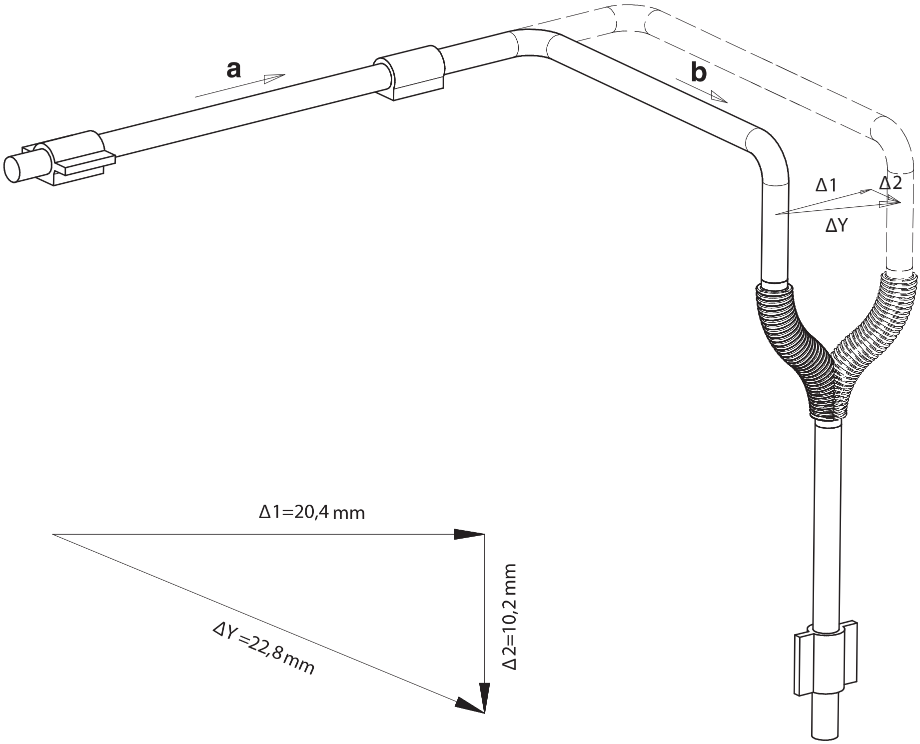
$$\frac{1}{2}(\Delta\text{+Y} + \Delta\text{-Y}) \leq Y \qquad (4.2)$$

Preloading is a very important factor for the optimum usage of the lateral expansion joints. Preloading can be calculated the formula given below.

$$P = \frac{1}{2}\left|\Delta\text{+Y} - \Delta\text{-Y}\right| \qquad (4.3)$$

Preloading is applied in the opposite direction where the expansion or compression occurs. In lateral expansion joint applications, the direction of the preloading is as important as the value of it. The direction can be calculated by the formula given below.

$$\alpha = \tan\text{-}1 \frac{\dot{\Delta}_2}{\Delta_1} \qquad (4.4) \quad \text{Fig. IV-4)}$$



Expansion of the pipelines on two plate

Figure IV-4

Pipe Diameter	200mm
Pipe Length a	40 m
Pipe Length b	20 m
Operating Pressure	4.5 atü
w	60 kg/m
Pipe Material	St 37
Fluid	sulfuric acid
Installation Temp	+15°C
Average Temp.	0°C
Max. Temp.	+60°C

Fixed Flanged Installation

Temperature:	Expansion:
0°C	δ_- - 23.0 mm/100 m
+15°C	δ_0 - 6.5 mm/100 m
+60°C	δ_+ + 44.6/100 m

$\Delta_+ = \delta_+ - \delta_o = 44.6 - (-6.5) = 51.1$ mm/100 m
$\Delta_- = \delta_o - \delta_- = -6.5 - (-23.0) = 16.5$ mm/100 m
Values fort he Pipe a should be mutiplied with 0.4
Values fort he Pipe b should be mutiplied with 0.2

Expansion Amounts

$\Delta_1 = 51.1 \times 0.4 = 20.4$ mm
$\Delta_2 = 51.1 \times 0.2 = 10.2$ mm

Compression Amounts

$\Delta_3 = 16.5 \times 0.4 = 6.6$ mm
$\Delta_4 = 16.5 \times 0.2 = 3.3$ mm

Total Expansion from the formula (4.1a)

$$\Delta_{+Y} = \sqrt{\Delta^2_1 + \Delta^2_2} = \sqrt{20.4^2 + 10.2^2} = 22.8 \text{ mm}$$

Total Compression from the formula (4.1b)

$$\Delta_{-Y} = \sqrt{\Delta^2_3 + \Delta^2_4} = \sqrt{6.6^2 + 3.3^2} = 7.4 \text{ mm}$$

Because the fluid is sulphuric acid, Stainless steel AISI 316L material is selected as the expansion joint material. At max temperature by using fig.II-2

C=0.9 is determined.

Nominal pressure is calculated as 4.5/0,9=5 atü. As a result of that, above pressure class 6 atü is selected. From the chapter IV, for 200mm diameter and selected pressure class, the lateral movement amount is held.

$$\frac{1}{2}(\Delta_{+Y} + \Delta_{-Y}) = \frac{1}{2}(22.8 + 7.4) = 15.1 \text{ mm}$$

Y value of the expansion joint with 16 corrugations is 21mm and 15.1 ≤ 21, this corrugation quantity is selected.

Preloading amount is calculated by the formula

$$P = \frac{1}{2}\left|\Delta_{+Y} + \Delta_{-Y}\right| = \frac{1}{2}\left|22.8 - 7.4\right| = 7.7 \text{ mm}$$

Direction of the preloading is calculated from the formula (4.4)

$$\alpha = \tan^{-1}\frac{\Delta_2}{\Delta_1} \tan^{-1}\frac{10.2}{20.4} = 26.6°$$

As it was defined before, Preloading is applied in the opposite

direction of the expansion.

IV.5 Design of the Fixed Points:

The designing process of the fixed points for lateral expansion joints is done in the same methods in chapter II-4 and III-4. As mentioned before, one of the most important advantages of the lateral expansion joints against axial expansion joints is; lateral expansion joints do not need guide and fixed points as many as axial expansion joints (needed).

The main force which is required for fixed point design is the frictional force. The formula given in chapter 3.3 is applied in the calculations of frictional force for lateral expansion joints as well.

$$f = ц \times w \times l \qquad (3.3)$$

Parameter (ц) is generally used as a fixed value which is 0.3. Pipe weight per unit is accepted 60kg. "I" represents the distance between the lateral expansion joint and the fixed point and the pipe length (a) is 40m.

Even a double planed movement is subjected, the guiding will be applied through only one plane. We take the total pipe length (a+b) into our calculations, that is because we need the total pipe weight for the second plane calculations.

Another important force as important as the frictional force is movement force which is caused by the lateral movements of the expansion joint. This force is simply calculated by multiplying the lateral spring rate with the total expansion or compression amount (higher one).

$$f = k_y \times \Delta_{+y} \quad (4.5)$$

Note: If $\Delta_{-Y} > \Delta_{+Y}$ Δ_{-Y} value is used.

The sum of all these forces mentioned above, reflect the required resistance value of the fixed point. Design of the fixed point for this chapter is explained with the Example given below.

l = 40 + 20 = 60 m
f = 0.3 x 60 x 60 =1080 kg

In order to calculate the movement force, Spring rate K_Y for the expansion joint given in the example is used. Δ_{+Y} is also used in the formula (4.5)

f = 9.8 kg/mm x 22.8 mm = 223.4 kg
Total force to be absorbed,
f = 1080.0 + 223.4 = 1303.4 kg

is calculated and the design of the fixed point is finalized.

Larger lateral expansion joints have smaller spring rates, this provides smaller movement force and, less stressed connections. Because of these features, larger expansion joints are preferred at the outlets of the sensitive tools likewise turbines, compressors and ceramics vessels.

IV.6 Guiding:

However, guiding applications for lateral expansion joints are not as crucial as the axial expansion joint connections, lateral run-outs in long pipeline applications can be prevented with guiding. Because of this, guiding must be applied at one dimension of the double dimensioned expansions according to the EJMA Standards. Guiding should be done according to the rules explained in chapter II-4. Reviewing the Example given in chapter IV-4 shows that the first guide should be placed 2.8m after the expansion joint with 200mm diameter. Following guides should be repeated at every 19.5m (4.5 atü, 200mm diameter).

Tie rods may be used in order to prevent the unwanted movements of the lateral expansion joints. These rods are less exposed to the thermal stresses, if they are partly insulated or left completely non-insulated.

V.7 Insulation:

As it was explained in chapter III-7 before, the insulation of the expansion joints that are used in the transportation of cold or hot fluids are done as the simple pipeline systems are done.

Choosing an expansion joint with an external cover will provide better results. If the expansion joints are insulated without an external protection, the insulation material can fill up the convolution spaces and reduce the flexibility of the bellows. In these cases, the insulation must be covered loosely around the expansion joint and fixed by the bands.

Tie rods may be used in lateral expansion joint designs in order to avoid unrequired movements. Non insulating or partly insulating these tie rods may reduce the thermal stress possibility.

Manufacturing Process of Lateral Expansion Joints:

a-Planning Stage
- Collecting the data
- Determining the Nominal Pressure
- Calculating the expansion and the compression amount of the pipeline.
- Dividing the pipeline in to sections.
- Selecting the Expansion Joint
- Determining the preloading amount.
- Designing the fixed points and guidings.
- Designing the insulation.

b- Installation Stage

• Protecting the bellows from the mechanical damages.
• Tie Rods or the hinges that are used to protect the lateral expansion joints must be installed with 90° angle to the movement plane.
• Covering the bellows with asbestos without chlorite against the arc splashes during the welding.
• For the flanged connections; centering the gaskets, levelling the screws and screwing in diagonally.
• Preventing improper pressure and torsion during the installation.
• Cleaning up the bellows internally against the harmful materials before and after installation.
• Using other selection methods or asking the manufacturer whether, the lateral and angular movements are subjected.

c-Operating Tips:

• Preventing the over-shocks caused by the improper installation, water hammer etc.
• Purifying the expansion joints internally from the corrosive materials as much as possible.

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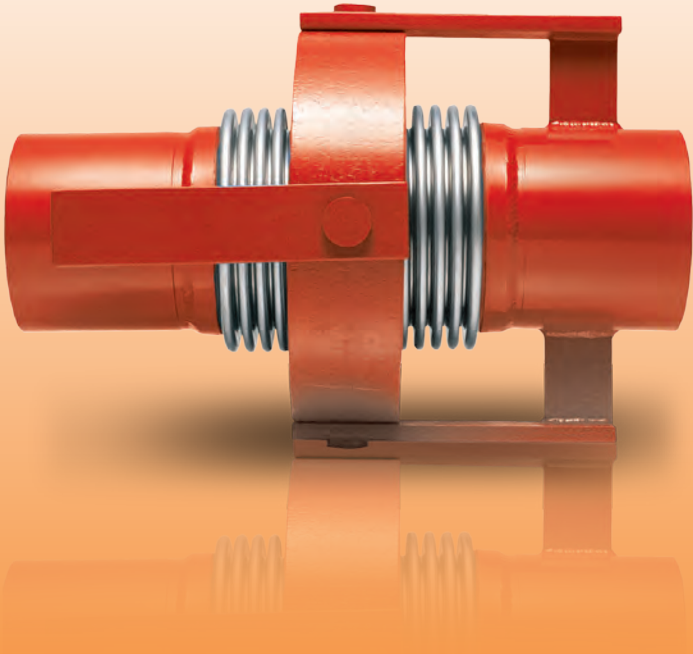
EXPANSION JOINTS

CHAPTER V

ANGULAR EXPANSION JOINTS



CHAPTER V

Angular Expansion Joints

V.1 Definition:

Angular expansion joints are used to absorb the movements on two or three dimensions and that changing the direction at the same time. Especially when the lateral movement is too high, angular expansion joints must be used as the double or triple groups. Various designs are possible depend on the plane number of the existed expansion. Different design types will be reviewed in this chapter.

The heavy duty design for lateral expansion joints that has been defined in chapter IV-1 before, may be used in angular expansion joint applications as well. Hinged expansion joints designed according to the heavy duty conditions can absorb the expansion movements and take the pipe load as well.

Double hinged angular expansion joints are also available besides of the single hinged expansion joint shown in the fig.I-10. Double hinged angular expansion joints enable the movements in all directions. Fig 1-13 illustrates that a double hinged expansion joint is able to cover a conic volume of movement area.

Various applications for both, single and double hinged expansion joints will be reviewed in this chapter.

Angular expansion joints have the same connection types like the other types.

- Welded End (fig III-1)
- Floating Flanged (fig.III-2)
- Fixed Flanged (fig III-3)

As it was indicated before, both welded end and flanged type of expansion joints can be manufactured according to any connection standard or specially design. The economical advantages of the floating flanged connections are the main selective reason. On the other hand, vacuumed or various levelled connections may force the use of fixed flanged connections compulsory.

V.2 Angular Expansion Joint Applications:

Angular expansion joint applications can be grouped as the single planed or multi planed applications. Both types of the applications may happen in various ways. The main principals will be defined with the figures in following sections.

V.2.a Angular Expansion Joint on One Plane:

Four different types of the angular expansion joint applications are possible on one plane.
i- The expansion amount of the pipeline is absorbed by two expansion joints that are moveable on two directions and located as vertically to the pipeline direction. (fig IV-1)

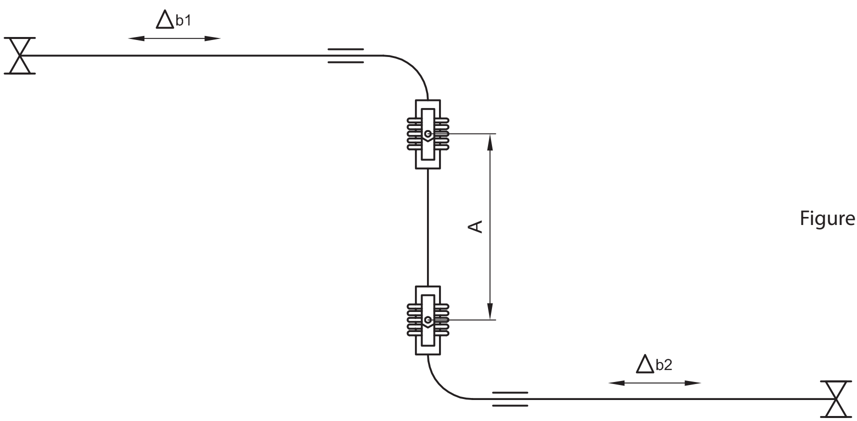


Figure V-1

ii- U-shaped angular expansion joint applications may be used to absorb the expansion in very long pipeline applications. In this type of applications, the expansion amount is absorbed by three expansion joints moveable in two directions. U-shaped applications are especially preferred, because of preventing the waste of space and providing economic solutions. (fig V-2)

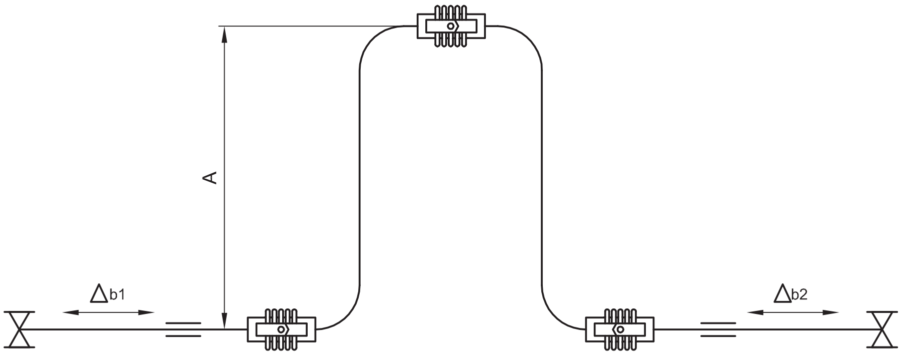


Figure V-2

iii- Another single planed application type is L-shaped applications. In this type of applications, three expansion joints moveable in two directions are used . The expansion joint is especially used to absorb the expansion of the vertical line's expansion amount. (fig V-3)

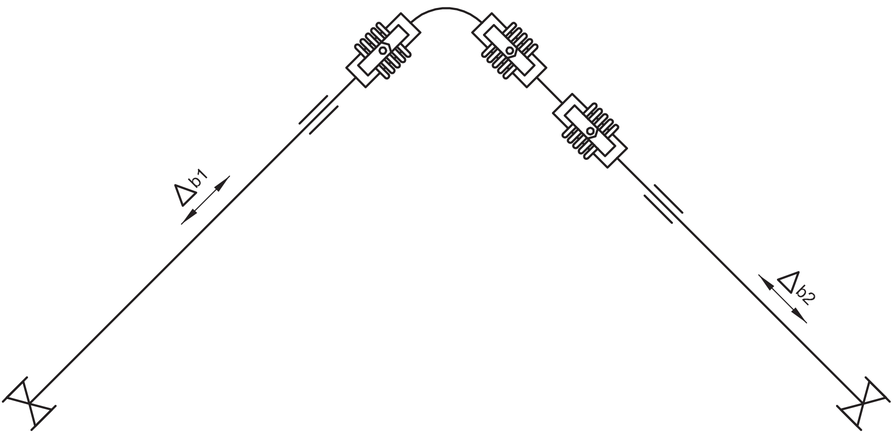


Figure V-3

iv- Last type is a Z-shaped, single plane application. Absorption principal is similar to L-shaped. The expansion amount of the pipeline is absorbed by an intermediate section which is located vertically to the main line. The larger expansion joint which is moveable in two direction is located on to the longer pipe piece.

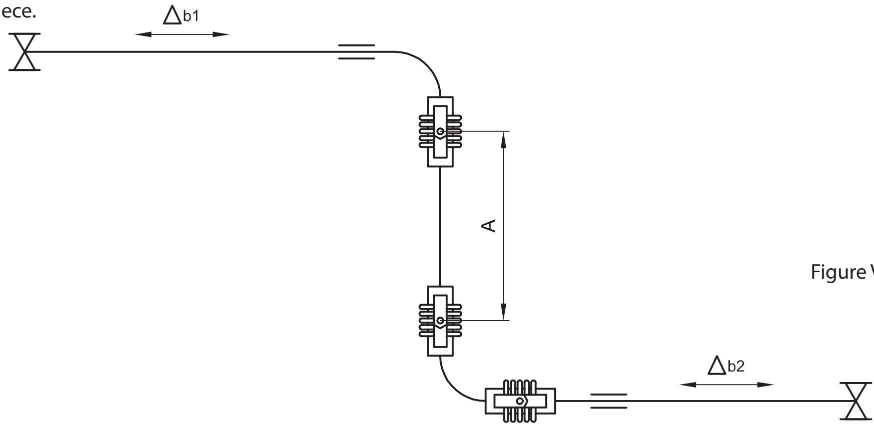


Figure V-4

V.2.b Angular Expansion Joints on Multi Planes:

The movement of the angular expansion joints on multi planes is reviewed in three types. i- As it is shown in fig V-5, two pipelines on one plane and another one on the third plane are located. The mid line which is directed vertically contains two expansion joints moveable on two directions. The expansion amount of this pipeline is assumed as small as to be ignored.

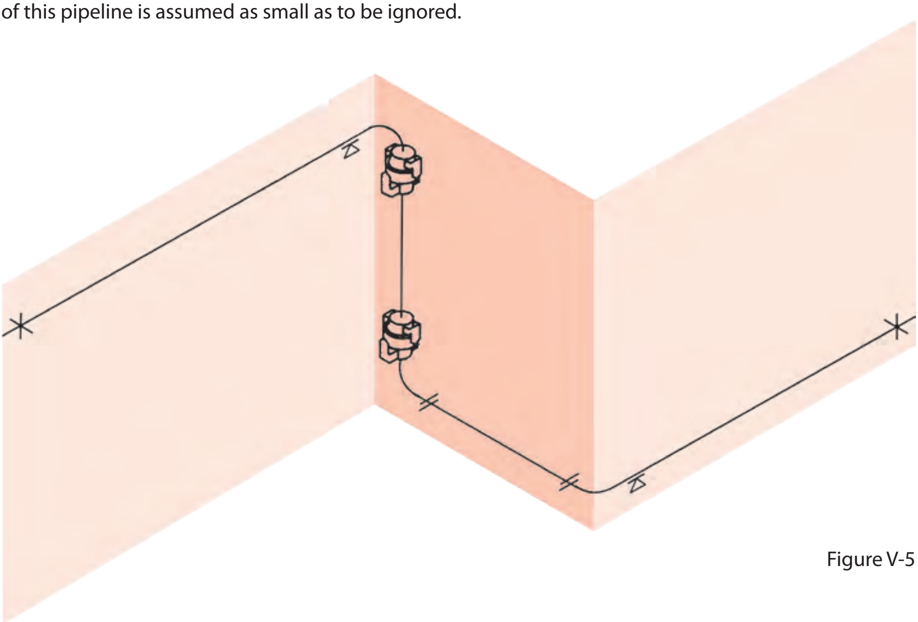


Figure V-5

ii- The pipeline given in fig.V-6 is as shaped as the previous figure, Multi planed Z-shaped angular expansion joint application contains two expansion joints moveable in two directions and the another one moveable in all directions. The last one should be placed at the end of the longer pipeline.

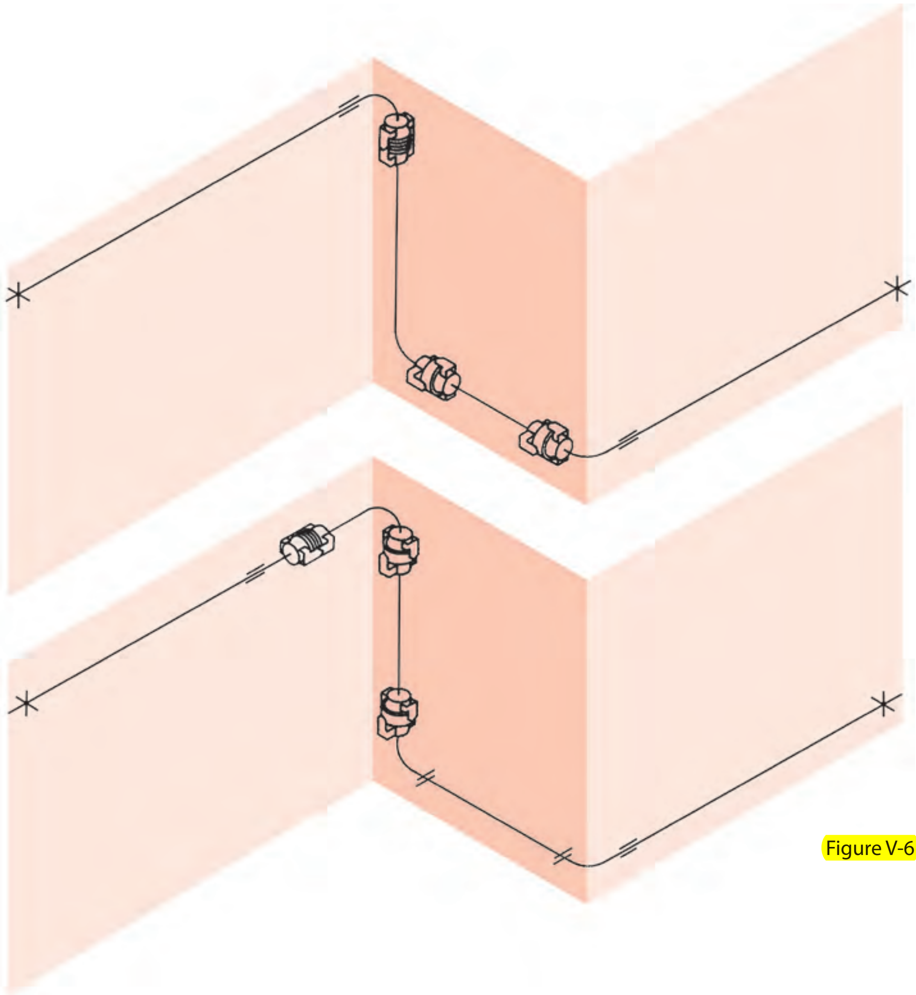


Figure V-6

iii- The pipeline given in fig. V-6 contains one more plane compared with the previous example. One expansion joint moveable in two directions is placed onto the longer horizontal pipeline and two expansion joints moveable in all directions are placed on the vertical pipeline.

As the conclusion, we can say that the expansion joints must be applied according to a system in order to absorb the expansion amount of the multi-planed applications.

V-3 Determining The Nominal Pressure:

After collecting the data about the operating pressure, operating temperature and expansion joint material, nominal pressure is calculated as in chapter II.1a

V-4 Dividing the pipeline in Sections:

It is unavoidable to divide the pipeline in section in following conditions;

• If the pipeline contains too many elbows on various planes.
• If the pipeline is too long.
• If the supporting elements that are expected to carry the total weight of the pipe and the fluid.

V.5 Selecting the type of angular expansion joint applications for single or multi planed systems:

Selecting the type of angular expansion joint applications given in Chapter V-2 depends on the following conditions.
• If enough application area is available for the application.
• Economical factors should be taken into account if more than one application methods are available.

V.6 Calculating the movement amount of the Angular expansion joint Systems:

As it was defined in chapter IV with Example 1, the expansion amount of each dimension should be summed vectorially in order to determine the total movement of the multi planed systems.

The application types reviewed in early sections of this chapter illustrated the pipelines that are multi planed and vertically located to each other. The total expansion amount of these types of pipeline systems are calculated with the formulas (4.1.a) and (4.1.b).

If the pipelines are connected to each other with an angle, than we need to apply a simple cosines method in order to calculate the total expansion amount. The expansion of the first dimension is represented with Δ_1 and the second is represented with Δ_2 and the angle between the pipelines is represented with Δ.

Total expansion amount is calculated with the formula below.

$$\Delta = \sqrt{\Delta^2{}_1 + \Delta^2{}_2 - 2\,\Delta_1 \Delta_2 \text{Cos}\,\alpha} \qquad (5.1)$$

The expansion amounts of the types shown in chapter V.2.a and V.2.b are calculated with the formulas given below.

V.2.a.i: Both pipelines are on the same plane and directions.

$$\Delta = \Delta_1 + \Delta_2 \qquad (5.2)$$

V.2.a.ii: Formula 5.2 is to be used
V.2.a.iii: Both pipelines are on the same plane but different dimensions.

$$A = \sqrt{\Delta^2{}_1 + \Delta^2{}_2} \qquad (5.3)$$

V.2.a.iv: The expansion amount of the intermediate pipeline can be ignored, total expansion is calculated as the sum of the horizontal pipelines. (Formula 5.2)

V.2.b.i: Even the pipelines are on the same plane, that is because a double dimensional expansion is subjected formula 5.3 is to be used.

V.2.b.ii: Formula 5.3 is to be used.

V.2.b.iii: That is because, the pipeline 2 could be ignored, total expansion joint is calculated with the formula below.

$$\Delta = \sqrt{(\Delta_{1a} + \Delta_{1b})^2 + \Delta^2{}_3} \qquad (5.4)$$

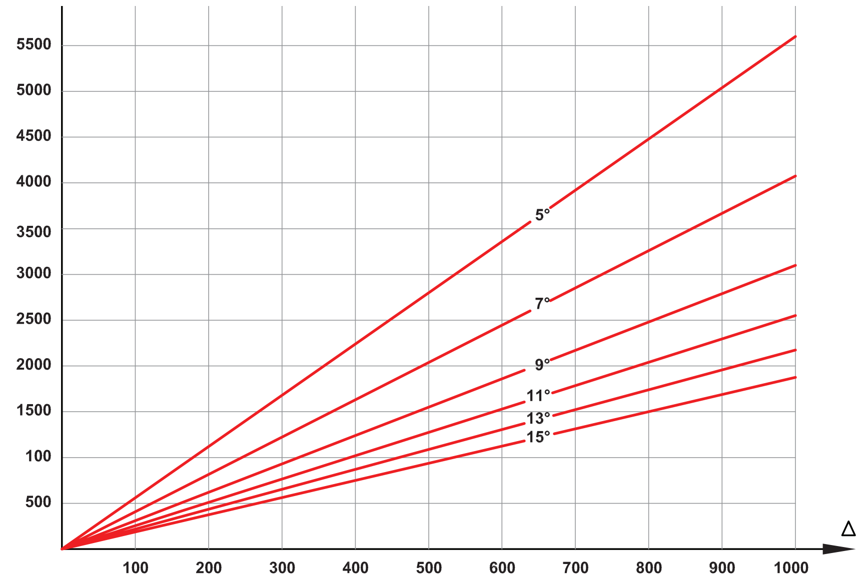
The main types of the angular expansion joint applications are given above, any other type of application could be possible with asking the manufacturer. It is possible to absorb expansions with minimum waste of space by applying angular expansion joints.

After collecting the data of total expansion amount and maximum movement, distance between two expansion joints could be calculated with the following formula.

$A = \Delta / \sin \alpha$
Angular movement α < C15°

$\sin \alpha = \alpha \times \pi / 180 = 0.01745\, \alpha$
$A = 28.6\Delta / \alpha$ (5.5)

That is because α is given in degrees, dimension A is equal to dimension Δ. Fig V-8 could be used in order to make the use of the formula 5.5 easier.



Distance between expansion joints dependent on the movement Figure V-8

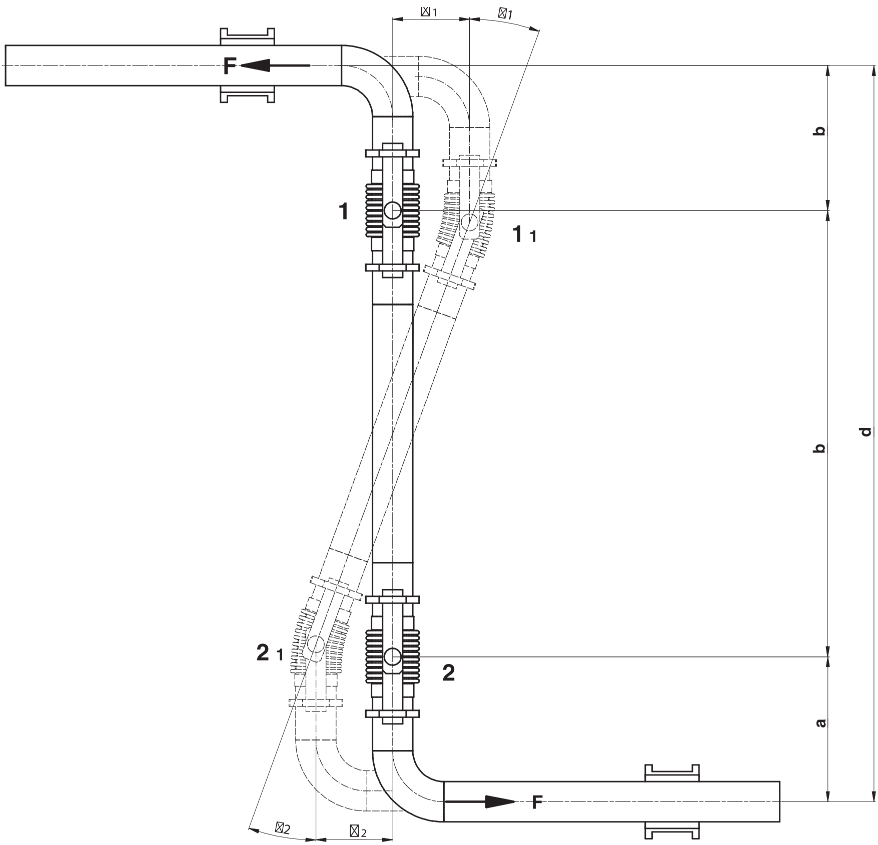
V.7 Pre Loading:

The amount and the direction of the preloading which is calculated with analytical methods for axial and lateral expansion joints can not be calculated by only one formula for the angular expansion joint applications.
Each application has a unique calculation method. The preloading amount of each application given in chapter V-2 will be calculated with the examples in following chapter.

V.8 Examples:

Example 1: (fig V-9)
Two long pipelines on two different levels and two different planes are shown, Angular expansion joint applications may offer a more economical solution rather than using axial expansion joints at a regular distance.
Data given:

Pipe Diameter	: 150 mm
Pipe Type	: 120
Pipe Material	: Carbon Steel
Pipe Length (upper	: 70 m
Pipe Length (lower)	: 90 m
Fluid	: Hot Water
Max. Pressure	: 7.0 atü
Installation Temperature	: +15°C
Average Temperature	: +90°C
Max. Temperature	: +130°C
Friction Rate	: 0.5



Angular expansion joints application on single plate — Figure V-9

Following calculations will be done according to these values.

Effective cross sectional area of an expansion joint with 150mm nominal diameter is 268 cm^2

Max temperature is +130C°, from the figure II.3 C value is found as 0.84 for stainless steel 304 material.

Nominal Pressure=7.0/0.84=8.33 atü

In order to meet these values, above pressure class 10 atü is chosen. Following values are taken form the tables at chapter IX.

Pipe Weight	: 54.16 kg/m
Fluid Weight	: 15.33 kg/m
Total Weight	: 69.46 kg/m

That is because, the assemblage temperature is below the average temperature, the average temperature is accepted as +15°C.

Temp.	Expansion
+15°C	= -6.5 mm/100 m
+130°C	= +126.0 mm/100 m

δ_1 = -4.6 mm
δ_{2-} = -5.9 mm
δ_{1+} = 88.2 mm
Δ_{2+} = 113.4 mm
Δ_1 = 88.2 - (-4.6) = 92.8 mm
Δ_2 = 113.4 - (-5.9) = 119.3 mm
$\Delta = \Delta_1 + \Delta_2$ = 119.3 + 92.8 = 212.1 mm

With the assumption that the expansion joints are able to make a ±15° angular movement, intermediate pipe length is calculated as;

A = 28.6 x 212.1/15 = 405 mm

It is now possible to make an expansion joint selection in this stage. The expansion joint from the 10 atü pressure class with 50mm nominal diameter and able to make an 15° angular movement has 8 corrugations. The angular spring rate of this expansion joint is 470 kg/m². The momentum which is the result of the maximum angular movement is calculated by the following formula.

$M = k_A \times \alpha$ (5.6)

α represents the max. angular movement. The force exists with this movement is calculated as;

$f_5 = 2M/A$ (5.7)

M = 4.70 x 15 = 70.50 kg-m
f = 2 x 70.500/0.405 = 348.1 5 kg

The force required for the design of the fixed point is the friction force which is caused by the total weight of the pipeline and the fluid transported through. This force is calculated by formula 3,3 and the values for upper pipeline and lower pipeline are given below.

f_3 =0.5 x 69.49 x 70 =2432.2 kg (upper pipeline)

These formulas are applied to the example given above as follows.

f_3 = 0.5 x 69.49 x 90 = 3127.1 kg (lower pipeline)

These calculations prove that the fixed point should be designed as it is able to resist against the force which is 2432.2 + 348.2 = 2780.4

kg + 348.2 = 3475.3 kg

The preloading amount which was seen in Chapter V.6 can be calculated for this example easily. Because, the assemblage temperature and the average temperatures are the same, half of the expansion amount must be applied as the preloading.

P = Δ/2 = 212.1/2 = 106.1 mm

The result proves that, only two fixed point are necessary at both ends of the pipeline. On the other hand, the guides should be located after the preloading is applied according to the EJMA rules. First guide should be located at 600mm distance from the start of the pipeline and the second guide should be located 2.1m after the first guide.

The distances between the other guides are appointed with the fig II.5. For 150mm nominal diameter and 7.0 atü pressure, guides should be applied at every 12.8m.

Example 2: (Fig V-10)

This example reflects the applications that are designed to absorb the expansion of very long pipelines. Inch waterch cases, simple and economical U turns are preferred instead of Ω applications that cause massive waste of space. U shaped expansion joint systems are usually located in the center of the pipeline systems in order to provide a symmetrical stress distribution.

Total angular movement provided by three angular expansion joints that are located two on the pipeline and one on the base of U shaped system is the same with the total movement of other two expansion joints. The length of the arms of U line is calculated depending on the total expansion amount.

The required data for Example 2 is given below.

Boru çapı	: 200 mm
Pipe material	: Carbon steel
Length of total pipeline	: 300 m
Fluid	: LPG
Max. Pressure	: 14.0 atü
Assemblage temperature	: + 21°C
Average temperature	: + 70°C
Max. temperature	: - 10°C
Friction rating	: 0.4

C value for the expansion joint which is made by stainless steel 304L material is 0,9 at +70 C°. As a result of this, nominal pressure is calculated as 14/0,9=15,6 atü. Upper pressure class 16 atü is chosen.

Pipe Weight : 100.85 kg/m
Fluid Weight : 16.0 kg/m
Total Weight : 116.85 kg/m

Temp.	Expansion
-10°C	-33.0 mm/100 m
+21°C	0 mm/100 m
+70°C	56.2 mm/100 m

$\delta_- = -33$ mm/100 m x 300 m = -99 mm
$\delta_0 = 0$ mm
$\delta_+ = +56.2$ / 100 m x 300 m = 168.6 mm
$\Delta_+ = \delta_+ - \delta_0 = 168.6$ mm
$\Delta_- = \delta_0 - \delta_- = 99$ mm
$\Delta = \Delta_+ + \Delta_- = 267.6$ mm

Ω application at long pipelines

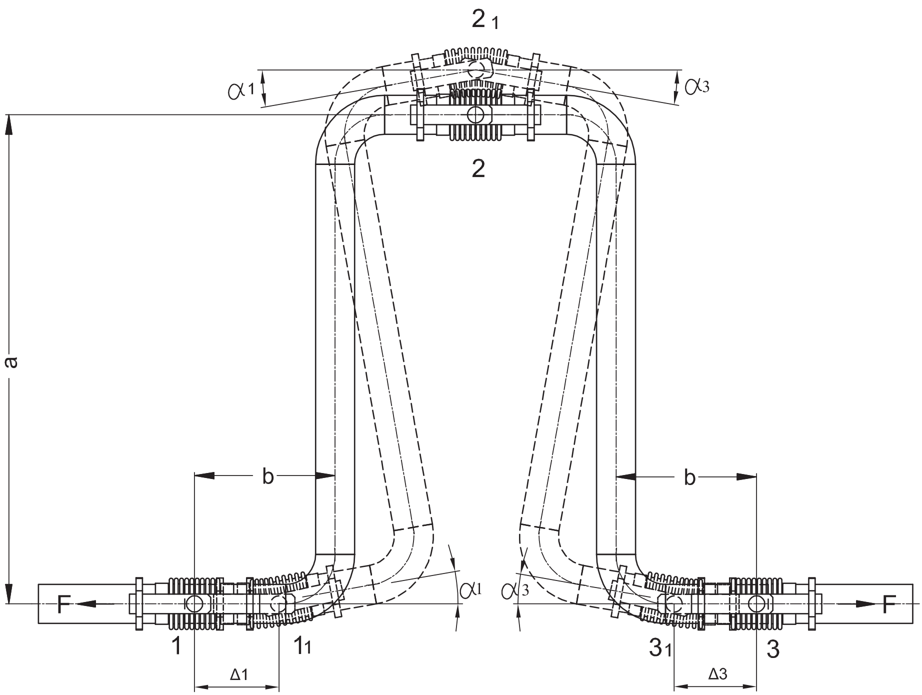


Figure V-10

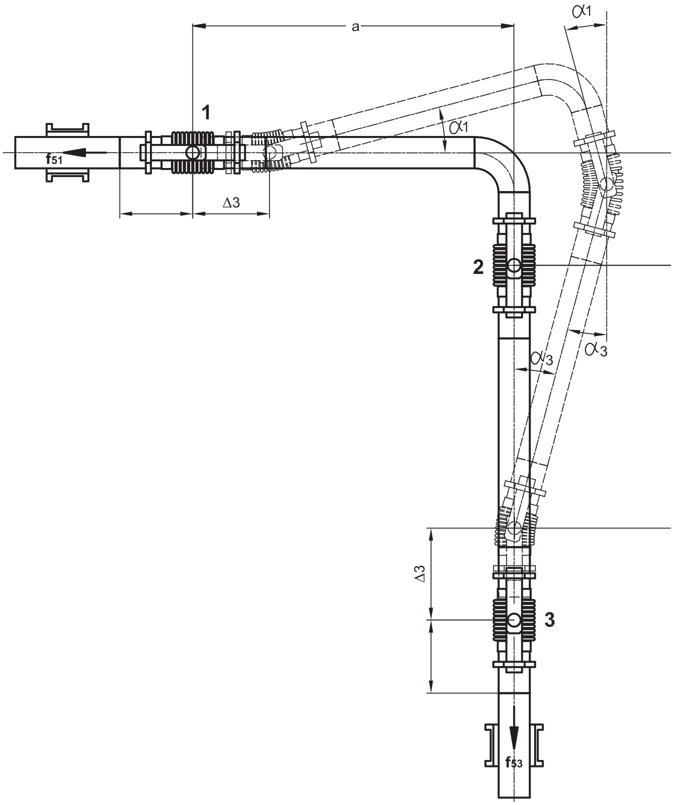


Figure V-11

L type angular expansion joint application on single plate

Because of the reasons explained above, while the a,b,c values are given, the angular movement of the expansion joint numbered 1 and connected horizontally;

$\alpha_1 = \sin^{-1} (\Delta 3/2a)$ (5.8)

The angular movement of the expansion joint numbered 3 and connected lower side vertically ;

$$\alpha_3 = \sin_{-1} \left\{ \frac{\Delta_1 + b \times \frac{\Delta_3}{a}}{2 \times c} \right\} \quad (5.9)$$

are calculated with these formulas. Here, represents horizontal, represents vertical pipe expansions. The angular movement of the expansion joint numbered 2 is the sum of the other two angles.

$\alpha_2 = \alpha_1 + \alpha_3$ (5.10)

The momentum caused by the angular expansion joints is calculated as formula given at 5.6. After calculating the M,M3 and M2 values another formula is formed in the way of 5.7 and the forces exist as a result of the angular movement are calculated.

$f_{51} = (M2 + M3) / c$ (5.11)
$f_{53} = (M2 + M1) / a$ (5.12)

Momentum values of the frictional forces are calculated with formula 3.3. After calculated all those values explained above, the design of the fixed points are completed.

The following example is given to explain the parameter shown above;

Pipe Diameter	: 250 mm
Pipe Material	: Carbon Steel
Pipe Length (horizontally)	: 90 m
Pipe Length (Vertically)	: 70 m
Connection Type	: Fixed Flanged
Fluid	: Hot Water
Max. Pressure	: 10 atü
Assembly Temperature	: +25°C
Min. Temperature	: -30°C
Max. Temperature	: +140°C
Friction Rate	: 0.3

For the expansion joint made of stainless steel (AISI 304l) at + 140°C; C=0.83 nominal Pressure=10.0/0.83 = 12.05 atü. Upper pres-sure class 13 atü should be selected.

Total weight of the pipe and the fluid is 158.57 kg/m

Temperature	Expansion
- 30°C	-54.7 mm/100 m
+25°C	4.5 mm/100 m
+140°C	140.4 mm/100m

For the horizontal pipe;

$\delta_- = -54.7 \times 0.9 = -49.2$ mm
$\delta_0 = 4.5 \times 0.9 = 4.1$ mm
$\delta_+ = 140.4 \times 0.9 = 126.4$ mm

$\Delta_+ = \delta_+ - \delta_0 = 122.3$ mm
$\Delta_- = \delta_0 - \delta_- = 53.3$ mm
$\Delta_1 = \Delta_+ + \Delta_- = 175.6$ mm

For the vertical pipe;

$\delta_- = -54.7 \times 0.7 = -38.3$ mm
$\delta_0 = 4.5 \times 0.7 = 2.9$ mm
$\delta_+ = 140.4 \times 0.7 = 98.3$ mm

$\Delta_+ = \delta_+ - \delta_0 = 95.4$ mm
$\Delta_- = \delta_0 - \delta_- = 41.2$ mm
$\Delta_3 = \Delta_+ + \Delta_- = 136.6$ mm

Assumed dimensions are;

a =1500 mm
b = 900 mm
c =1500 mm

The dimensions will be used in formulas (5.8),(5.10)

$\alpha_1 = \sin^{-1} (136.6/2 \times 1500) = 2.6°$

$$\alpha_3 = \sin^{-1} = \left\{ \frac{175.6 + 900 \times \frac{136.6}{1500}}{2 \times 1500} \right\} = 4.9$$

$\alpha_2 = 2.6° + 4.9° = 7.5°$

According to the calculations above, the expansion joint number 2 is selected with 250mm diameter and 18 corrugations from 16 atü pressure class.

$(7.5° < 12°)$ $k_A = 133$ kg – m/°
Expansion joints number 1 and 3 are selected with 4 corrugations.
$(4.9° < 6)$ $k_A = 266$ kg-m/°
Formula 5.6 is applied to each expansion joint

$M_1 = 266 \times 2.6 = 691.6$ kg-m
$M_3 = 266 \times 4.9 = 1303.4$ kg-m
$M_2 = 133 \times 7.5 = 997.5$ kg-m

The effective forces are calculated by using formulas (5.11) and (5.12).

$f_{51} = (977.5 + 1303.4) / 1.5 = 1533.9$ kg
$f_{53} = (997.5 + 691.6) / 1.5 = 1126.1$ kg

The frictional forces caused by the pipeline weight

f = 0.3 X 158.57 X 90 = 4281.4 kg
f = 0.3 X 158.57 X 90 = 3330.0 kg

According to these calculations, horizontal pipe fixed point should be designed as it resists against 5815.3 kg and the vertical fixed point to resist against 4456,1 kg. Desired resistance rate may be calculated by multiplying those values with certain safety factors.

As it was defined before, Pre-loading is very important to provide the best possible using conditions. Preloading amount should be calculated individually for each pipe.

Applying the formula (4.3) to horizontal pipe,

$P_y =$ 1 122.3 – 53.3 = 34.5 mm

To the vertical pipe;

$P_d =$ 1 95.4 – 41.2 = 27.1 mm

Guiding is possible after completing the preloading.

The first guide should be located 1000mm after the expansion joints number 1 and 3, second guide should be located after 3 and 5.

Using fig.II.5 at 10 atü pressure and 250mm diameter, guides should be applied at every 18.5 meters.

V-9 Insulation:

The insulation for the angular expansion joints is applied as the lateral expansion joints which is explained in chapter IV.7.

V.10 Manufacturing Process of Angular Expansion Joints:

a. Planning Stage

- Collecting the data
- Determining the Nominal Pressure
- Calculating the expansion and the compression amount of the pipeline.
- Dividing the pipeline in to sections.
- Selecting the Expansion Joint
- Determining the preloading amount.
- Designing the fixed points and guides
- Designing the insulation.

b. Installation Stage

- Protecting the bellows from the mechanical damages.
- Tie Rods or the hinges that are used to protect the lateral expansion joints must be installed with 90° angle to the movement plane.
- Covering the bellows with asbestos without chlorite against the arc splashes during the welding.
- For the flanged connections; centering the gaskets, levelling the screws and screwing in diagonally.
- Preventing improper pressure and torsion during the installation.
- Cleaning up the bellows internally against the harmful materials before and after installation.
- Using other selection methods or asking the manufacturer whether the lateral and angular movements are subjected.

c. Operation Tips:

- Preventing the over-shocks caused by the improper installation,

water hammer etc.

- Purifying the expansion joints internally from the corrosive mate-

rials as much as possible.

AYVAZ

EXPANSION JOINTS

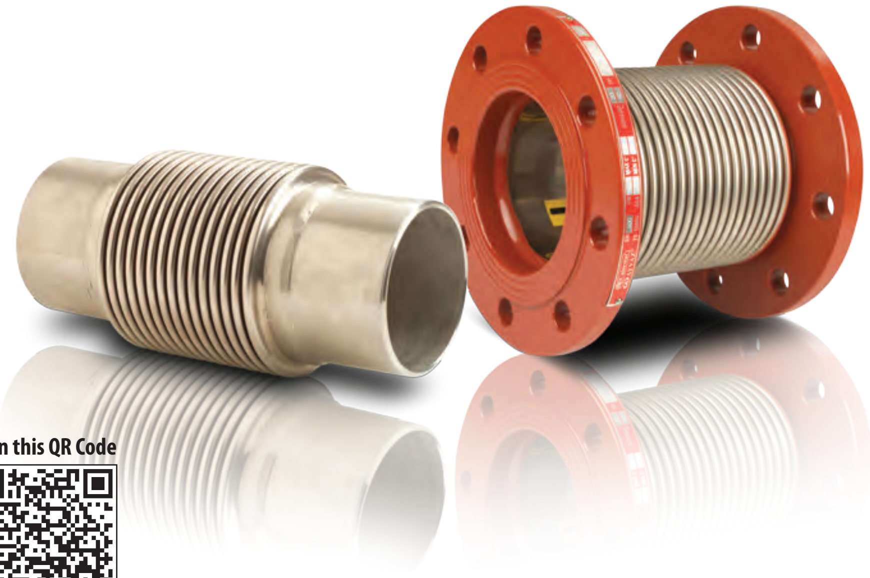
CHAPTER VI

STANDARD PRODUCT RANGE

CHAPTER VI

AYVAZ

AXIAL EXPANSION JOINTS



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Axial expansion joints aim to absorb the axial expansions.

- They do not change the direction of the flow
- Additional assemblage distance is not necessary
- Dividing the pipeline helps to prevent stress of lateral forces

Movement Absorption

Axial shift and slight all-around movement of the expansion joint is possible. Axial expansion joints with two bellows are used to absorb larger movements.

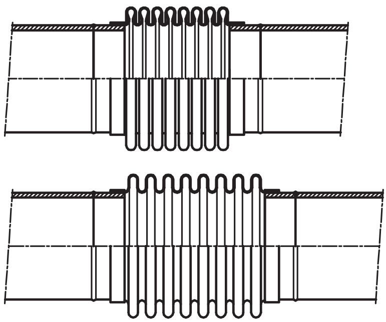
Advantages of Axial Expansion Joints

- Easy to absorb the expansion movements
- No direction changes of the flow
- Minimum application area
- Possible lateral and angular expansion absorption by the additional bellows.
- To provide a non-stressed area where the pressure is not too high such as pump and compressor applications.
- Low application costs

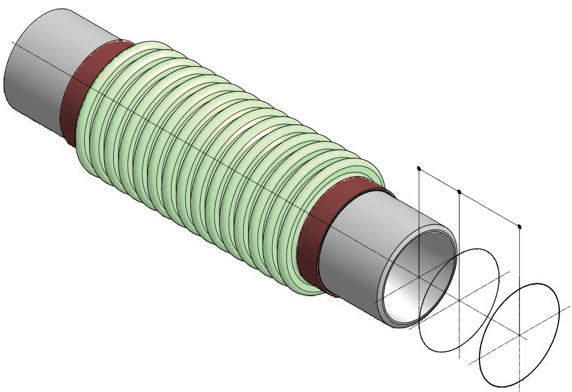
DESIGN

Structure	
Bellow Material	Stainless Steel AISI 321 (opt.304,316L,316TI,309)
Connection Types	Fixed and Floating Flanged and Welded Ended
Flange Material	Carbon Steel St.37.2 as standard, the material can be customised on request
Inner Sleeve	Available in stainless steel AISI 321 (opt. 304, 316L, 316TI, 309) on request
Operation Conditions	
Operating Temperature	-80C°/+600C°
Operating Pressure	Can be produced with different pressure rates PN 2,5/6/16/25/40/64
Nominal Diameters	DN 25 (1") - DN 2600 (104")

Movement of axial expansion joint



Working simulation of axial expansion joint



AYVAZ

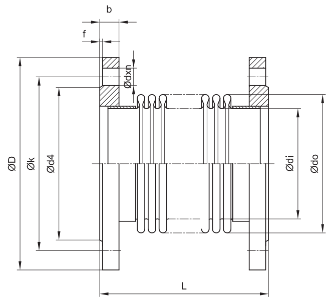
AXIAL EXPANSION JOINTS

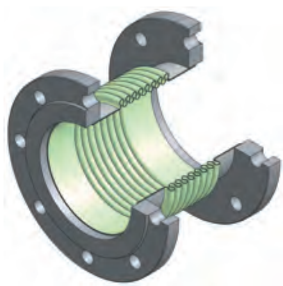
Axial Expansion Joint with 30mm expansion capacity without inner sleeve

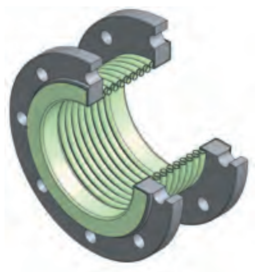
Available Types (Standard Versions)

Name	Expansion Amount	Design Pressure	Definition
MKSF-30	-10/+20mm	16 bar	Axial Expansion Joint with 30mm expansion capacity and fixed flanges
MKDF-30	-10/+20mm	16 bar	Axial Expansion Joint with 30mm expansion capacity and floating flanges

* Special designed axial expansion joints with customized features are available on request.
** Subject to technical alterations and deviations resulting from the manufacturing process without giving any notification.







Flange (DIN EN 1092/1) PN 16							Bellow				MKSF-30		MKDF-30	
DN	ØD	Øk	Ød4	f	b	Ødxn	Ødi	Ødo	Effective Bellow Area cm^2	Axial Spring Rate N/mm	L	Code	L	Code
DN25	115	85	68	2	16	Ø 14x4	38	48,2	14,58	82,1	120	702.041.101.002	110	702.031.101.002
DN32	140	100	78	2	18	Ø 18x4	42,4	55	18,62	49,7	125	702.041.101.004	115	702.031.101.004
DN40	150	110	88	3	18	Ø 18x4	48,3	61	23,44	60,8	130	702.041.101.006	120	702.031.101.006
DN50	165	125	102	3	20	Ø 18x4	60,3	76	36,46	104,5	120	702.041.101.008	110	702.031.101.008
DN65	185	145	122	3	20	Ø 18x4	76,1	95	57,45	87,8	120	702.041.101.010	110	702.031.101.010
DN80	200	160	138	3	20	Ø 18x8	88,9	111	78,42	178,9	120	702.041.101.012	110	702.031.101.012
DN100	220	180	158	3	22	Ø 18x8	114,3	140	137,09	252,2	130	701.041.101.014	115	701.031.101.014
DN125	250	210	188	3	22	Ø 18x8	139,7	164	181,01	320,0	135	172.041.101.016	130	172.031.101.016
DN150	285	240	212	3	24	Ø 23x8	168,3	200	266,20	196,4	160	702.041.101.018	145	702.031.101.018
DN200	340	295	268	3	26	Ø 23x12	219,1	250	431,86	694,2	160	702.041.101.020	140	702.031.101.020
DN250	405	355	320	3	29	Ø 27x12	273	323	697,11	590,0	170	702.041.101.022	150	702.031.101.022
DN300	460	410	378	4	32	Ø 27x12	323,9	380	972,37	496,8	170	702.031.101.024	150	702.031.101.024

All the dimensions in the table are given in "mm".
Other flange types made according to different standarts (ANSI, BS, UNI) are also available

Application of Fixed Points

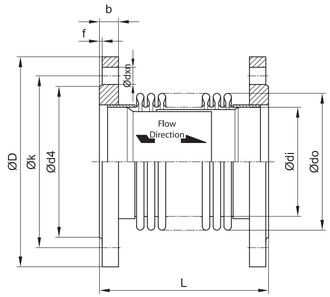
By using axial expansion joints in pipeline applications, it will be possible to build up well structured and freely moving straight pipelines. Axial expansion absorption can only be possible with applying appropriate guides which are strong enough to meet the pressure at both ends.

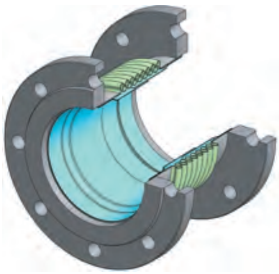
Axial Expansion Joint with 30mm expansion capacity with inner sleeve

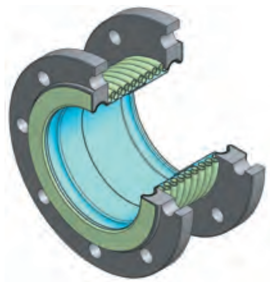
Available Types (Standard Versions)

Name	Expansion Amount	Design Pressure	Definition
MKSF-30L	-10/+20mm	16 bar	Axial Expansion Joint with 30mm expansion capacity and fixed flanges
MKDF-30L	-10/+20mm	16 bar	Axial Expansion Joint with 30mm expansion capacity and floating flanges

* Special designed axial expansion joints with customized features are available on request.
** Subject to technical alterations and deviations resulting from the manufacturing process without giving any notification.







Flange (DIN EN 1092/1) PN 16							Bellow				MKSF-30L		MKDF-30L	
DN	ØD	Øk	Ød4	f	b	Ødxn	Ødi	Ødo	Effective Bellow Area cm^2	Axial Spring Rate N/mm	L	Code	L	Code
DN25	115	85	68	2	16	Ø 14x4	38	48,2	14,58	82,1	120	702.041.102.002	110	702.031.102.002
DN32	140	100	78	2	18	Ø 18x4	42,4	55	18,62	49,7	125	702.041.102.004	115	702.031.102.004
DN40	150	110	88	3	18	Ø 18x4	48,3	61	23,44	60,8	130	702.041.102.006	120	702.031.102.006
DN50	165	125	102	3	20	Ø 18x4	60,3	76	36,46	104,5	120	702.041.102.008	110	702.031.102.008
DN65	185	145	122	3	20	Ø 18x4	76,1	95	57,45	87,8	120	702.041.102.010	110	702.031.102.010
DN80	200	160	138	3	20	Ø 18x8	88,9	111	78,42	178,9	120	702.041.102.012	110	702.031.102.012
DN100	220	180	158	3	22	Ø 18x8	114,3	140	137,09	252,2	130	701.041.102.014	115	701.031.102.014
DN125	250	210	188	3	22	Ø 18x8	139,7	164	181,01	320,0	135	172.041.102.016	130	172.031.102.016
DN150	285	240	212	3	24	Ø 23x8	168,3	200	266,20	196,4	160	702.041.102.018	145	702.031.102.018
DN200	340	295	268	3	26	Ø 23x12	219,1	250	431,86	694,2	160	702.041.102.020	140	702.031.102.020
DN250	405	355	320	3	29	Ø 27x12	273	323	697,11	590,0	170	702.041.102.022	150	702.031.102.022
DN300	460	410	378	4	32	Ø 27x12	323,9	380	972,37	496,8	170	702.031.102.024	150	702.031.102.024

All the dimensions in the table are given in "mm".
Other flange types made according to different standarts (ANSI, BS, UNI) are also available.

Application of Fixed Points

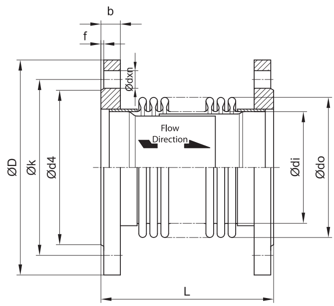
By using axial expansion joints in pipeline applications, it will be possible to build up well structured and freely moving straight pipelines. Axial expansion absorption can only be possible with applying appropriate guides which are strong enough to meet the pressure at both ends.

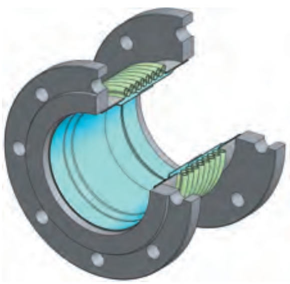
Axial Expansion Joint with 60mm expansion capacity with inner sleeve

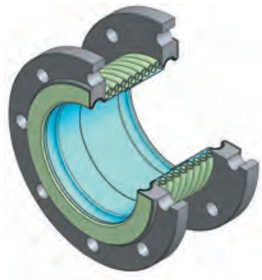
Available Types (Standard Versions)

Name	Expansion Amount	Design Pressure	Definition
MKSF-60L	-20/+40mm	16 bar	Axial Expansion Joint with 60mm expansion capacity and fixed flanges
MKDF-60L	-20/+40mm	16 bar	Axial Expansion Joint with 60mm expansion capacity and floating flanges

* Special designed axial expansion joints with customized features are available on request.
** Subject to technical alterations and deviations resulting from the manufacturing process without giving any notification.







Flange (DIN EN 1092/1) PN 16							Bellow				MKSF-60L		MKDF-60L	
DN	ØD	Øk	Ød4	f	b	Ødxn	Ødi	Ødo	Effective Bellow Area cm²	Axial Spring Rate N/mm	L	Code	L	Code
DN50	165	125	102	3	20	Ø 18x4	60,3	76	36,46	55,7	200	702.041.202.008	190	702.031.202.008
DN65	185	145	122	3	20	Ø 18x4	76,1	95	57,45	43,9	205	702.041.202.010	195	702.031.202.010
DN80	200	160	138	3	20	Ø 18x8	88,9	111	78,42	89,4	200	702.041.202.012	190	702.031.202.012
DN100	220	180	158	3	22	Ø 18x8	114,3	140	137,09	126,1	215	701.041.202.014	200	701.031.202.014
DN125	250	210	188	3	22	Ø 18x8	139,7	164	181,01	160,0	225	172.041.202.016	210	172.031.202.016
DN150	285	240	212	3	24	Ø 23x8	168,3	200	266,20	98,2	250	702.041.202.018	245	702.031.202.018
DN200	340	295	268	3	26	Ø 23x12	219,1	250	431,86	347,1	265	702.041.202.020	245	702.031.202.020
DN250	405	355	320	3	29	Ø 27x12	273	323	697,11	295,0	270	702.041.202.022	250	702.031.202.022
DN300	460	410	378	4	32	Ø 27x12	323,9	380	972,37	248,4	170	702.031.202.024	250	702.031.202.024

All the dimensions in the table are given in "mm".
Other flange types made according to different standarts (ANSI, BS, UNI) are also available

Application of Fixed Points

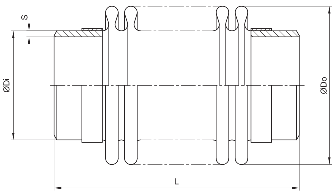
By using axial expansion joints in pipeline applications, it will be possible to build up well structured and freely moving straight pipelines. Axial expansion absorption can only be possible with applying appropriate guides which are strong enough to meet the pressure at both ends.

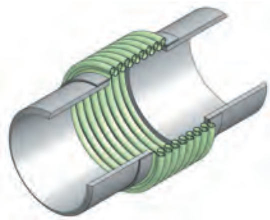
Axial Expansion Joint with Welded Ends

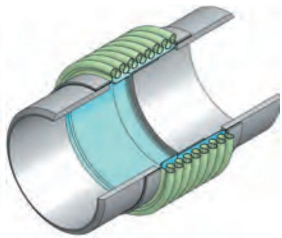
Available Types (Standard Versions)

Name	Expansion Amount	Design Pressure	Definition
MKKB-30	-10/+20mm	16 bar	Axial Expansion Joint with 30mm expansion capacity
MKKB-30L	-10/+20mm	16 bar	Axial Expansion Joint with 30mm expansion capacity and inner sleeve
MKKB-60L	-20/+40mm	16 bar	Axial Expansion Joint with 60mm expansion capacity and inner sleeve

* Special designed axial expansion joints with customized features are available on request.
** Subject to technical alterations and deviations resulting from the manufacturing process without giving any notification.





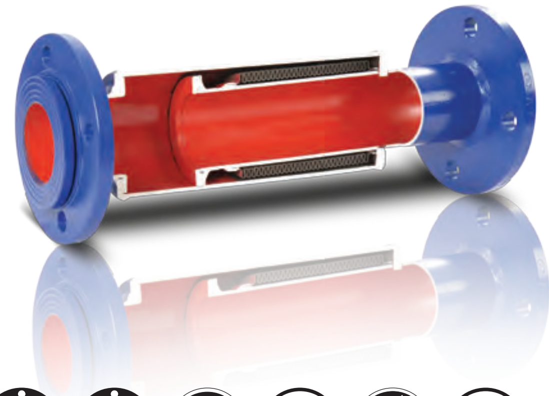


DN	Bellow				S	MKKB-30		MKKB-30L		MKKB-60L	
	ØDi	ØDo	Effective Bellow Area cm²	Axial Spring Rate N/mm		L	Code	L	Code	L	Code
DN25	38	48.8	14,58	82,1	2.6	210	702.051.101.006	210	702.051.102.006		
DN32	42.4	55.6	18,62	49,7	2.6	215	702.051.101.008	215	702.051.102.008		
DN40	48.3	61.5	23,44	60,8	2.6	220	702.051.101.010	220	702.051.102.010		
DN50	60.3	76.9	36,46	104,5	2.9	210	702.051.101.012	210	702.051.102.012	290	702.051.202.012
DN65	76.1	95.9	57,45	87,8	2.9	210	701.051.101.014	210	701.051.102.014	285	701.051.202.014
DN80	88.9	112.1	78,42	178,9	3.2	215	172.051.101.016	215	172.051.102.016	300	172.051.202.016
DN100	114.3	140.9	137,09	252,2	3.6	215	702.051.101.018	215	702.051.102.018	300	702.051.202.018
DN125	139.7	165.7	181,01	320,0	4	220	702.051.101.020	220	702.051.102.020	310	702.051.202.020
DN150	168.3	201.1	266,20	196,4	4.5	245	702.051.101.022	245	702.051.102.022	345	702.051.202.022
DN200	219.1	252.3	431,86	694,2	6.3	235	702.051.101.024	235	702.051.102.024	340	702.051.202.024
DN250	273	325.8	697,11	590,0	6.3	240	702.051.101.026	240	702.051.102.026	340	702.051.202.026
DN300	323.9	382.9	972,37	496,8	7.1	250	702.051.101.028	250	702.051.102.028	340	702.051.202.028

All the dimensions in the table are given in "mm".

Application of Fixed Points

By using axial expansion joints in pipeline applications, it will be possible to build up well structured and freely moving straight pipelines. Axial expansion absorption can only be possible with applying appropriate guides which are strong enough to meet the pressure at both ends.



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Compensating larger amount of thermal expansions by axial expansion joints are only possible by increasing the number of corrugations of the bellow, but this increases the possibility of torsion. Applying inner sleeves may reduce the torsion but they also reduce the movement ability of the expansion joints. Ayvaz's Externally pressurized expansion joints provide the most suitable solution for such cases.

Movement Absorption

X-pressed expansion joints change the direction of the flow and convey the pressure to the bellows externally. Resistance of externally pressurized bellows against high pressure and torsion forces increases. This firm structure makes compensating large movements possible safely.

Advantages of X-Pressed Expansion Joints

- Easy to absorb large expansion movements
- Reducing the number of axial expansion joints saves on time and cost
- Minimum application area
- Preventing axial inaccuracies increases the system safety
- Using internal guide rings in their design provides highly stable structure for connections

DESIGN

Structure

Bellow Material	Stainless Steel AISI 321 (opt.304,316L,316TI,309)
Pipe Material	Carbon Steel St.37.2 as standard, the material can be customised on request
Connection Types	Fixed and Floating Flanged and Welded End
Flange Material	Carbon Steel St.37.2 as standard, the material can be customised on request
Inner Sleeve	Available in stainless steel AISI 321 (opt.304,316L,316TI,309) on request

Operation Conditions

Operating Temperature	-80C°/+600C°
Operating Pressure	Can be produced with different pressure rates PN 2,5/6/16/25/40/64
Nominal Diameters	DN 25 (1")- DN 1500 (60")

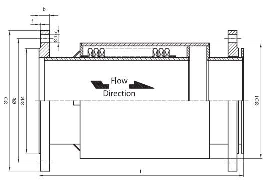
X-Pressed Expansion Joints with Fixed flange and Floating Flange on the other end

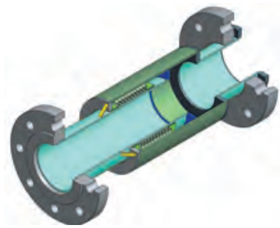
Available Types (Standard Versions)

Name	Expansion Amount	Design Pressure	Definition
DBKF-30	-10/+20mm	16 bar	X-Pressed Expansion Joint with 30mm expansion capacity and Flanged
DBKF-60	-20/+40mm	16 bar	X-Pressed Expansion Joint with 60mm expansion capacity and Flanged
DBKF-90	-30/+60mm	16 bar	X-Pressed Expansion Joint with 90mm expansion capacity and Flanged
DBKF-120	-40/+80mm	16 bar	X-Pressed Expansion Joint with 120mm expansion capacity and Flanged

* Special designed X-Pressed expansion joints with customized features are available on request.
** Subject to technical alterations and deviations resulting from the manufacturing process without giving any notification.

DBKF-30 & DBKF-60





Flange (DIN EN 1092/1) PN 16							Bellow			DBKF-30			DBKF-60		
DN	ØD	Øk	Ød4	f	b	Ødxn	Ødi	Ødo	Effective Bellow Area cm^2	L	Axial Spring Rate N/mm	Code	L	Axial Spring Rate N/mm	Code
DN25	115	85	68	2	16	Ø 14x4	38	48,2	14,58	360	82,1	702.060.201.002	490	41,1	702.060.202.002
DN32	140	100	78	2	18	Ø 18x4	42,4	55	18,62	360	49,7	702.060.201.004	490	24,8	702.060.202.004
DN40	150	110	88	3	18	Ø 18x4	48,3	61	23,44	380	60,8	702.060.201.006	500	30,4	702.060.202.006
DN50	165	125	102	3	20	Ø 18x4	60,3	76	36,46	370	104,5	702.060.201.008	480	55,7	702.060.202.008
DN65	185	145	122	3	20	Ø 18x4	76,1	95	57,45	370	87,8	702.060.201.010	470	43,9	702.060.202.010
DN80	200	160	138	3	20	Ø 18x8	88,9	111	78,42	370	178,9	702.060.201.012	470	89,4	702.060.202.012
DN100	220	180	158	3	22	Ø 18x8	114,3	140	137,09	380	252,2	702.060.201.014	480	126,1	702.060.202.014
DN125	250	210	188	3	22	Ø 18x8	139,7	164	181,01	380	320,0	702.060.201.016	490	160,0	702.060.202.016
DN150	285	240	212	3	24	Ø 23x8	168,3	200	266,20	400	196,4	702.060.201.018	510	98,2	702.060.202.018
DN200	340	295	268	3	26	Ø 23x12	219,1	250	431,86	420	694,2	702.060.201.020	530	347,1	702.060.202.020
DN250	405	355	320	3	29	Ø 27x12	273	323	697,11	440	590,0	702.060.201.022	540	295,0	702.060.202.022
DN300	460	410	378	4	32	Ø 27x12	323,9	380	972,37	460	496,8	702.060.201.024	570	248,4	702.060.202.024

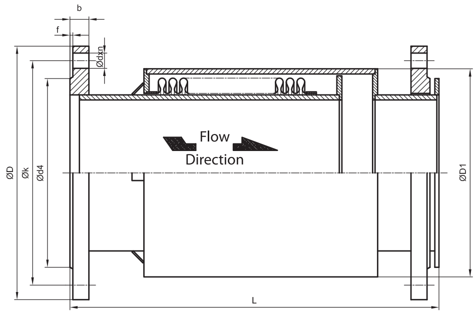
All the dimensions in the table are given in "mm".
Other flange types made according to different standarts (ANSI, BS, UNI) are also available

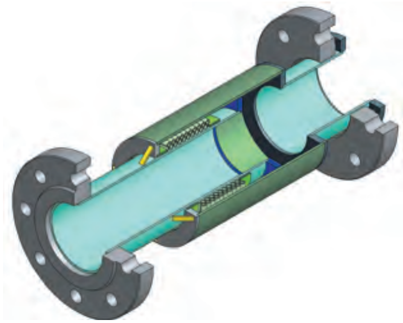
Application of Fixed Points

By using Externally pressurized axial expansion joints in pipeline applications, it will be possible to build up well structured and freely moving straight pipelines. Externally pressurized axial expansion absorption can only be possible with applying appropriate guides which are strong enough to meet the pressure at both ends.

X-Pressed Expansion Joints with Fixed flange and Floating Flange on the other end

DBKF-90 & DBKF-120





Flange (DIN EN 1092/1) PN 16							Bellow			DBKF-90			DBKF-120		
DN	ØD	Øk	Ød4	f	b	Ødxn	Ødi	Ødo	Effective Bellow Area cm^2	L	Axial Spring Rate N/mm	Code	L	Axial Spring Rate N/mm	Code
DN25	115	85	68	2	16	Ø 14x4	38	48,2	14,58	520	41,1	702.060.203.002	600	34,2	702.060.204.002
DN32	140	100	78	2	18	Ø 18x4	42,4	55	18,62	520	24,8	702.060.203.004	660	17,7	702.060.204.004
DN40	150	110	88	3	18	Ø 18x4	48,3	61	23,44	530	30,4	702.060.203.006	680	20,3	702.060.204.006
DN50	165	125	102	3	20	Ø 18x4	60,3	76	36,46	510	55,7	702.060.203.008	680	32,1	702.060.204.008
DN65	185	145	122	3	20	Ø 18x4	76,1	95	57,45	500	43,9	702.060.203.010	740	23,6	702.060.204.010
DN80	200	160	138	3	20	Ø 18x8	88,9	111	78,42	500	89,4	702.060.203.012	650	55,9	702.060.204.012
DN100	220	180	158	3	22	Ø 18x8	114,3	140	137,09	510	126,1	702.060.203.014	690	78,8	702.060.204.014
DN125	250	210	188	3	22	Ø 18x8	139,7	164	181,01	520	160	702.060.203.016	700	100	702.060.204.016
DN150	285	240	212	3	24	Ø 23x8	168,3	200	266,20	540	98,2	702.060.203.018	700	70,1	702.060.204.018
DN200	340	295	268	3	26	Ø 23x12	219,1	250	431,86	560	347,1	702.060.203.020	770	198,3	702.060.204.020
DN250	405	355	320	3	29	Ø 27x12	273	323	697,11	570	295	702.060.203.022	830	177	702.060.204.022
DN300	460	410	378	4	32	Ø 27x12	323,9	380	972,37	600	248,4	702.060.203.024	810	149	702.060.204.024

All the dimensions in the table are given in "mm".
Other flange types made according to different standarts (ANSI, BS, UNI) are also available

Application of Fixed Points

By using Externally pressurized axial expansion joints in pipeline applications, it will be possible to build up well structured and freely moving straight pipelines. Externally pressurized axial expansion absorption can only be possible with applying appropriate guides which are strong enough to meet the pressure at both ends.

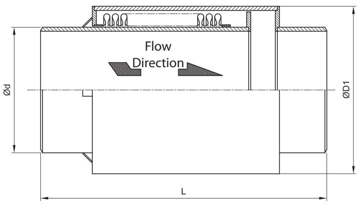
X-Pressed Expansion Joints with Welded Ends

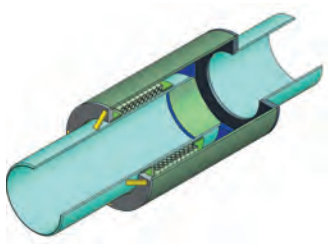
Available Types (Standard Versions)

Name	Expansion Amount	Design Pressure	Definition
DBKK-30	-10/+20mm	16 bar	X-Pressed Expansion Joint with 30mm expansion capacity and welded ends
DBKK-60	-20/+40mm	16 bar	X-Pressed Expansion Joint with 60mm expansion capacity and welded ends
DBKK-90	-30/+60mm	16 bar	X-Pressed Expansion Joint with 90mm expansion capacity and welded ends
DBKK-120	-40/+80mm	16 bar	X-Pressed Expansion Joint with 120mm expansion capacity and welded ends

* Special designed X-Pressed expansion joints with customized features are available on request.
** Subject to technical alterations and deviations resulting from the manufacturing process without giving any notification.

DBKK-30 & DBKK-60





DN	Bellow			DBKK-30			DBKK-60		
	Ød	ØD1	Effective Bellow Area cm²	L	Axial Spring Rate N/mm	Code	L	Axial Spring Rate N/mm	Code
DN25	38	76,1	14,58	340	82,1	702.060.101.002	470	41,1	702.060.102.002
DN32	42,4	76,1	18,62	340	49,7	702.060.101.004	470	24,8	702.060.102.004
DN40	48,3	76,1	23,44	360	60,8	702.060.101.006	480	30,4	702.060.102.006
DN50	60,3	101	36,46	350	104,5	702.060.101.008	460	55,7	702.060.102.008
DN65	76,1	114,3	57,45	350	87,8	702.060.101.010	450	43,9	702.060.102.010
DN80	88,9	139,7	78,42	350	178,9	702.060.101.012	450	89,4	702.060.102.012
DN100	114,3	168,3	137,09	360	252,2	702.060.101.014	460	126,1	702.060.102.014
DN125	139,7	219,1	181,01	360	320,0	702.060.101.016	470	160	702.060.102.016
DN150	168,3	245	266,20	380	196,4	702.060.101.018	490	98,2	702.060.102.018
DN200	219,1	323,9	431,86	400	694,2	702.060.101.020	510	347,1	702.060.102.020
DN250	273	355,6	697,11	420	590,0	702.060.101.022	520	295	702.060.102.022
DN300	323,9	406,4	972,37	440	496,8	702.060.101.024	550	248,4	702.060.102.024

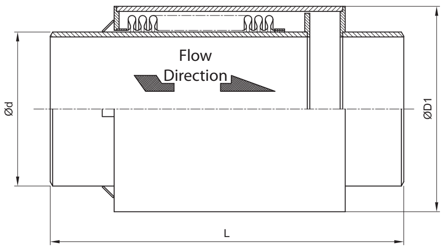
All the dimensions in the table are given in "mm".

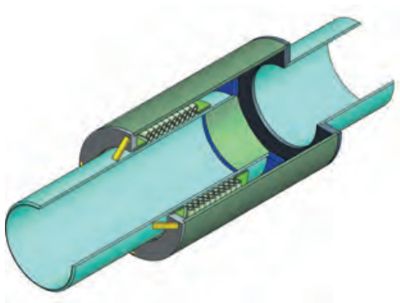
Application of Fixed Points

By using Externally pressurized axial expansion joints in pipeline applications, it will be possible to build up well structured and freely moving straight pipelines. Externally pressurized axial expansion absorption can only be possible with applying appropriate guides which are strong enough to meet the pressure at both ends.

X-Pressed Expansion Joints with Welded Ends

DBKK-90 & DBKK-1200



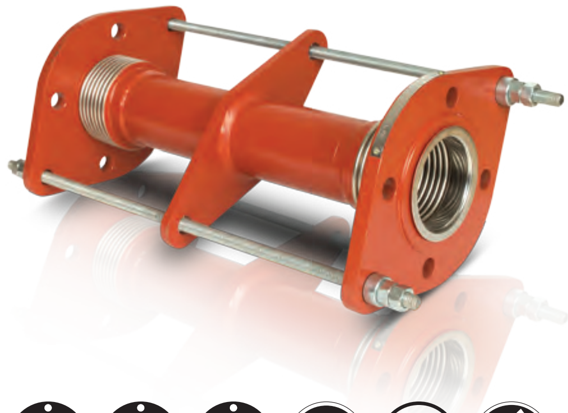


DN	Bellow			DBKK-90			DBKK-120		
	Ød	ØD1	Effective Bellow Area cm^2	L	Axial Spring Rate N/mm	Code	L	Axial Spring Rate N/mm	Code
DN25	38	76,1	14,58	500	41,1	702.060.103.002	580	34,2	702.060.104.002
DN32	42,4	76,1	18,62	500	24,8	702.060.103.004	640	17,7	702.060.104.004
DN40	48,3	76,1	23,44	510	30,4	702.060.103.006	660	20,3	702.060.104.006
DN50	60,3	101	36,46	490	55,7	702.060.103.008	660	32,1	702.060.104.008
DN65	76,1	114,3	57,45	480	43,9	702.060.103.010	720	23,6	702.060.104.010
DN80	88,9	139,7	78,42	480	89,4	702.060.103.012	630	55,9	702.060.104.012
DN100	114,3	168,3	137,09	490	126,1	702.060.103.014	670	78,8	702.060.104.014
DN125	139,7	219,1	181,01	500	160	702.060.103.016	680	100	702.060.104.016
DN150	168,3	245	266,20	520	98,2	702.060.103.018	680	70,1	702.060.104.018
DN200	219,1	323,9	431,86	540	347,1	702.060.103.020	750	198,3	702.060.104.020
DN250	273	355,6	697,11	550	295	702.060.103.022	810	177	702.060.104.022
DN300	323,9	406,4	972,37	580	248,4	702.060.103.024	790	149	702.060.104.024

All the dimensions in the table are given in "mm".

Application of Fixed Points

By using Externally pressurized axial expansion joints in pipeline applications, it will be possible to build up well structured and freely moving straight pipelines. Externally pressurized axial expansion absorption can only be possible with applying appropriate guides which are strong enough to meet the pressure at both ends.



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The movements occured in two directions can only be absorbed by using Lateral Epansion Joints. Universal tied expansion joints are made up of two bellows connected each other by an intermediate pipe and a system of tie rods able to withstand the thrust resulted of the internal pressure.

Movement Absorption

This type of expansion joints are used to absorb lateral movements in all planes. Also, with a special positioning of two tie rods at 180 degrees, the expansion joints bocomes able to absorb some lateral and angular deflections at the same time. The amount of lateral deflection depends on the convolution number of the bellows on each side of the expansion joint. This amount can also be increased by changing the length of the intermediate pipe. The tie rods are also effective to prevent possible torsion forces.

Advantages of Universal Tied Expansion Joints

- Absorption of lateral movements in all planes
- Easy to absorb large expansion movements
- Minimum application area
- Preventing axial inaccuracies increases the system safety

DESIGN

Structure

Bellow Material	Stainless Steel AISI 321 (opt.304,316L,316TI,309)
Connection Types	Fixed Flanged and Welded End
Flange Material	Carbon Steel St.37.2 as standard, the material can be customised on request
Intermediate Pipe Mater.	Carbon Steel St.37.2 as standard, the material can be customised on request
Tie Rod Material	Carbon Steel St.37.2 as standard, the material can be customised on request

Operation Conditions

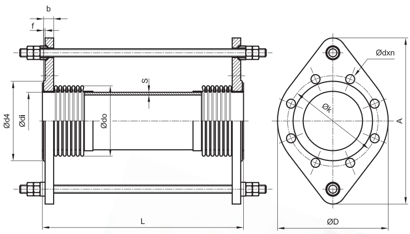
Operating Temperature	-80°C/+600°C
Operating Pressure	PN 2,5/6/16/25/40/64
Nominal Diameters	DN25 (1") - DN1000 (40")

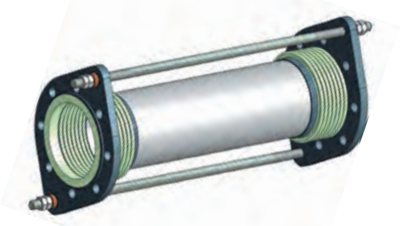
Universal Tied Expansion Joints, Flanged

Available Types (Standard Versions)

Name	Axial Expansion Amount	Lateral Expansion Amount	Design Pressure	Definition
DLTKF-25	±15/30mm	±25mm	16 bar	Universal Tied Expansion Joint with 25mm lateral expansion,flanged
DLTKF-50	±15/30mm	±50mm	16 bar	Universal Tied Expansion Joint with 50mm lateral expansion,flanged
DLTKF-75	±15/30mm	±75mm	16 bar	Universal Tied Expansion Joint with 75mm lateral expansion,flanged
DLTKF-100	±15/30mm	±100mm	16 bar	Universal Tied Expansion Joint with 100mm lateral expansion,flanged

* Special designed Universal Tied Expansion Joints with customized features are available on request.
** Subject to technical alterations and deviations resulting from the manufacturing process without giving any notification.





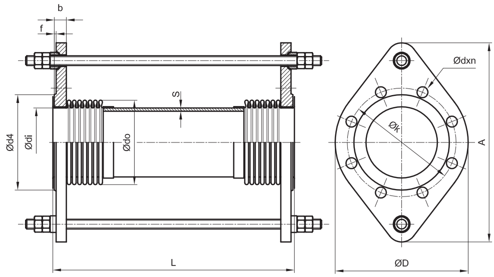
Flange (DIN EN 1092/1) PN 16								
DN	A	ØD	Øk1	k2	Ød4	f	b	Ødxn
DN25	185	115	85	150	68	2	16	Ø14x4
DN32	210	140	100	180	78	2	18	Ø18x4
DN40	220	150	110	185	88	3	18	Ø18x4
DN50	250	165	125	205	102	3	20	Ø18x4
DN65	270	185	145	225	122	3	20	Ø18x4
DN80	310	200	160	251	138	3	20	Ø18x8
DN100	330	220	180	271	158	3	22	Ø18x8
DN125	366	250	210	304	188	3	22	Ø18x8
DN150	420	285	240	347	212	3	24	Ø23x8
DN200	510	340	295	411	268	3	26	Ø23x12
DN250	573	405	355	484	320	3	29	Ø27x12
DN300	660	460	410	555	378	4	32	Ø27x12

All the dimensions in the table are given in "mm".
Other flange types made according to different standarts (ANSI, BS, UNI) are also available.

DN	Bellow					DLTKF-25				DLTKF-50			
	Ødi	Ødo	S	Axial Spring Rate N/mm	Effective Bellow Area cm^2	EXPANSION		L	Code	EXPANSION		L	Code
						Axial mm	Lateral mm			Axial mm	Lateral mm		
DN25	38	48,2	2,6	20,15	14,58	±15	±25	250	702.070.201.002	±15	±50	350	702.070.202.002
DN32	42,2	55	2,6	13,34	18,62	±15	±25	250	702.070.201.004	±15	±50	350	702.070.202.004
DN40	48,3	61	2,6	15,79	23,44	±15	±25	250	702.070.201.006	±15	±50	350	702.070.202.006
DN50	60,3	76	2,9	21,25	36,46	±15	±25	350	702.070.201.008	±15	±50	450	702.070.202.008
DN65	76,1	95	2,9	17,33	57,45	±30	±25	350	702.070.201.010	±30	±50	450	702.070.202.010
DN80	88,9	111	3,2	18,2	78,42	±30	±25	400	702.070.201.012	±30	±50	500	702.070.202.012
DN100	114,3	140	3,6	21,49	137,09	±30	±25	400	702.070.201.014	±30	±50	500	702.070.202.014
DN125	139,7	164	4	27,86	181,01	±30	±25	450	702.070.201.016	±30	±50	650	702.070.202.016
DN150	168,3	200	4,5	28,34	266,20	±30	±25	450	702.070.201.018	±30	±50	650	702.070.202.018
DN200	219,1	250	6,3	79,1	431,86	±30	±25	500	702.070.201.020	±30	±50	700	702.070.202.020
DN250	273	323	6,3	37,49	697,11	±30	±25	600	702.070.201.022	±30	±50	800	702.070.202.022
DN300	323,9	380	7,1	59,61	972,37	±30	±25	750	702.070.201.024	±30	±50	950	702.070.202.024

All the dimensions in the table are given in "mm".

Universal Tied Expansion Joints, Flanged



Flange (DIN EN 1092/1) PN 16								
DN	A	ØD	Øk1	k2	Ød4	f	b	Ødxn
DN25	185	115	85	150	68	2	16	Ø14x4
DN32	210	140	100	180	78	2	18	Ø18x4
DN40	220	150	110	185	88	3	18	Ø18x4
DN50	250	165	125	205	102	3	20	Ø18x4
DN65	270	185	145	225	122	3	20	Ø18x4
DN80	310	200	160	251	138	3	20	Ø18x8
DN100	330	220	180	271	158	3	22	Ø18x8
DN125	366	250	210	304	188	3	22	Ø18x8
DN150	420	285	240	347	212	3	24	Ø23x8
DN200	510	340	295	411	268	3	26	Ø23x12
DN250	573	405	355	484	320	3	29	Ø27x12
DN300	660	460	410	555	378	4	32	Ø27x12

All the dimensions in the table are given in "mm". Other flange types made according to different standarts (ANSI, BS, UNI) are also available

DN	Bellow					DLTKF-75				DLTKF-100			
	Ødi	Ødo	S	Axial Spring Rate N/mm	Effective Bellow Area mm^2	Expansion Axial mm	Expansion Lateral mm	L	Code	Expansion Axial mm	Expansion Lateral mm	L	Code
DN25	38	48,2	2,6	20,15	14,58	±15	±75	450	702.070.203.002	±15	±100	550	702.070.204.002
DN32	42,2	55	2,6	13,34	18,62	±15	±75	450	702.070.203.004	±15	±100	550	702.070.204.004
DN40	48,3	61	2,6	15,79	23,44	±15	±75	450	702.070.203.006	±15	±100	550	702.070.204.006
DN50	60,3	76	2,9	21,25	36,46	±15	±75	550	702.070.203.008	±15	±100	650	702.070.204.008
DN65	76,1	95	2,9	17,33	57,45	±30	±75	550	702.070.203.010	±30	±100	650	702.070.204.010
DN80	88,9	111	3,2	18,2	78,42	±30	±75	600	702.070.203.012	±30	±100	700	702.070.204.012
DN100	114,3	140	3,6	21,49	137,09	±30	±75	600	702.070.203.014	±30	±100	700	702.070.204.014
DN125	139,7	164	4	27,86	181,01	±30	±75	750	702.070.203.016	±30	±100	850	702.070.204.016
DN150	168,3	200	4,5	28,34	266,20	±30	±75	750	702.070.203.018	±30	±100	850	702.070.204.018
DN200	219,1	250	6,3	79,1	431,86	±30	±75	700	702.070.203.020	±30	±100	900	702.070.204.020
DN250	273	323	6,3	37,49	697,11	±30	±75	800	702.070.203.022	±30	±100	1000	702.070.204.022
DN300	323,9	380	7,1	59,61	972,37	±30	±75	1050	702.070.203.024	±30	±100	1150	702.070.204.024

All the dimensions in the table are given in "mm"

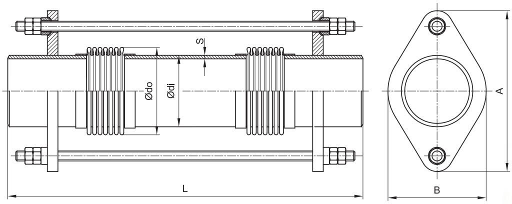
UNIVERSAL TIED EXPANSION JOINTS

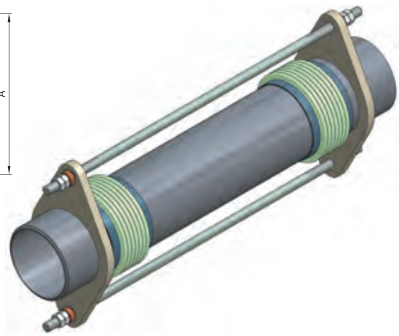
Universal Tied Expansion Joints, Welded End

Available Types (Standard Versions)

Name	Axial Expansion Amount	Lateral Expansion Amount	Design Pressure	Definition
DLTKKB-25	±15/30mm	±25mm	16 bar	Universal Tied Expansion Joint with 25mm lateral expansion, welded end
DLTKKB-50	±15/30mm	±50mm	16 bar	Universal Tied Expansion Joint with 50mm lateral expansion,welded end
DLTKKB-75	±15/30mm	±75mm	16 bar	Universal Tied Expansion Joint with 75mm lateral expansion,welded end
DLTKKB-100	±15/30mm	±100mm	16 bar	Universal Tied Expansion Joint with 100mm lateral expansion,welded end

* Special designed Universal Tied Expansion Joints with customized features are available on request.
** Subject to technical alterations and deviations resulting from the manufacturing process without giving any notification.

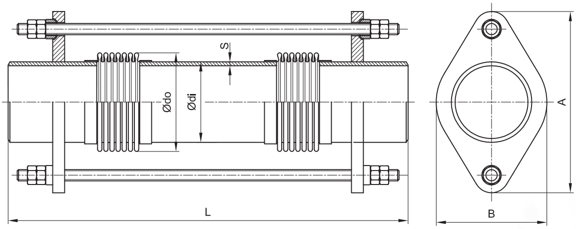


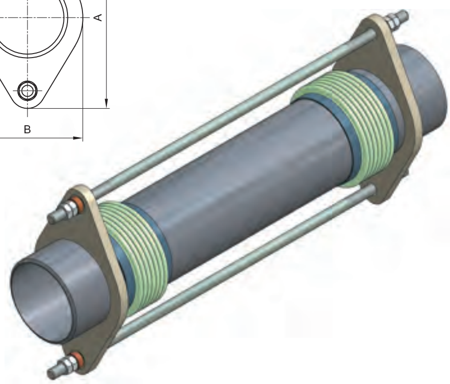


DN	S	A	B	Bellow				DLTKKB-25				DLTKKB-50			
				Ødi	Ødo	Axial Spring Rate N/mm	Effective Bellow Area cm^2	Expansion		L	Code	Expansion		L	Code
								Axial mm	Lateral mm			Axial mm	Lateral mm		
DN25	2,6	135	54	38	48,2	20,15	14,58	±15	±25	540	702.070.101.002	±15	±50	640	702.070.102.002
DN32	2,6	140	64	42,2	55	13,34	18,62	±15	±25	540	702.070.101.004	±15	±50	640	702.070.102.004
DN40	2,6	150	70	48,3	61	15,79	23,44	±15	±25	540	702.070.101.006	±15	±50	640	702.070.102.006
DN50	2,9	165	86	60,3	76	21,25	36,46	±15	±25	610	702.070.101.008	±15	±50	710	702.070.102.008
DN65	2,9	190	102	76,1	95	17,33	57,45	±30	±25	610	702.070.101.010	±30	±50	710	702.070.102.010
DN80	3,2	221	115	88,9	111	18,2	78,42	±30	±25	660	702.070.101.012	±30	±50	760	702.070.102.012
DN100	3,6	249	146	114,3	140	21,49	137,09	±30	±25	660	702.070.101.014	±30	±50	760	702.070.102.014
DN125	4	292	172	139,7	164	27,86	181,01	±30	±25	700	702.070.101.016	±30	±50	900	702.070.102.016
DN150	4,5	342	200	168,3	200	28,34	266,20	±30	±25	700	702.070.101.018	±30	±50	900	702.070.102.018
DN200	6,3	413	260	219,1	250	79,1	431,86	±30	±25	750	702.070.101.020	±30	±50	950	702.070.102.020
DN250	6,3	488	315	273	323	37,49	697,11	±30	±25	850	702.070.101.022	±30	±50	1050	702.070.102.022
DN300	7,1	580	368	323,9	380	59,61	972,37	±30	±25	1000	702.070.101.024	±30	±50	1200	702.070.102.024

All the dimensions in the table are given in “mm”.

Universal Tied Expansion Joints, Welded End





DN	S	A	B	Bellow				DLTKF-75				DLTKF-100			
				Ødi	Ødo	Axial Spring Rate N/mm	Effective Bellow Area cm^2	Expansion		L	Code	Expansion		L	Code
								Axial mm	Lateral mm			Axial mm	Lateral mm		
DN25	2,6	135	54	38	48,2	20,15	14,58	±15	±75	740	702.070.103.002	±15	±100	840	702.070.104.002
DN32	2,6	140	64	42,2	55	13,34	18,62	±15	±75	740	702.070.103.004	±15	±100	840	702.070.104.004
DN40	2,6	150	70	48,3	61	15,79	23,44	±15	±75	740	702.070.103.006	±15	±100	840	702.070.104.006
DN50	2,9	165	86	60,3	76	21,25	36,46	±15	±75	810	702.070.103.008	±15	±100	910	702.070.104.008
DN65	2,9	190	102	76,1	95	17,33	57,45	±30	±75	810	702.070.103.010	±30	±100	910	702.070.104.010
DN80	3,2	221	115	88,9	111	18,2	78,42	±30	±75	860	702.070.103.012	±30	±100	960	702.070.104.012
DN100	3,6	249	146	114,3	140	21,49	137,09	±30	±75	860	702.070.103.014	±30	±100	960	702.070.104.014
DN125	4	292	172	139,7	164	27,86	181,01	±30	±75	1000	702.070.103.016	±30	±100	1100	702.070.104.016
DN150	4,5	342	200	168,3	200	28,34	266,20	±30	±75	1000	702.070.103.018	±30	±100	1100	702.070.104.018
DN200	6,3	413	260	219,1	250	79,1	431,86	±30	±75	1050	702.070.103.020	±30	±100	1150	702.070.104.020
DN250	6,3	488	315	273	323	37,49	697,11	±30	±75	1150	702.070.103.022	±30	±100	1250	702.070.104.022
DN300	7,1	580	368	323,9	380	59,61	972,37	±30	±75	1300	702.070.103.024	±30	±100	1400	702.070.104.024

All the dimensions in the table are given in "mm".

Application of Fixed Points

By using Universal Tied Expansion Joints in pipeline applications, it will be possible to build up well structured and freely moving straight pipelines. Lateral expansion absorption can only be possible with applying appropriate guides which are strong enough to meet the pressure at both ends.

AYVAZ

DOUBLE GIMBAL EXPANSION JOINTS

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Gimbal type expansion joints are designed to permit angular rotation in any plane by the use of two pairs of hinges affixed to a common floating gimbal ring. Simply, a double gimbal expansion joint is consisted of two single gimbal expansion joints and an intermediate pipe connects them each other. The advantage of this arrangement is the ability to absorb a large lateral movement in any plane at each end. Because the gimbals are attached to each end of the bellows, the thermal expansion of the intermediate pipe will not be absorbed by the universal but must be accepted by the adjacent piping.

Movement Absorption

This type of expansion joints are used to absorb axial and lateral movements in all planes. The amount of lateral deflection depends on the convolution number of the bellows on each side of the expansion joint. This amount can also be increased by changing the length of the intermediate pipe.Hinges and gimbals provide proper positioning and prevent installation inaccuracies.

Advantages of Double Gimbal Expansion Joints

• Protects the pipeline systems against collapse and breakages by compensating seismic motions (earth-quake) and large lateral and angular movements.
• Movement of bellows is more controlled.
• Internal flow liners for eliminating velocity problems may be fitted.
• Anchors only require to absorb spring forces.
• Pressure thrust is restrained by the hardware

DESIGN

Structure

Bellow Material	Stainless Steel AISI 321 (opt.304,316L,316TI,309)
Connection Types	Fixed and Floating Flanged and Welded End
Flange Material	Carbon Steel St.37.2 as standard, the material can be customised on request
Intermediate Pipe Material	Carbon Steel St.37.2 as standard, the material can be customised on request
Hinge and Gimbal Material	Carbon Steel St.37.2 as standard, the material can be customised on request

Operation Conditions

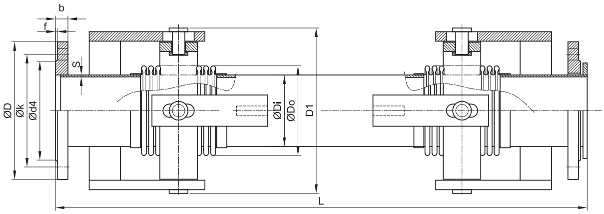
Operating Temperature	-80°C/+600°C
Operating Pressure	PN 2,5/6/16/25/40/64
Nominal Diameters	DN25 (1”) - DN1000 (40”)

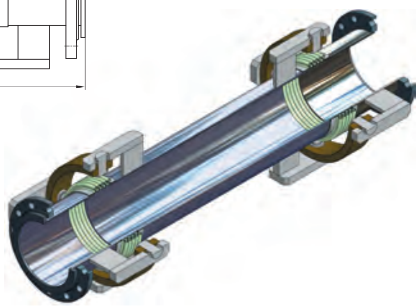
Double Gimbal Expansion Joints, Flanged

Available Types (Standard Versions)

Name	Axial Expansion Amount	Lateral Expansion Amount	Design Pressure	Definition
SISKKF-50	±50mm	±50mm	16 bar	Double Gimbal Expansion Joint with 50mm lateral expansion,flanged
SISKKF-100	±50mm	±100mm	16 bar	Double Gimbal Expansion Joint with 100mm lateral expansion,flanged
SISKKF-150	±50mm	±150mm	16 bar	Double Gimbal Expansion Joint with 150mm lateral expansion,flanged
SISKKF-200	±50mm	±200mm	16 bar	Double Gimbal Expansion Joint with 200mm lateral expansion,flanged

* Special designed Double Gimbal Expansion Joints with customized features are available on request.
** Subject to technical alterations and deviations resulting from the manufacturing process without giving any notification.





Flange (DIN EN 1092/1) PN 16								
DN	A	ØD	Øk1	k2	Ød4	f	b	Ødxn
DN25	185	115	85	150	68	2	16	Ø14x4
DN32	210	140	100	180	78	2	18	Ø18x4
DN40	220	150	110	185	88	3	18	Ø18x4
DN50	250	165	125	205	102	3	20	Ø18x4
DN65	270	185	145	225	122	3	20	Ø18x4
DN80	310	200	160	251	138	3	20	Ø18x8
DN100	330	220	180	271	158	3	22	Ø18x8
DN125	366	250	210	304	188	3	22	Ø18x8
DN150	420	285	240	347	212	3	24	Ø23x8
DN200	510	340	295	411	268	3	26	Ø23x12
DN250	573	405	355	484	320	3	29	Ø27x12
DN300	660	460	410	555	378	4	32	Ø27x12

All the dimensions in the table are given in "mm".
Other flange types made according to different standarts (ANSI, BS, UNI) are also available

AYVAZ

DOUBLE GIMBAL EXPANSION JOINTS

DN	Bellow			D1	s	SISKKF-50					SISKKF-100				
	ØDi	ØD0	Effective Bellow Area			Expansion			L	Code	Expansion			L	Code
						± X	±Z	± Y			± X	±Z	± Y		
DN25	38	48,2	14,58	90	2,3	50	50	50	720	702.070.301.002	50	50	100	920	702.070.302.002
DN32	42,2	55	18,62	105	2,6	50	50	50	720	702.070.301.004	50	50	100	920	702.070.302.004
DN40	48,3	61	23,44	115	2,6	50	50	50	720	702.070.301.006	50	50	100	920	702.070.302.006
DN50	60,3	76	36,46	140	2,9	50	50	50	800	702.070.301.008	50	50	100	1000	702.070.302.008
DN65	76,1	95	57,45	160	2,9	50	50	50	800	702.070.301.010	50	50	100	1000	702.070.302.010
DN80	88,9	111	78,42	190	3,2	50	50	50	830	702.070.301.012	50	50	100	1030	702.070.302.012
DN100	114,3	140	137,09	250	3,6	50	50	50	850	702.070.301.014	50	50	100	1050	702.070.302.014
DN125	139,7	164	181,01	285	4	50	50	50	980	702.070.301.016	50	50	100	1180	702.070.302.016
DN150	168,3	200	266,20	350	4,5	50	50	50	980	702.070.301.018	50	50	100	1180	702.070.302.018
DN200	219,1	250	431,86	420	6,3	50	50	50	1140	702.070.301.020	50	50	100	1340	702.070.302.020
DN250	273	323	697,11	480	6,3	50	50	50	1140	702.070.301.022	50	50	100	1340	702.070.302.022
DN300	323,9	380	972,37	540	7,1	50	50	50	1200	702.070.301.024	50	50	100	1400	702.070.302.024

DN	Bellow			D1	s	SISKKF-150					SISKKF-200				
	ØDi	ØD0	Effective Bellow Area			Expansion			L	Code	Expansion			L	Code
						± X	±Z	± Y			± X	±Z	± Y		
DN25	38	48,2	14,58	90	2,3	50	50	150	1120	702.070.303.002	50	50	200	1320	702.070.304.002
DN32	42,2	55	18,62	105	2,6	50	50	150	1120	702.070.303.004	50	50	200	1320	702.070.304.004
DN40	48,3	61	23,44	115	2,6	50	50	150	1120	702.070.303.006	50	50	200	1320	702.070.304.006
DN50	60,3	76	36,46	140	2,9	50	50	150	1200	702.070.303.008	50	50	200	1420	702.070.304.008
DN65	76,1	95	57,45	160	2,9	50	50	150	1250	702.070.303.010	50	50	200	1500	702.070.304.010
DN80	88,9	111	78,42	190	3,2	50	50	150	1270	702.070.303.012	50	50	200	1500	702.070.304.012
DN100	114,3	140	137,09	250	3,6	50	50	150	1300	702.070.303.014	50	50	200	1550	702.070.304.014
DN125	139,7	164	181,01	285	4	50	50	150	1480	702.070.303.016	50	50	200	1780	702.070.304.016
DN150	168,3	200	266,20	350	4,5	50	50	150	1480	702.070.303.018	50	50	200	1780	702.070.304.018
DN200	219,1	250	431,86	420	6,3	50	50	150	1700	702.070.303.020	50	50	200	2050	702.070.304.020
DN250	273	323	697,11	480	6,3	50	50	150	1700	702.070.303.022	50	50	200	2100	702.070.304.022
DN300	323,9	380	972,37	540	7,1	50	50	150	1750	702.070.303.024	50	50	200	2150	702.070.304.024

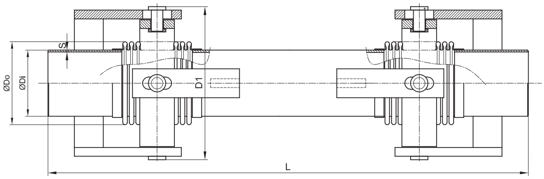
All the dimensions in the table are given in "mm".

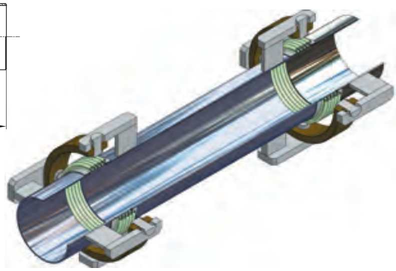
Double Gimbal Expansion Joints, Welded End

Available Types (Standard Versions)

Name	Axial Expansion Amount	Lateral Expansion Amount	Design Pressure	Definition
SISKB-50	±50mm	±50mm	16 bar	Double Gimbal Expansion Joint with 50mm lateral expansion,welded end
SISKB-100	±50mm	±100mm	16 bar	Double Gimbal Expansion Joint with 100mm lateral expansion,welded end
SISKB-150	±50mm	±150mm	16 bar	Double Gimbal Expansion Joint with 150mm lateral expansion,welded end
SISKB-200	±50mm	±200mm	16 bar	Double Gimbal Expansion Joint with 200mm lateral expansion,welded end

* Special designed Double Gimbal Expansion Joints with customized features are available on request.
** Subject to technical alterations and deviations resulting from the manufacturing process without giving any notification.



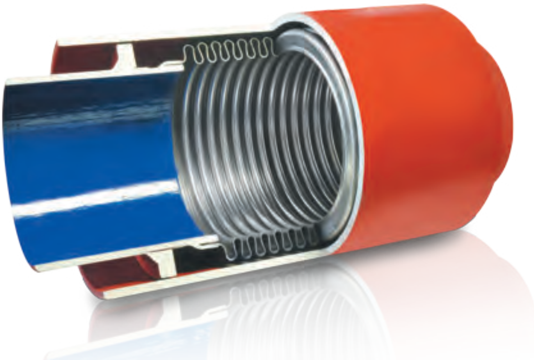


Double Gimbal Expansion Joints, Welded End

DN	Bellow			D1	s	SISKB-50					SISKB-100				
	ØDi	ØD0	Effective Bellow Area			Expansion			L	Code	Expansion			L	Code
						± X	±Z	± Y			± X	±Z	± Y		
DN25	38	48,2	14,58	90	2,3	50	50	50	707	702.070.401.002	50	50	100	907	702.070.402.002
DN32	42,2	55	18,62	105	2,6	50	50	50	707	702.070.401.004	50	50	100	907	702.070.402.004
DN40	48,3	61	23,44	115	2,6	50	50	50	707	702.070.401.006	50	50	100	907	702.070.402.006
DN50	60,3	76	36,46	140	2,9	50	50	50	785	702.070.401.008	50	50	100	985	702.070.402.008
DN65	76,1	95	57,45	160	2,9	50	50	50	785	702.070.401.010	50	50	100	958	702.070.402.010
DN80	88,9	111	78,42	190	3,2	50	50	50	815	702.070.401.012	50	50	100	1015	702.070.402.012
DN100	114,3	140	137,09	250	3,6	50	50	50	835	702.070.401.014	50	50	100	1035	702.070.402.014
DN125	139,7	164	181,01	285	4	50	50	50	963	702.070.401.016	50	50	100	1163	702.070.402.016
DN150	168,3	200	266,20	350	4,5	50	50	50	963	702.070.401.018	50	50	100	1163	702.070.402.018
DN200	219,1	250	431,86	420	6,3	50	50	50	1120	702.070.401.020	50	50	100	1320	702.070.402.020
DN250	273	323	697,11	480	6,3	50	50	50	1120	702.070.401.022	50	50	100	1320	702.070.402.022
DN300	323,9	380	972,37	540	7,1	50	50	50	1177	702.070.401.024	50	50	100	1377	702.070.402.024

DN	Bellow			D1	s	SISKB-150					SISKB-200				
	ØDi	ØD0	Effective Bellow Area			Expansion			L	Code	Expansion			L	Code
						± X	±Z	± Y			± X	±Z	± Y		
DN25	38	48,2	14,58	90	2,3	50	50	150	1107	702.070.403.002	50	50	200	1307	702.070.404.002
DN32	42,2	55	18,62	105	2,6	50	50	150	1107	702.070.403.004	50	50	200	1307	702.070.404.004
DN40	48,3	61	23,44	115	2,6	50	50	150	1107	702.070.403.006	50	50	200	1307	702.070.404.006
DN50	60,3	76	36,46	140	2,9	50	50	150	1185	702.070.403.008	50	50	200	1405	702.070.404.008
DN65	76,1	95	57,45	160	2,9	50	50	150	1235	702.070.403.010	50	50	200	1485	702.070.404.010
DN80	88,9	111	78,42	190	3,2	50	50	150	1255	702.070.403.012	50	50	200	1485	702.070.404.012
DN100	114,3	140	137,09	250	3,6	50	50	150	1285	702.070.403.014	50	50	200	1535	702.070.404.014
DN125	139,7	164	181,01	285	4	50	50	150	1463	702.070.403.016	50	50	200	1763	702.070.404.016
DN150	168,3	200	266,20	350	4,5	50	50	150	1463	702.070.403.018	50	50	200	1763	702.070.404.018
DN200	219,1	250	431,86	420	6,3	50	50	150	1680	702.070.403.020	50	50	200	2030	702.070.404.020
DN250	273	323	697,11	480	6,3	50	50	150	1680	702.070.403.022	50	50	200	2080	702.070.404.022
DN300	323,9	380	972,37	540	7,1	50	50	150	1727	702.070.403.024	50	50	200	2127	702.070.404.024

District Heating Expansion Joints



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Ayvaz's highly flexible metal bellowed expansion joints are designed to absorb large axial movements specially for installation in district heating pipe systems. The axial forces in the pipeline are directly transferred through adjoining end surfaces of the pipes as to protect the bellows against overloading in cases that the bellows are fully compressed.

Movement Absorption

The highly flexible bellow of the compensator ensures absorption of large axial movements. The cover, optional guides and rings of the compensator contribute high stability. The cover likewise absorbs eventual misalignments in the pipeline, which can occur if the pipeline hangs a bit in the compensator. This should however be avoided.

Advantages of Ex-pressed Expansion Joints

- Absorption of large axial movements
- Pipeline protection
- Easy installation and insulation
- Protection against torsion

DESIGN

Structure

Bellow Material	Stainless Steel AISI 321 (opt.304,316L,316TI,309)
Connection Types	Welded End
Connection Material	Carbon Steel St.37.2 as standard, the material can be customised on request
Cover Material	Carbon Steel St.37.2 as standard, the material can be customised on request

Operation Conditions

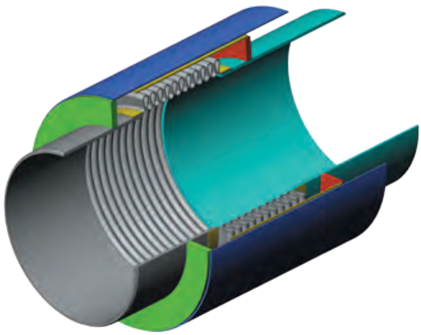
Operating Temperature	-80°C/+600°C
Operating Pressure	PN 16
Nominal Diameters	DN 50 (2") - DN1000 (40")

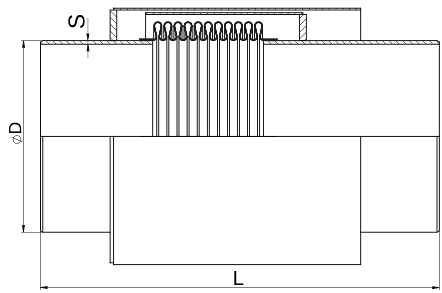
District Heating Expansion Joints

Name	Expansion Amount	Design Pressure	Definition
DSTKKB-1	±30-105	16 bar	Single bellowed district heating expansion joint with welded ends
DSTKKB-2	±60-210	16 bar	Double bellowed district heating expansion joint with welded ends

* Special designed, Double Plied Vibration Absorbers with customized features are available on request.
** Subject to technical alterations and deviations resulting from the manufacturing process without giving any notification.

Single Bellowed District Heating Expansion Joint With Welded Ends

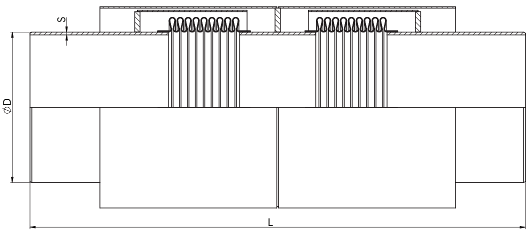


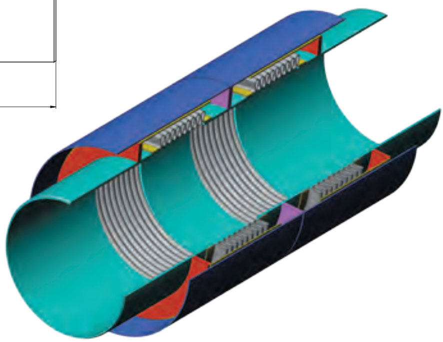


DN	ØD	s	L	Axial Movement (+/- mm)	Axial Spring Rate N/mm	Effective Bellow Area cm^2	Life Cycle (100%)	Life Cycle (50%)	Life Cycle (33%)	Code
DN50	57	3,5	540	+/- 30	223,8	32,78	83	1130	5929	702.151.060.014
DN65	76	3,5	550	+/- 30	266,8	55,44	104	1388	7094	702.151.060.016
DN80	89	3,5	570	+/- 35	333,4	78,57	99	1406	7753	702.151.070.018
DN100	108	4	620	+/- 50	376,2	114,47	73	1029	5265	702.151.100.020
DN125	133	4	630	+/- 50	363,7	169,79	101	1351	6945	702.151.100.022
DN150	159	4,5	640	+/- 50	412,1	237,88	138	1885	9863	702.151.100.024
DN200	219	6	750	+/- 70	643,1	434,28	71	1003	5168	702.151.140.026
DN250	273	7	780	+/- 80	618,2	694,00	141	1912	9978	702.151.160.028
DN300	325	7	790	+/- 90	695,6	952,63	105	1409	7208	702.151.180.030
DN350	377	8	800	+/- 90	694,6	1285,59	171	2314	11986	702.151.180.032
DN400	426	8	840	+/- 100	681,3	1633,78	124	1592	7745	702.151.200.034
DN500	530	8	830	+/- 100	732,5	2464,00	161	2097	10414	702.151.200.038
DN600	630	8	890	+/- 100	851	3422,57	152	1968	9716	702.151.200.042
DN700	720	8	1010	+/- 105	975,5	4419,64	126	1618	7906	702.151.210.046
DN800	820	8	1050	+/- 105	1081,4	5676,79	117	1497	7266	702.151.210.050
DN900	920	10	1050	+/- 105	1215,7	7091,07	117	1487	7221	702.151.210.054
DN1000	1020	10	1080	+/- 105	1350	8662,50	116	1480	7185	702.151.210.058

All the dimensions in the table are given in "mm".

Double Bellowed District Heating Expansion Joint With Welded Ends





DN	ØD	s	L	Axial Movement (+/- mm)	Axial Spring Rate N/mm	Effective Bellow Area cm^2	Life Cycle (100%)	Life Cycle (50%)	Life Cycle (33%)	Code
DN50	57	3,5	870	+/- 60	133,4	32,78	83	1130	5929	702.152.060.014
DN65	76	3,5	880	+/- 60	111,9	55,44	104	1388	7094	702.152.060.016
DN80	89	3,5	920	+/- 70	166,7	78,57	99	1406	7753	702.152.070.018
DN100	108	4	1030	+/- 100	188,1	114,47	73	1029	5265	702.152.100.020
DN125	133	4	1050	+/- 100	181,85	169,79	101	1351	6945	702.152.100.022
DN150	159	4,5	1070	+/- 100	206,05	237,88	138	1885	9863	702.152.100.024
DN200	219	6	1280	+/- 140	321,55	434,28	71	1003	5168	702.152.140.026
DN250	273	7	1340	+/- 160	309,1	694,00	141	1912	9978	702.152.160.028
DN300	325	7	1370	+/- 180	347,8	952,63	105	1409	7208	702.152.180.030
DN350	377	8	1390	+/- 180	347,3	1285,59	171	2314	11986	702.152.180.032
DN400	426	8	1460	+/- 200	340,65	1633,78	124	1592	7745	702.152.200.034
DN500	530	8	1450	+/- 200	366,25	2464,00	161	2097	10414	702.152.200.038
DN600	630	8	1570	+/- 200	425,5	3422,57	152	1968	9716	702.152.200.042
DN700	720	8	1800	+/- 210	487,75	4419,64	126	1618	7906	702.152.210.046
DN800	820	8	1880	+/- 210	540,7	5676,79	117	1497	7266	702.152.210.050
DN900	920	10	1870	+/- 210	607,85	7091,07	117	1487	7221	702.152.210.054
DN1000	1020	10	1930	+/- 210	675	8662,50	116	1480	7185	702.152.210.058

All the dimensions in the table are given in "mm".

VIBRATION ABSORBERS

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Besides of compensating thermal expansions, the most important function of expansion joints is to solve the problems caused by the system vibration. Expansion joints are very effective especially on compensating the vibrations with high frequency and low oscillation.

Movement Absorption

Pump Connections: Expansion joints are used at the connections of the pump to the pipelines around the pump's inlet and outlet. The fixed points right after the expansion joints are used to prevent the vibration through pipeline which is caused by the pump. Use of expansion joints for vibration absorbing is also useful to prevent the noise caused by the vibration. **Compressor Connections:** In most cases, although the insulation applications, compressor movements cause vibration in the connected pipe-lines. Using expansion joint after the compressor absorbs the vibration caused by the compressor and provides ideal operation conditions for the system.

Advantages of Double Double Plied Vibration Absorbers

- They prevent damage to pumps result of the piping stress.
- They absorb vibration and noise in pump connections.
- They are installed easily and prevent the possible pump failures.
- They have a compact design that reduces the waste of space.
- The bellows and the braiding are manufactured with stainless steel material
- To provide required piping flexibility to the systems in order to maintain proper operating conditions.
- To protect equipment from stress due to misalignment.

DESIGN

Structure

Bellow Material	Stainless Steel AISI 321 (opt.304,316L,316TI,309) Double Plied
Connection Types	Fixed Flanged
Flange Material	Carbon Steel St.37.2 as standard, the material can be customised on request
Tie Rod Material	Carbon Steel St.37.2 as standard, the material can be customised on request
Carbon Steel	St.37.2 as standard, the material can be customised on request

Operation Conditions

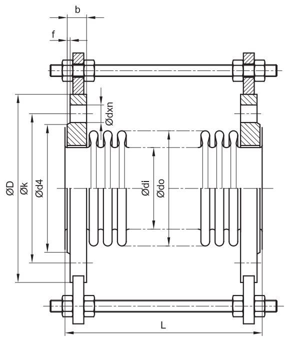
Operating Temperature	-80°C/+600°C
Operating Pressure	PN 2,5/6/16/25/40/64
Nominal Diameters	DN25 (1") - DN1000 (40")

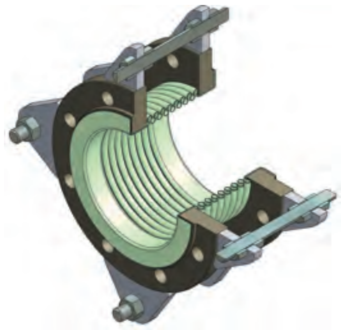
Double Plied Expansion Joints with tie rods

Available Types (Standard Versions)

Name	Axial Expansion Amount	Design Pressure	Definition
MKTY-30	-20/+10	16 bar	Double Plied Vibration Absorber with 30mm axial expansion, flanged

* Special designed, Double Plied Vibration Absorbers with customized features are available on request.
** Subject to technical alterations and deviations resulting from the manufacturing process without giving any notification.





DN	Flange (DIN EN 1092/1) PN 16						Bellow			L	Code
	ØD	Øk	Ød4	f	b	Ødxn	Ødi	Ødo	Effective Bellow Area cm²		
DN25	115	85	68	2	16	Ø 14x4	38	48,2	14,58	110	702.031.103.102
DN32	140	100	78	2	18	Ø 18x4	42,4	55	18,62	115	702.031.103.104
DN40	150	110	88	3	18	Ø 18x4	48,3	61	23,44	120	702.031.103.106
DN50	165	125	102	3	20	Ø 18x4	60,3	76	36,46	110	702.031.103.108
DN65	185	145	122	3	20	Ø 18x4	76,1	95	57,45	110	702.031.103.110
DN80	200	160	138	3	20	Ø 18x8	88,9	111	78,42	110	702.031.103.112
DN100	220	180	158	3	22	Ø 18x8	114,3	150	137,09	115	702.031.103.114
DN125	250	210	188	3	22	Ø 18x8	139,7	164	181,01	120	702.031.103.116
DN150	285	240	212	3	24	Ø 23x8	168,3	200	266,20	145	702.031.103.118
DN200	340	295	268	3	26	Ø 23x12	219,1	250	431,86	140	702.031.103.120
DN250	405	355	320	3	29	Ø 27x12	273	323	697,11	150	702.031.103.122
DN300	460	410	378	4	32	Ø 27x12	323,9	380	972,37	150	702.031.103.124

All the dimensions in the table are given in "mm".
Other flange types made according to different standarts (ANSI, BS, UNI) are also available

Application of Fixed Points

By using appropriate expansion joints in pipeline applications, it will be possible to build up well structured and freely moving straight pipelines. Proper expansion absorption can only be possible with aplying suitable guides which are strong enough to meet the pressure at both ends.

Braided Expansion Joints

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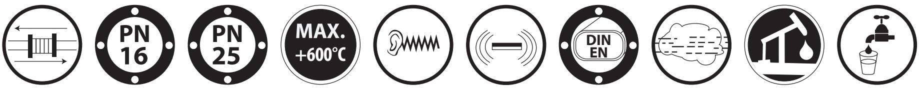


Ayvaz's braided expansion joints are assembled using annularly corrugated stainless steel bellows and high strength stainless steel braiding. They are designed for optimum performance in vibration applications and to reduce vibration in mechanical piping systems.

Movement Absorption

Braided expansion joints are constructed with a corrugated inner bellows and braided cover that helps increasing the pressure resistance rating and provides end limitations that annihilate the need for additional control assemblies.

Advantages of Using Braided Expansion Joints:

- They prevent damage to pumps result of the piping stress.
- They absorb vibration and noise in pump connections.
- They are installed easily and prevent the possible pump failures.
- They have a compact design that reduces the waste of space.
- The bellows and the braiding are manufactured with stainless steel material
- To provide required piping flexibility to the systems in order to maintain proper operating conditions.
- To protect equipment from stress due to misalignment.

DESIGN

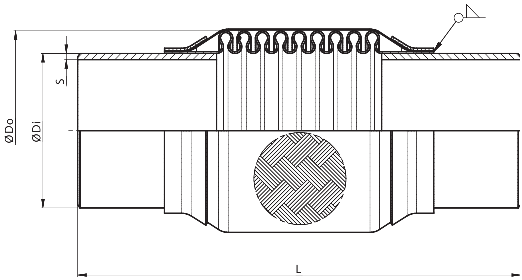
Structure

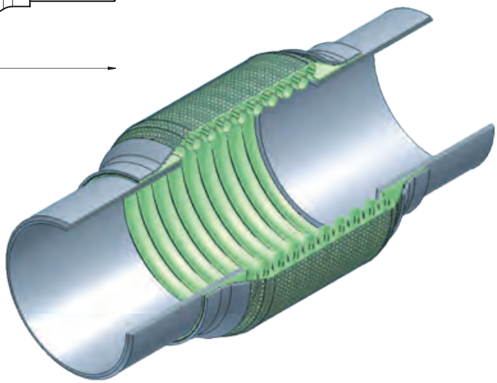
Bellow Material	Stainless Steel AISI 321 (opt.304,316L,316TI,309)
Braiding Material	Stainless Steel AISI 304
Connection Types	Fixed and Floating Flanged and Welded End
Flange Material	Carbon Steel St.37.2 as standard, the material can be customised on request

Operation Conditions

Operating Temperature	-80°C/+600°C
Operating Pressure	PN 16/25
Nominal Diameters	DN25 (1") - DN250 (10")

Braided Expansion Joints





DN	Bellow			S	L	Code
	ØDi	ØD0	Effective Bellow Area cm^2			
DN32	42,4	55	18,85	2,6	200	702.351.101.008
DN40	48,3	61	23,66	2,6	200	702.351.101.010
DN50	60,3	76	36,94	2,9	200	702.351.101.012
DN65	76,1	95	58,06	2,9	200	702.351.101.014
DN80	88,9	111	79,29	3,2	215	702.351.101.016
DN100	114,3	150	127,81	3,6	215	702.351.101.018
DN125	139,7	164	183,04	4	215	702.351.101.020
DN150	168,3	200	267,80	4,5	215	702.351.101.022
DN200	219,1	250	436,10	6	215	702.351.101.024
DN250	273	323	703,68	6	250	702.351.101.026

All the dimensions in the table are given in "mm".

* Subject to technical alterations and deviations resulting from the manufacturing process without giving any notification.

AYVAZ

BRAIDED LOOP JOINTS

U-Flex & V-Flex

FM APPROVED

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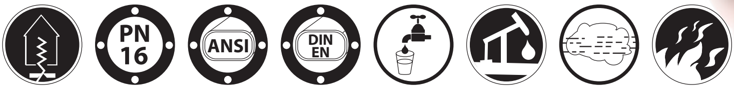


Ayvaz U-Flex and V-Flex assemblies provide highly flexible and reliable connection features for fire protection lines, seismic security areas, dilatation points and industrial applications. These assemblies are used to absorb the movements caused by the potential break downs and depressions especially where the seismic movements may cause hazardous results. Ayvaz U-Flex and V-Flex assemblies that are manufactured with FM certificate prevent the structural deformations such as cracks and break downs of rigid connections by the required flexibility they provide and offer easy, safe and reliable installation features for the users.

DESIGN

Ayvaz U-Flex and V-Flex assemblies are consisted of the parallel corrugated metal hose with braiding and Carbon Steel connection and direction parts likewise turns and elbows at various angles. Flexible metal hose provides high movement capacity in all directions to the assemblies and the braiding increases the pressure resistance accordingly

Structure

Bellow Material	Stainless Steel AISI 316L / AISI 321
Braiding Material	Stainless Steel AISI 304
Connection Types	Flange, Welded End, Grooved
Flange Material	Carbon Steel St. 37.2 , the material can be customized on request
Elbow and Turn Material	Carbon Steel St. 37.2 , the material can be customized on request

Operation Conditions

Operating Temperature	-80°C/+600°C
Operating Pressure	16 bar
Nominal Diameters	DN15 (1/2”) - DN250 (10”)

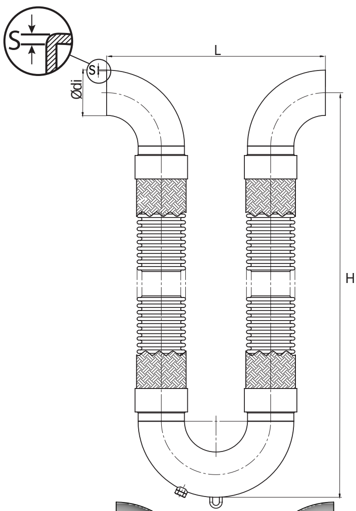
U-Flex,Braided Loop Joints

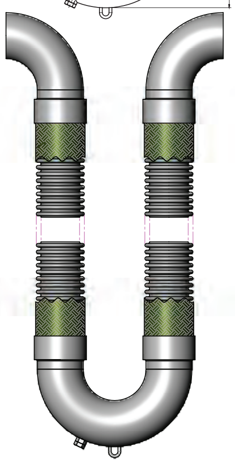
FM APPROVED

Available Types (Standard Versions)

Name	Movement Amount All Plates	Design Pressure	Definition
U-Flex	50mm-100mm	175 psi	U-type, 3D braided Loop-joint, Welded End
U-Flex	50mm-100mm	175 psi	U-type, 3D braided Loop-joint, Flanged
U-Flex	50mm-100mm	175 psi	U-type, 3D braided Loop-joint, Grooved End

U-type, 3D braided Loop-joint, Welded End



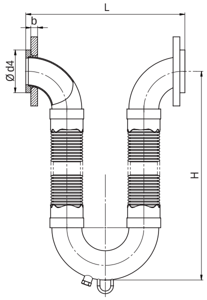


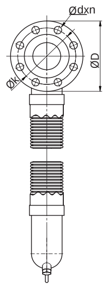
* Special designed, Braided Loop Joints with customized features are available on request.
** Subject to technical alterations and deviations resulting from the manufacturing process without giving any notification.

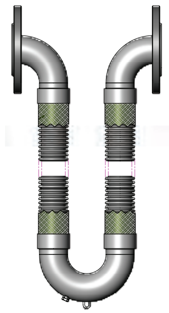
DN	Ødi	S	Movement in all directions ±mm	L	H	Code
DN15	21,3	2,6	±50	150	325	702.080.301.010
			±100	225	425	702.080.301.015
DN20	26,9	2,6	±50	131,25	325	702.080.301.020
			±100	231,25	450	702.080.301.025
DN25	33,7	2,6	±50	152	380	702.080.301.030
			±100	254	510	702.080.301.035
DN32	42,4	2,6	±50	190	410	702.080.301.040
			±100	273	535	702.080.301.045
DN40	48,3	2,6	±50	228	435	702.080.301.050
			±100	292	585	702.080.301.055
DN50	60,3	2,9	±50	304	485	702.080.301.060
			±100	356	635	702.080.301.065
DN65	76,1	2,9	±50	380	535	702.080.301.070
			±100	456	762	702.080.301.075
DN80	88,9	3,2	±50	456	585	702.080.301.080
			±100	608	890	702.080.301.085
DN100	114,3	3,6	±50	608	715	702.080.301.090
			±100	760	1020	702.080.301.095
DN125	139,7	4	±50	760	815	702.080.301.100
			±100	920	1170	702.080.301.105
DN150	168,3	4,5	±50	920	940	702.080.301.110
			±100	1220	1475	702.080.301.115
DN200	219,1	6,3	±50	1220	1220	702.080.301.120
			±100	1120	1375	702.080.301.125
DN250	273	7,1	±50	1524	1400	702.080.301.130
			±100	1524	1702	702.080.301.135

All the dimensions in the table are given in “mm”.

U-type, 3D braided Loop-joint, Flanged







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DN	Flange (DIN EN 1092/1) PN 16					Movement in all directions ±mm	L mm	H mm	Code
	ØD mm	Øk mm	b mm	Ødxn	Ød4 mm				
DN15	95	65	14	Ø14x4	45	±50	165	330	702.080.303.010
						±100	240	435	702.080.303.015
DN20	105	75	16	Ø14x4	58	±50	145	330	702.080.303.020
						±100	245	460	702.080.303.025
DN25	115	85	16	Ø14x4	68	±50	222	380	702.080.303.030
						±100	324	510	702.080.303.035
DN32	140	100	18	Ø18x4	78	±50	260	410	702.080.303.040
						±100	343	535	702.080.303.045
DN40	150	115	18	Ø18x4	88	±50	300	435	702.080.303.050
						±100	362	585	702.080.303.055
DN50	165	125	20	Ø18x4	102	±50	375	485	702.080.303.060
						±100	426	635	702.080.303.065
DN65	185	145	20	Ø18x4	122	±50	450	535	702.080.303.070
						±100	450	715	702.080.303.075
DN80	200	160	20	Ø18x8	138	±50	536	585	702.080.303.080
						±100	536	765	702.080.303.085
DN100	220	180	22	Ø18x8	158	±50	680	715	702.080.303.090
						±100	680	890	702.080.303.095
DN125	250	210	22	Ø18x8	188	±50	832	815	702.080.303.100
						±100	832	1020	702.080.303.105
DN150	285	240	24	Ø23x8	212	±50	992	940	702.080.303.110
						±100	992	1170	702.080.303.115
DN200	340	295	26	Ø23x12	268	±50	1292	1220	702.080.303.120
						±100	1292	1475	702.080.303.125
DN250	405	355	29	Ø27x12	320	±50	1600	1400	702.080.303.130
						±100	1600	1702	702.080.303.135

All the dimensions in the table are given in “mm”.
Other flange types made according to different standarts (ANSI, BS, UNI) are also available.

V-Flex,Braided Loop Joints

Available Types (Standard Versions)

Name	Movement Amount All Plates	Design Pressure	Definition
V-Flex	100mm	16 bar	U-type, 3D braided Loop-joint, Welded End
V-Flex	100mm	16 bar	U-type, 3D braided Loop-joint, Flanged
V-Flex	100mm	16 bar	U-type, 3D braided Loop-joint, Grooved End

* Special designed, Braided Loop Joints with customized features are available on request.
** Subject to technical alterations and deviations resulting from the manufacturing process without giving any notification.

V-type, 3D braided Loop-joint, Welded End

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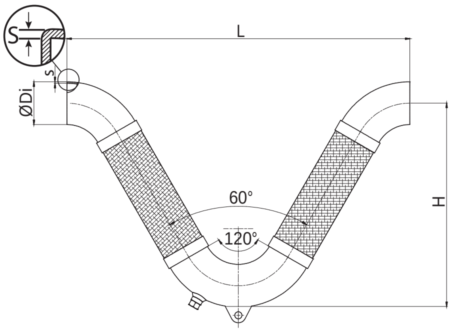
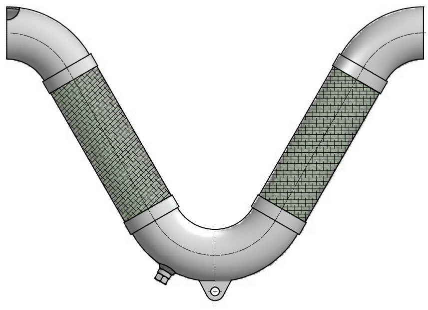
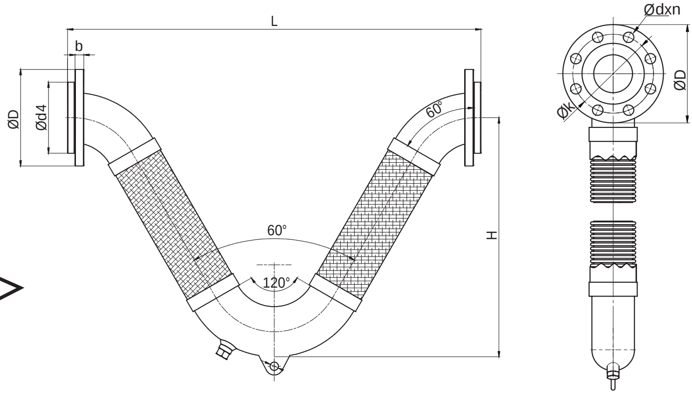




DN	ØDi	s	H	L	Movement in all directions ±mm	Code
DN15	21,3	2,6	330	505	±100	702.090.301.015
DN20	26,9	2,6	330	505	±100	702.090.301.025
DN25	33,7	2,6	505	330	±100	702.090.301.035
DN32	42,4	2,6	505	330	±100	702.090.301.045
DN40	48,3	2,6	505	330	±100	702.090.301.055
DN50	60,3	2,9	515	350	±100	702.090.301.065
DN65	76,1	2,9	620	415	±100	702.090.301.075
DN80	88,9	3,2	720	470	±100	702.090.301.085
DN100	114,3	3,6	880	545	±100	702.090.301.095
DN125	139,7	4	1070	650	±100	702.090.301.105
DN150	168,3	4,5	1255	750	±100	702.090.301.115
DN200	219,1	6,3	1520	850	±100	702.090.301.125
DN250	273	7,1	1970	1080	±100	702.090.301.135

All the dimensions in the table are given in "mm".

V-type, 3D braided Loop-joint, Flanged



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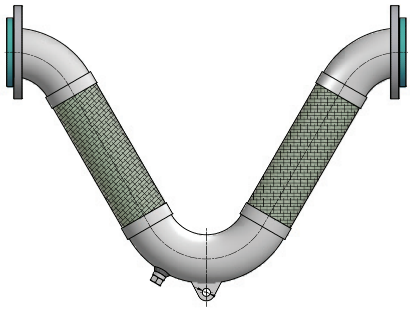

DN	Flange (DIN EN 1092/1) PN 16					H mm	L mm	Movement in all directions ±mm	Code
	ØD mm	Øk mm	b mm	Ødxn	Ød4 mm				
DN25	115	85	16	Ø14x4	68	330	530	±50	702.090.303.035
DN32	140	100	18	Ø18x4	78	330	530	±50	702.090.303.045
DN40	150	115	18	Ø18x4	88	310	530	±50	702.090.303.055
DN50	165	125	20	Ø18x4	102	350	570	±50	702.090.303.065
DN65	185	145	20	Ø18x4	122	415	675	±50	702.090.303.075
DN80	200	160	20	Ø18x8	138	470	785	±50	702.090.303.085
DN100	220	180	22	Ø18x8	158	545	945	±50	702.090.303.095
DN125	250	210	22	Ø18x8	188	650	1140	±50	702.090.303.105
DN150	285	240	24	Ø23x8	212	750	1325	±50	702.090.303.115
DN200	340	295	26	Ø23x12	268	850	1600	±50	702.090.303.125
DN250	405	355	29	Ø27x12	320	1080	2045	±50	702.090.303.135

All the dimensions in the table are given in "mm".
Other flange types made according to different standarts (ANSI, BS, UNI) are also available.

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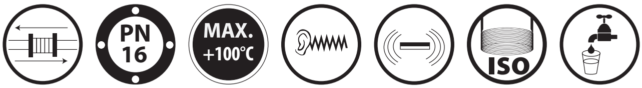


Especially for the very high buildings, thermal expansions caused by rapid temperature changes at heating and hot water lines cause dangerous pipe movements, bends and breakages around the connection areas. These thermal movements are also the reason of the inconvenient noises for domestic use in particularly. Ayvaz's pipe expansion joints are prefferred for both indoor and outdoor uses with their decorative designs.

Movement Absorption

Pipe expansion joints provide axial movement absorption and maintain the pipeline security. A heating pipeline system at 90/70°C causes approximately 3 mm of movement for each floor of the buildings. For the buildings higher than 10 floors, use of the pipe expansion joints becomes compulsory in order to absorbe total expansion amount. Pipe expansion joint application must be repeated for every 10 floors.

Advantages of Pipe Expansion Joints

- They prevent damage to pipelines result of the line movements
- They absorb the possible noises and provide convenience for the users
- They are installed easily and provide time and money saving
- They have a compact and decorative design that reduces the waste of space
- They help to protect equipment from stress due to misalignment

DESIGN

Structure

Bellow Material	Stainless Steel AISI 316L / AISI 321
Body Material	Aluminium (Opt. Stainless Steel)
Connection Types	Threaded and Welded End

Operation Conditions

Operating Temperature	Max 100°C
Operating Pressure	PN 16
Nominal Diameters	DN15 (1/2") - DN100 (4")

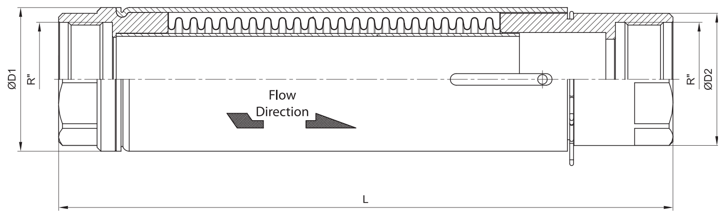
PIPE EXPANSION JOINTS

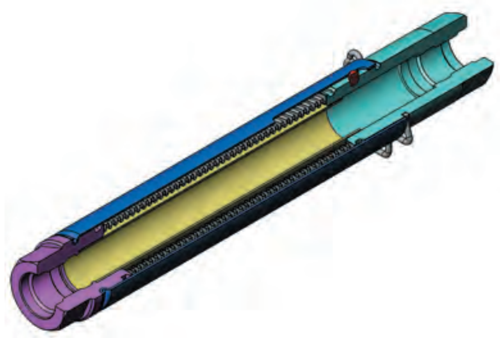
Available Types (Standard Versions)

Name	Axial Movement Amount	Design Pressure	Definition
BKD-50	+5 / - 45 mm (Up to 2")	16 bar	Pipe Expansion Joint with 50mm axial expansion, threaded
	+15 / - 35 mm (Above 2")		
BKKB-50	+5 / - 45 mm (Up to 2")	16 bar	Pipe Expansion Joint with 50mm axial expansion, welded end
	+15 / - 35 mm (Above 2")		

* Special designed, Pipe expansion joints with customized features are available on request.
** Subject to technical alterations and deviations resulting from the manufacturing process without giving any notification.

BKD-50 Pipe Expansion Joint with 50 mm axial expansion, threaded

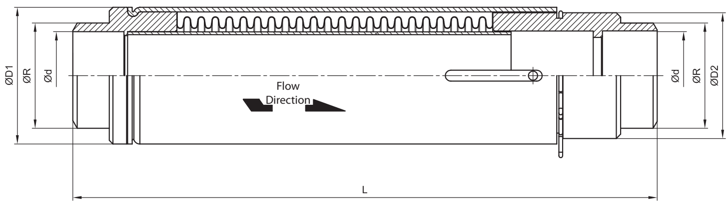


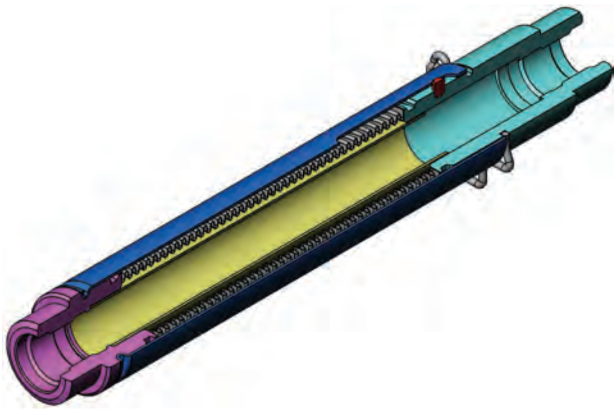


R"	ØD1	ØD2	AA	L	Code
R1/2"	38	35	32	260	702.020.010.002
R3/4"	38	35	32	260	702.020.010.004
R1"	48	44	41	285	702.020.010.006
R1 1/4"	60	54	50	320	702.020.010.008
R1 1/2"	75	69	65	320	702.020.010.010
R2"	75	69	65	320	702.020.010.012

All the dimensions in the table are given in "mm".

BKKB-50 Pipe Expansion Joint with 50mm axial expansion, welded end





DN/ØR"		ØD1	ØD2	Ød	L	Code
DN15	Ø21,3	38	35	16,3	260	702.020.020.002
DN20	Ø26,9	38	35	20,9	260	702.020.020.004
DN25	Ø33,7	48	44	27,7	285	702.020.020.006
DN32	Ø42,2	60	54	36,4	320	702.020.020.008
DN40	Ø48,3	75	69	42,3	320	702.020.020.010
DN50	Ø60,3	75	69	54,3	320	702.020.020.012
DN65	Ø76,1	107	95	70,3	330	702.020.020.014
DN80	Ø88,9	127	111	81,5	330	702.020.020.016
DN100	Ø107,1	158	140	114,3	330	702.020.020.018
DN125	Ø164	164	139,7	131,7	330	702.020.020.020

All the dimensions in the table are given in "mm".

RUBBER EXPANSION JOINTS

Ayvaz's Rubber Expansion joints are used in various areas such as;

- Mechanical installation and machine engineering.
- Domestic water and liquid industry.
- Shipbuilding and marine engineering.
- Power plants and nuclear stations.
- HVAC applications.

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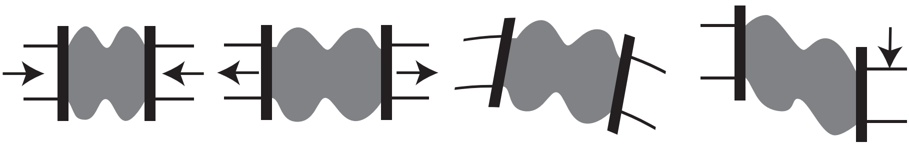
Compression Elongation Angular movement Transverse movement



Movement Absorption

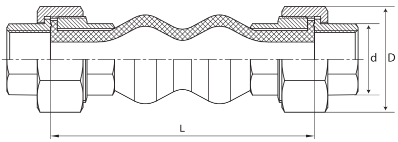
- To compensate thermal expansion and compression.
- To reduce tension in the pipelines.
- To prevent noise and vibration to protect the connected systems.
- To compensate for ground, and settlement of especially the new buildings.
- To provide proper sealing with their elastic structures where the pipelines pass through walls.

Advantages

- Ayvaz rubber expansion joints provide excellent compensating features by their highly rated rubber bellows which is consisted of special synthetic rubber, steel wire and nylon braid fibre.
- They may be produced with flange and threaded connections.
- They may have two bellowed structure in order to absorb large movements.

Ayvaz's Rubber expansion joints are designed to compensate axial, lateral, angular and transverse movements at the same time.

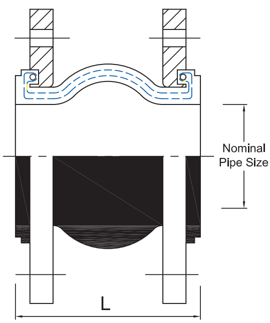
Rubber Expansion Joint DKK-10



DN	Rc"	L	Axial Move-ment (mm)	Lateral Move-ment (mm)	Angular Move-ment (±°)	Code
DN15	1/2"	165	-22/+6	-22/+22	-30/+30	708.150.100.010
DN20	3/4"	165	-22/+6	-22/+22	-30/+30	708.150.100.020
DN25	1"	175	-22/+6	-22/+22	-30/+30	708.150.100.030
DN32	1 1/4"	186	-22/+6	-22/+22	-30/+30	708.150.100.040
DN40	11/2"	186	-22/+6	-22/+22	-30/+30	708.150.100.050
DN50	2"	186	-22/+6	-22/+22	-30/+30	708.150.100.060
DN65	21/2"	218	-22/+6	-22/+22	-30/+30	708.150.100.070
DN80	3"	260	-22/+6	-22/+22	-30/+30	708.150.100.080

*Special designed, rubber expansion joints with customized features are available on request.
** Subject to technical alterations and deviations resulting from the manufacturing process without giving any notification.

Rubber Expansion Joint LKA-10



DN	L	Axial Movement (mm)	Lateral Movement (mm)	Angular Movement (±°)	Code
15	100	-10/+10	-10/+10	-10/+10	708.150.200.010
20	100	-10/+10	-10/+10	-10/+10	708.150.200.020
25	100	-10/+10	-10/+10	-10/+10	708.150.200.030
32	100	-10/+10	-10/+10	-10/+10	708.150.200.040
40	100	-10/+10	-10/+10	-10/+10	708.150.200.050
50	100	-10/+10	-10/+10	-10/+10	708.150.200.060
65	100	-10/+10	-10/+10	-10/+10	708.150.200.070
80	100	-10/+10	-12/+12	-12/+12	708.150.200.080
100	100	-10/+10	-12/+12	-12/+12	708.150.200.090
125	120	-10/+10	-12/+12	-12/+12	708.150.200.100
150	120	-10/+10	-12/+12	-12/+12	708.150.200.110
200	120	-10/+10	-12/+12	-12/+12	708.150.200.120
250	120	-10/+10	-12/+12	-12/+12	708.150.200.130
300	120	-10/+10	-12/+12	-12/+12	708.150.200.140
350	266	-25/+16	-18/+18	-15/+15	708.150.200.150
400	266	-20/+16	-18/+18	-15/+15	708.150.200.160
450	200	-20/+12	-18/+18	-15/+15	708.150.200.170
500	200	-20/+12	-18/+18	-15/+15	708.150.200.180
600	250	-20/+12	-18/+18	-15/+15	708.150.200.190

AYVAZ
EXPANSION JOINTS

CHAPTER VII

EXPANSION JOINT APPLICATIONS

CHAPTER VII

Various Expansion Joint Designs:

Axial, lateral or angular expansion joints are used to prevent the expansion and vibration problems. But, in some cases that the operating pressure exceeds the permissible levels or standard expansion joint designs can not meet the requirements, balanced or expansion joints are suggested to be used.

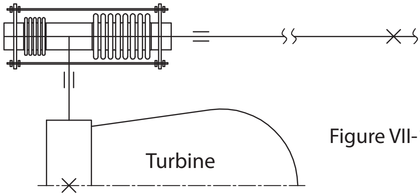


Figure VII-1

VII. 1 Pressure Balanced Expansion Joints:

If the pressure tension or the axial expansion movements rise up to the extremely high levels, pressure balanced expansion joints may provide the proper absorption without delivering those movements to the pipe systems. This type of expansion joints are manufactured with tie rods that balance the force which causes movement at bellows.

A typical application of pressure balanced expansion joints is given in fig VII.1. In this application, the axial and lateral movements around the outlet of the turbine are absorbed by the pressure balanced expansion joint.

Using fixed points at the ends of pipe and turbine lines and the intermediate sliding supports provide absorption capability for the vibration consisted. Those equipment are also very useful not to deliver the forces resulted of the expansion of the pipeline to the turbine.

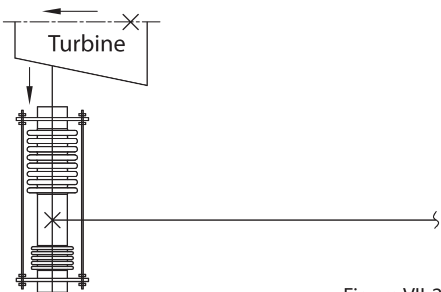


Figure VII-2

Fig VII-2 illustrates another pressure balanced expansion joint application. In this application, a pressure balanced expansion joint is fixed from the middle of it to the near of the outlet of a turbine which is fixed by a fixes point.

That is because, there is just a little distance between the expansion joint and the turbine, there is no need for any guiding for this application.

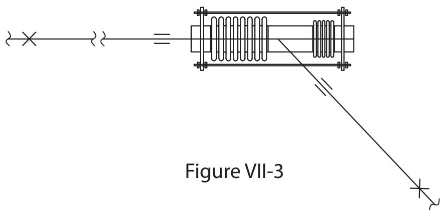


Figure VII-3

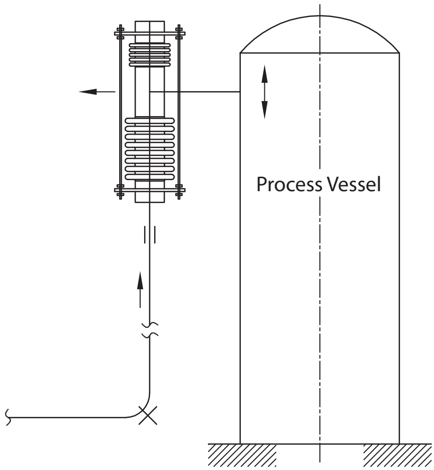


Figure VII-4

If the pipelines are forced to make turns bigger than 90º, pressure balanced expansion joints may be used. While the main pipelines cause axial expansion, heat expansion, through lateral pipelines cause both axial and lateral expansions. As it is seen in the figure VII-1, total expansion is managed by the guides and the fixed points located at the both ends of the pipeline.

Fig. VII-4 also shows another application type of the pressure balanced expansion joints. Expansion difference of the process vessel and the pipeline which are located parallel to the each other can be absorbed by one pressure balanced expansion joint. On the other hand, the pipeline should be fixed to the ground by fixed point. The guide located underneath the expansion joint provides the axial guiding. If the expansion joint's application height is extremely high, the expansion joint may be fixed directly to the process vessel.

Apart from all these reasons, some other natural effects likewise wind may cause lateral movements, the movements caused by these effects can also be absorbed by pressure balanced expansion joints.

VII . 2 Universal Expansion Joints:

It was explained how to sort the expansion problems of the angular expansion joints by the given examples in the chapter V. In these examples the angular expansion joints are taken considered as complete systems. For these situations where the movement is multi directional, it is not enough to use only angular expansion joints. The appropriate solution for these kind of problems is the usage of universal expansion joints. The tie rods located through the expansion joint enable the axial and lateral movements. Tie rods balance the movement between the bellows, the pressure load is compensated by the fixed points at the ends of pipeline.

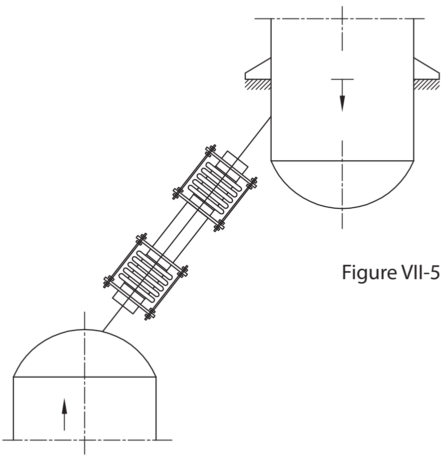


Figure VII-5

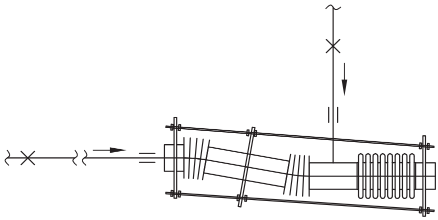


Figure VII-6

Figure VII-5 illustrates the application mentioned above. As it is seen the expansions of the process vessels are opposite directional. Universal expansion join is used in the middle of pipe system. The process vessels must be designed as to compensate the pressure load of the pipeline system.

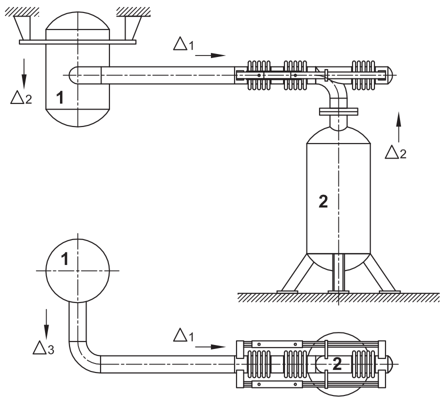


Figure VII-7

Operating temperatures and pressures have been increasing related the technological developments. In the modern designs, the main intention is in the way of using less material and setting large thermal units. Because of that, the number of guide bearings and fixed points is needed to be decreased. These factors make the usage of universal expansion joints the common solution for such cases.

Pressured balanced universal expansion joints needed to be used inch waterch cases that to compensate very big lateral expansions without using enough guide bearings. Figure VII-6 illustrates an example of this kind of application. As it is seen in this figure, the bellow at right expands only axially, to be able to achieve this, correct design of the tie tods is compulsory.

Figure VII-7 shows the connection between two process vessels. The expansions of process vessels numbered 1 and 2 are vertically opposite directional. Because of the horizontal movement of pipe connection and the vessel numbered 1, the expansion joint must be able to move in all plates. The tie rods of universal expansion joints for such purposes are manufactured wit double gimbals.

VII . 3 Externally Pressurized Expansion Joints:

In order to compensate very large expansions at very long pipelines, different expansion joint designs are required. Compensating large amount of thermal expansions by axial expansion joints is only possible by increasing the number of corrugations of the bellow, but this increases the possibility of torsion. Applying inner sleeves may reduce the torsion but they also reduce the movement ability of the expansion joints. Externally pressurized expansion joints provide the most suitable solution for such cases. But this type of application are only possible for small and medium sized expansion joints.

As it is seen in figure VII-8, ex-pressed expansion joints change the direction of the flow and convey the pressure to the bellows externally. Resistance of externally pressurized bellows against high pressure and torsion forces increases. This firm structure makes compensating large movements possible safely.

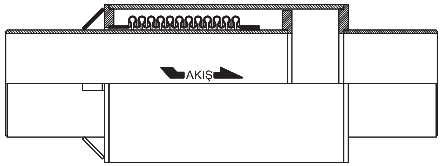


Figure VII-8

VII . 4 Expansion Joint Accessories:

According to the application area, some accessories may be required in order to maintain the maximum operation of the expansion joints. These accessories are reviewed below.

VII . 4. a Tie Rods:

As it was explained before, various type of forces occur during the operation of the expansion joints. Numeric examples regarding these forces are gives in chapters III,IV,V. The most operational elements to compensate these forces are the fixed points. But in some cases, the fixed points are not enough to compensate all these forces, inch waterch cases tie rods must be used. (See. Fig. 1-5). The design of the tie rods is done by the manufacturer it is required. Preventing the pressure tension is the first priority while the tie rod design is done. Taking the effect of the following forces in to calculation of the design provides healthy solutions.

- The weight of the intermediate pipe between the bellows and the insulation material
- The weight of the fluid transported during the operation or test
- Rapid loads of the natural events such as wind and earth quake.
- Possible axial torsions

The design is completed with taking the flow and temperature conditions into account. The length and the diameter of the tie rods are calculated according to the given parameters and the diameter of the expansion joint.

VII . 4. b Inner Sleeves:

Inner sleeves are the elements that increase the efficiency of axial expansion joints. Use of these elements is compulsory for following conditions.
- If the friction loses of the fluid is too high.
- If the speed of the fluid is too high and this causes the vibration which is very close the resonance value.

(The speed value that may cause resonance is indicated by the manufacturer. If turbulence occurs because of any reason likewise, changing the flow direction, valves, elbows etc., exact flow speed is multiplied by a safety factor.)

- If any catalyser or acidic condition at high temperature exist, erosion danger is possible.
- If backflow occurs.
- In order to protect the bellows against high temperature and save the physical features.

For the following conditions, Inner sleeve use is notrecommended:

During the transportation of fluids with very high viscosity such as bitumen, inner sleeves must not be used. Because of the fast solidification, this kind of fluids may cause the early fatigue of the expansion joints.

Inner sleeves may be manufactured from carbon steel, any stainless steel or the same material as bellows. Inner sleeve design is dependent on nominal diameter of the expansion joint, fluid speed and its own length. If the direction of the fluid is vertical, discharging holes must be opened underneath the inner sleeves. This prevents the possible particle accumulation around the bellow corrugations.

VII. 4. c Protective Cover:

Protective cover have been reviewed in Chapter II.1 before, these elements are assembled to the expansion joint externally and protect the bellows against mechanical damages. If the expansion joint is needed to be insulated, the insulation material should be covered around the cover.

VII. 5 Expansion Joint Connection Types:

The connection of the expansion joints to the pipeline systems is done by three ways.

VII. 5. a Welded End: (Fig.III.1)

In this kind of connections, the expansion joint bellow is welded to the welded end. The expansion joint is welded to the pipeline from both sides.

VII. 5. b Floating Flange: (Fig.III.2)

In floating flange expansion joints, the bellow is folded upon the flanges, so the fluid is not in contact with the flanges. Freely rotating flanges provides easy installation features to the expansion joints.

VII. 5. c Fixed Flange: (Fig.III.3)

Expansion joint's bellow is welded to flange or flange neck. As it was explained before, this type of connection is especially suggested for high pressured systems.

VII. 6 Flange Using Methods:

The users must provide as much as information about the flanges while ordering. Especially, special expansion joint designs require special flange types. For example, using rotating flanges for cases that the flat flange usage is advised may cause serious results during the operation. Because of that, selection of fixed flanged expansion joints would be more appropriate for such cases. Manufacturer can use flanges from different standards such as DIN or ANSI or any other standard. Special flange dimensions and material selection may be possible on request. Flange dimensions from ANSI norm is limited up to 24", on the other hand it is possible to produce expansion joints with flanges of DIN norm up to 3000mm. For the flanges bigger than 24", a detailed flange selection table must be filled or using flanges from DIN norm should be suggested.

See the flange tables in Chapter IX for correct flange selection.

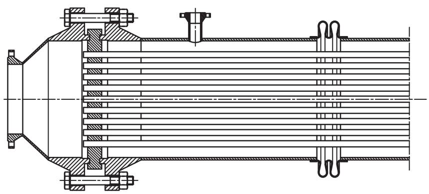
VII. 7. Special Design Applications:

Beside of, compensating thermal expansions and vibrations, expansion joints are also used for solving customized problems. Some examples for special expansion joint applications are given below.

VII. 7. a Heat Exchanger Application:

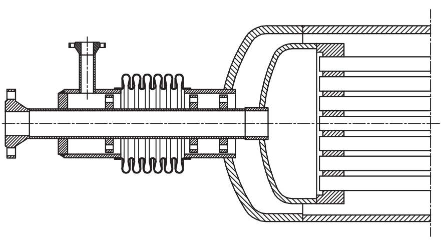
Expansion joint applications for heat exchangers are done by two ways.

In the fig VII-9, the expansion joint assembled on the body of the heat exchanger compensates the expansion. This application is available for small or medium sized projects.



Şekil VII-9

For the bigger heat exchanger projects, the application given in fig.VII-10 must be used. Inch waterch designs, the main part of the heat exchanger expands freely and this expansion is compensated by a small sized expansion joint.



Şekil VII-10

VII. 7. b Expansion joint application as disassembly part:

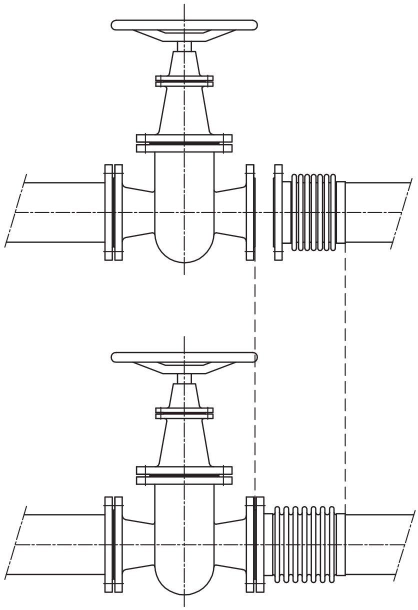


Figure VII-11

In rigid pipeline systems, disassembly of the elements likewise, valves etc… is very difficult even sometimes impossible. This kind of problems may be solved with using axial expansions. Inch waterch cases, the expansion joint's bellow is compressed and extra installation space is created.

Fig VII-11 illustrated the use of an axial expansion joint as a disassembly part. Also this type of application is very useful to create a stress-free operation area.

VII. 7.c Valve sealing:

Especially, for the vacuum applications or acid transportation pipelines, stainless steel bellows are used as the sealing parts in the valves, connected with these pipelines. Fig.VII-12

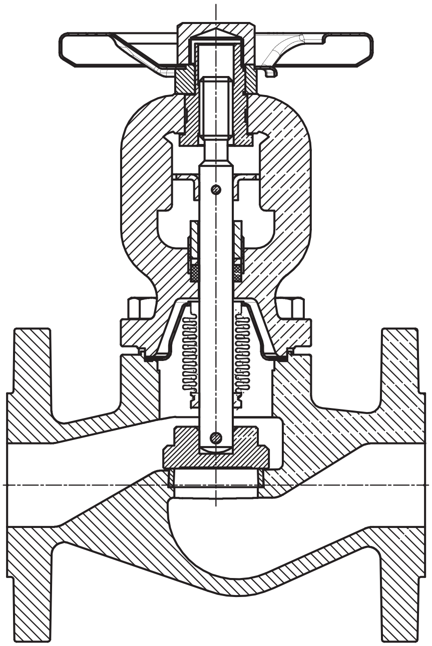


Figure VII-12

VII. 7.d Application at Long Pipeline Systems:

The thermal expansion and erosion cause stresses at very long pipelines, the pipelines exposed to these stresses may be broken. Using the expansion joints as it is seen in fig.VII-13 may be the solution for both issues. Expansion joint designs are dependent on the weather conditions and erosion risks relatively.

VII. 7.e Flexible Engine-Spindle Connection:

Another problem occurs during the power transfer from engine to spindle is the flexibility of the connection. If appropriate flexibility cannot be met, very strong stresses may occur at the spindle and cause danger for the system and the engine as well.

VII. 7. f In central Heating Systems:

The length of the pipelines at the central heating systems may be very long. In case that the expansion of these long pipelines is not compensated, that may cause breaks and leakages even damages in the building structure.

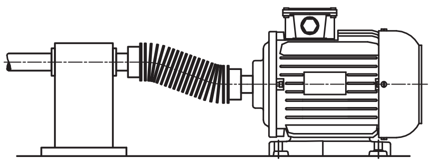
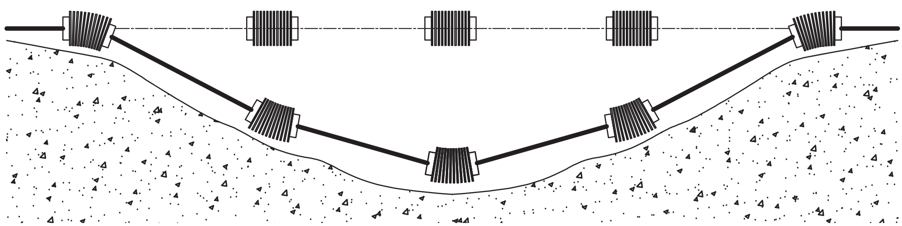


Figure VII-14

Fig VII-14 illustrates the use of expansion joints for the axial and lateral flexibility between the engine and the spindle in order to provide ideal operation conditions.

Figure VII-13



VII. 7. f In central Heating Systems:

The length of the pipelines at the central heating systems may be very long. In case that the expansion of these long pipelines is not compensated, that may cause breaks and leakages even damages in the building structure.

Fig VII-15 illustrates the expansion joint application at the pipelines located in the concrete building structure.

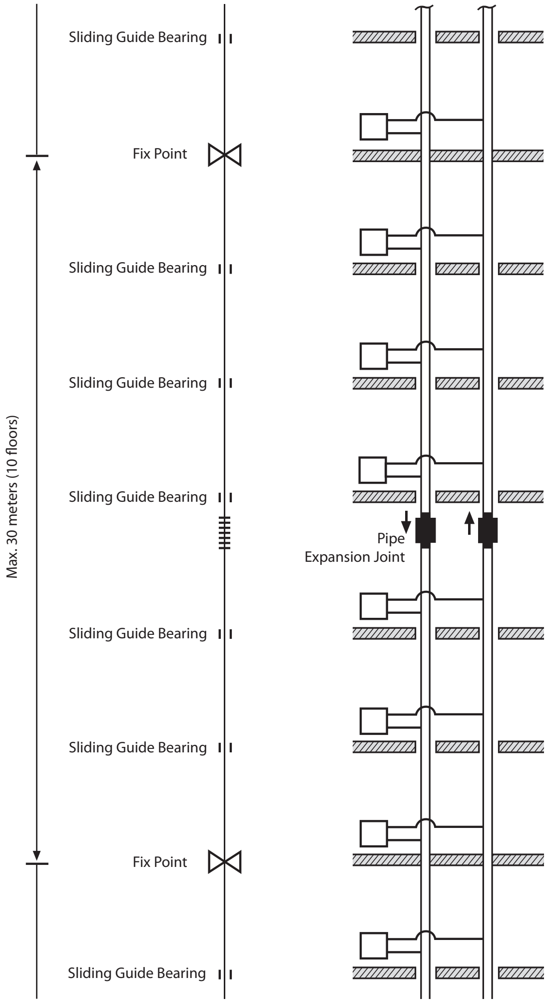


Figure VII-15

Fig VII-15 illustrates the expansion joint application at the pipelines located in the concrete building structure.

VI. 7. g Double layered pressured vessels:

Fig VII-16 illustrates the way of use of the expansion joints to compensate the expansion difference between the layers of the double layered pressure vessels.

The examples given above are the most common use of expansion joint applications. For different and special purposed expansion joint assemblies. Please contact with the manufacturer.

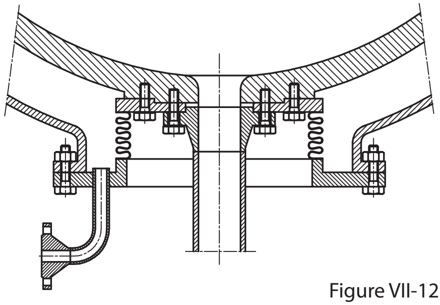


Figure VII-12

Vibration Absorbers

VII. 1 Vibration Absorbing Expansion Joints:

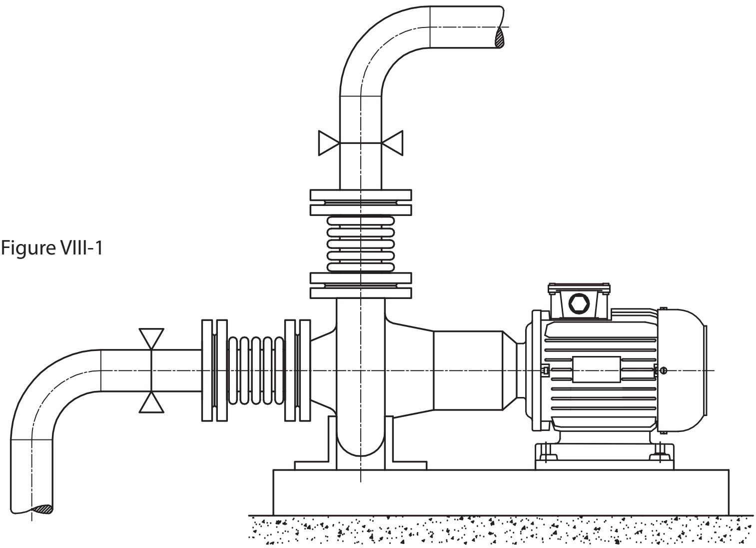
Besides of compensating thermal expansions, the most important function of expansion joints is to sort the problems caused by the system vibration. Expansion joints are very effective especially on compensating the vibrations with high frequency and low oscillation. In cases that the system's oscillation is to high likewise piston engines, expansion joints cannot be used for vibration absorbing.

In other words, we can roughly say that the oscillation of the system vibration should not exceed 10% of total movement of the expansion joint.

Another important point on expansion joint selection is the frequency of periodic movement. If the frequency of the system to be absorbed is close to natural frequency, this may be very dangerous. If it is possible, the oscillation of the vibration can be changed by relocating the loading points.

The manufacturer can detect the characteristics of the bellows and present the customer.

Figure VIII-1



At high flow rates, turbulence zones inside the bellow convolutions may occur. The occurred turbulence is the main reason of the vibration that may damage the system. Inner sleeve application through the internal surface of the expansion joint can prevent the turbulence and related vibration problems.

The easiest solution for vibration absorbing can be provided axial expansion joints. In order to prevent the vibration, the force applied to the fixed points must also be examined.

Generally, the pressure at low diameter pipelines is higher than high diameters. As a result of that, the force applied to the fixed points is also lower because of the cross section area of these pipelines.

Another important matter caused by the vibration creating elements is the assembly difficulties. Expansion joints can provide the required tolerance for installation.

Apart from the problems given above, in order to prevent corrosion, the expansion joints can be manufactured different materials. The corrosion table given in chapter IX helps for selecting the most appropriate material for different fluids.

VII. 2 Application Examples:

Examples of the use of expansion joints as vibration absorbers will be reviewed in this chapter. Pump and expansion joint applications will be given with related figures.

VII. 2a. Pumps (Figure VIII-1):

As it is seen in the figure, expansion joints are used at the connections of the pump to the pipeline, where the pump inlet and outlet are.

The fixed points right after the expansion joints are used to prevent the vibration through pipeline which is caused by the pump.

Use of expansion joints for vibration absorbing is also useful to prevent the noise caused by the vibration.

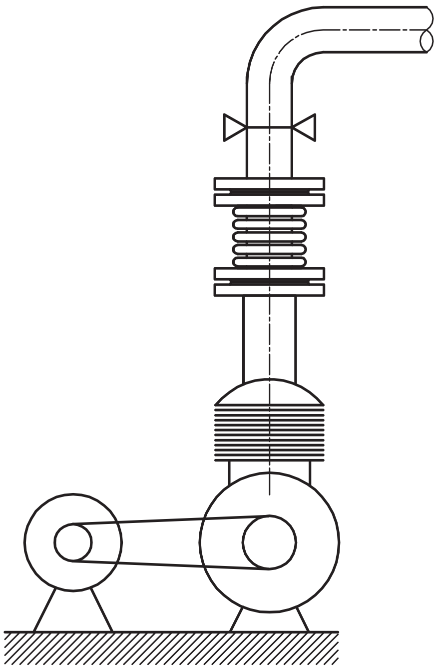
VII. 2b. Expansion Joints (Figure VIII-2):

Absorbing the vibration by expansion joint use is given in figure VIII-2. In most cases, although the insulation, compressor movements cause vibration in the connected pipelines.

Use expansion joint after the compressors absorbs the vibration caused by compressors and provides ideal operation conditions for the system.

In this chapter, only the most common expansion joint applications are given for vibration absorption. In cases that different vibration matters are faced, the users must contact with the manufacturer.

Figure VIII-2



AYVAZ

EXPANSION JOINTS

CHAPTER VIII

CORROSION

CHAPTER VIII

CORROSION

TYPES OF CORROSION

According to the explanation of DIN 50900 (DIN EN ISO 8044), corrosion is the reaction of the metallic materials with their environment that causes serious changes and damages in the structure of the materials. In most cases, corrosion takes an electro-chemical shape, as a result of that many different types of corrosion may occur.

The most important corrosion types for ferritic and non-ferritic materials are explained as follows.

Equal Surface Corrosion

The complete surface of the material is effected from this kind of corrosion. The loss from the weight of the material can be specified with g/m^2h and the fall of the wall thickness with mm/year. This kind of corrosion can be seen in normal steels and includes rusting as well. Equal surface corrosion can affect the stainless steels under only very inconvenient conditions. Other abrasive corrosion types may be caused by the liquids such as acids, bases and salt solutions.

During the design of the components that are subject to corrosion, the tolerances for wall thickness of the flexible pipe and hose assemblies with tin walled products can't be used. This situation is influential on the selection of materials. The resistance of the materials against equal surface corrosion is dependent on the quality of surface.

Pitting Corrosion

The corrosion which is restricted locally can consist under some certain conditions. This type of local corrosion is named after its appearance. Especially in the cases that chlorine and iodine ions present in hydrous solutions, pitting corrosion arises from the effects of these ions.

Unlike the equal surface corrosion, this kind of corrosion can't be calculated and it is only kept under control by choosing the best possible material. The resistance of the stainless steel materials against the pitting corrosion increases in line with the amount of molybdenum content in the chemical formula of the material.

The resistance of the materials against pitting corrosion can be compared with the cumulated reaction values (WS=Cr+3.3:Mo); the higher reaction value means the higher resistance.

Intercrystalline Corrosion

Intercyristalline corrosion is local corrosion type which effect the grain boundries of materials first. This kind of corrosion is caused by the deflection around the grain boundries that reduces the resistance of the materials.

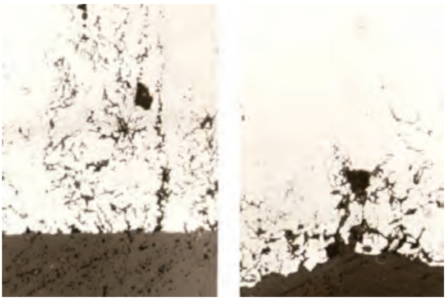
Intercrystalline corrosion may grow up till the grain composition is dissolved.

This deflection movement is dependent on the time and temperature for CrNi coated steels. In cases that the critical temperature is between 550 and 650 °C, the time needed to be spent for the deflection to begin is the subject of the type of the steel. For example while welding the materials that have a high thermal capacity and wall thickness, this situation must be considered. The changes in the material structure dependent on this deflection can be turned around by thermal treatments to be applied to the materials (1000-1050 °C).

This type of corrosion can be reduced by using balancing materials such as low carbon content stainless steel or titanium or niobium.

The intention of intercrstalline corrosion of the materials can be indicated by standard tests (DIN EN ISO 3651-2)

During our ordering process and inspections we request the test results of the materials which proof the eligibility of the material to the standards and resistance against intercrystalline corrosion from the manufacturers.



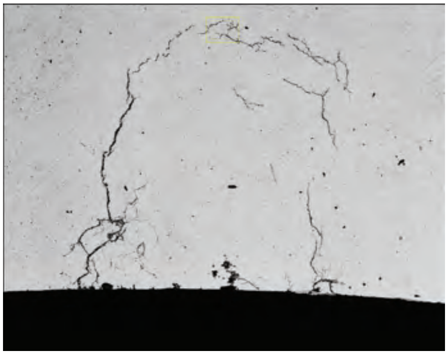
Stress Corrosion Cracking

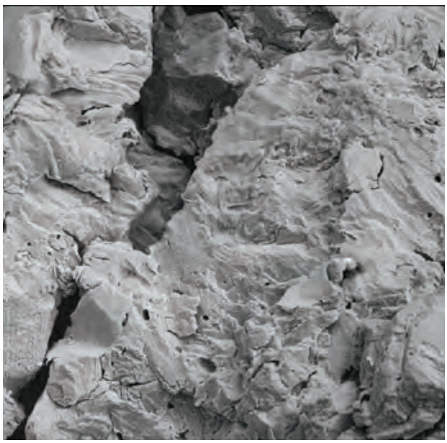
This type of corrosion is generally seen in the austenitic materials that exposed to the corrosive effects and internal or external tensile stress. The most important reason of this type of corrosion is the alkaline solutions that content chlorine. The shape of the crack can be transcrystalline as in the figure 4 as well as intercrystalline as in the figure 5. Transcrystalline cracks may only occur at tempeartures higher than 50 °C, on the other hand intercrystalline cracks can be seen at temperature as low as room temperature in especially austenitic materials.

At elevated temperatures, stress corrosion cracking may be sourced by very little chlorine and lye concentrations. From that point the corrosive effect will always lead to the transcrystalline form of corrosion.

The stress corrosion cracking takes similar shape in the non-ferritic materials as in the austenitic metals. Intercrystaline corrosion cracking may cause the similar damages at higher temperatures than 400°C in high concentrated nickel and nickel alloys as at higher temperatures than 250°C in steam solutions content hydrogen sulphur.

In order to detect and prevent this type of corrosion, it is required to have detailed information about the operation conditions and to make the selection carefully on the basis of expert knowledge.





Crevice Corrosion

Crevice corrosion is a corrosion type which is located in crevices that are caused by the design of the deflections. This kind of corrosion is the result of the lack of oxygen in the crevices. Oxygen has a protective effect on passive layer of the passive materials.

Because of the risk of crevice corrosion, it is required to avoid the designs that contain crevices and makes the deflections possible. The resistance of the high-alloy steels and nickel containing materials against this type of corrosion is dependent on the molybdenum amount in the chemical structure of the material.

As in the pitting corrosion, the cumulative reaction values can be used in order to investigate the resistance of the materials against crevice corrosion.

Contact Corrosion

Contact corrosion is an expression that is used to define the corrosion which is caused by the combination of different materials.

The effect which is named as "practical galvanic potentials" and is used to express the contact corrosion risk in seawater . The materials located close to each other in the diagram are mutually compatible materials. Anodic metal corrodes increases in line with the distance between two materials.

The active or passive characteristics of the materials must be considered carefully for possible contact conditions.

For example; the corrosion products, deflections or the mechanical damages on the surface are likely to activate the corrosion risk of a CrNi Steel. This may cause a potential difference between the active and passive surfaces of the materials and the corrosion in cases if an additional electrolyte exists.

Dezincing

Dezincing is a type of corrosion that is seen in copper-zinc alloys which contain more than 20% zinc in compositions. During the corrosion activity, copper is generally separated from zinc by taking a spongy form.

Zinc may stay either in the solution or above the corrosion level as in the basic salt form. Dezincing may happen on the surface or may be restricted locally as well as it may happen in far deep from the surface.

We can count the tick layers consisted from the corrosion products, water or the lime deposits that are the results of other extraneous matters on the material surfaces as the accelerating factors of dezincing corrosion.

EXPANSION JOINTS

APPENDIX

APPENDIX

Chemical Resistance

Material	Density g. kg/dm³	Specific Heat cp kJ/(kg.K)	Melting Point °C	Melting Heat kJ/kg	Boiling Point °C	Boiling Heat kJ/kg
SOLID MATERIALS						
Gold	19.32	0.130	1063	67.0	2700	1758
Aluminium	2.70	0.921	660	355.0	2270	11723
Antimony	6.69	0.209	630.5	167.5	1635	1256
Copper	8.96	0.385	1083	209.3	2330	4647
Bismuth	9.80	0.126	271	54.4	1560	837
Mercury	13.55	0.138	-38.9	11.7	357	301
Zinc	7.14	0.385	419.4	112.2	907	1800
Ferrit (Pure)	7.87	0.465	1530	272.1	2500	6364
Silver	10.45	0.234	960.8	104.7	1950	2177
Iridium	22.42	0.134	2600	117.2	-	3894
Tin	7.28	0.226	231.9	58.6	2300	2596
Chrome	7.19	0.506	1890	293.1	2642	6155
Lead	11.34	0.130	327.3	23.9	1730	921
Sulphur	2.07	0.720	112.8	39.4	444.6	293
Magnesium	1.74	1.034	650	209.3	1100	5652
Manganese	7.3	0.507	1250	251.2	2100	4187
Molybdenum	10.2	0.271	2625	-	3560	7118
Nickel	8.90	0.444	1455	293.1	3000	6197
Platinum	21.45	0.134	1773	113.0	3804	2512
Titanium	4.54	0.471	1800	-	3000	-
Tungsten	19.3	0.134	3380	251.2	6000	4815
LIQUID MATERIALS						
Acetone	0.79	2.160	-94.3	96.3	56.1	523.4
Benzol	0.88	1.738	5.5	127.3	80.1	395.7
Sea water	1.03		-2.0		100.5	
Ethyl alcohol	0.79	2.470	-114.5	104.7	78.3	841.6
Etilether	0.71	2.328	-116.3	100.5	34.5	360.1
Glycerin	1.26	2.428	18.0	200.5	290.0	854.1
Methylalcohol	0.79	2.470	-98.0	100.5	64.5	1101.1
N-Hexane	0.66	1.884	-95.3	146.4	68.7	330.8
NHektan	0.68	2.219	-90.6	141.5	98.4	318.2
Water	1.00	4.183	0.0	332.4	100.0	2257.1
Turpentine oil	0.87	1.800	-10.0	116.0	160.0	293.1
Food Salt Sol.	1.19	3.266	-18.0		108.0	
GASES	kg./m³	kJ /(m³K)				
Ammonia	0.771	2.060	-77.7	332.0	-33.4	1371
Argon	1.784	0.523	-189.4	29.3	-185.9	163
Nitrogen	1.250	1.043	-210.0	25.5	-195.8	198
Ethylene	1.261	1.465	-169.5	104.3	-103.9	523
Air	1.293	1.001	-	-	-194.0	197
Helium	0.178	5.234	-	37.7	-268.9	21
Hydrogen	0.90	14.235	-259.2	58.2	-252.8	454
Carbon dioxide	1.977	0.825	-56.6	180.9	-78.5	576
Carbon Monoxide	1.250	1.051	-205.1	30.1	-191.5	216
Sulphure dioxide	2.926	0.632	-75.5	115.9	-10.2	390
Methane	0.717	2.177	-182.5	58.6	-161.5	548
oxygen	1.429	0.913	-218.8	13.8	-183.0	214

Chemical Resistance

Meanings of Abbreviations

Assesment	Corrosion Behaviour	Suitability
1	Resistant	Suitable
2	Risk of Corrosion	Restricted Suitability
3	Not Resistant	Unsuitable

Chemical Composion	Temperature °C	304, 321	304L, 316L	Carbon Steel	Brass	Bronze	Monel
Ethyl alcohol	Boiling and 20 °C	1	1	1	1	1	1
Methyl alcohol	20 °C - 65 °C	1	1	1	1	1	1
Aluminum, molten	760 °C	3	3	3	3	3	3
Aluminium Acetate, Saturated Aluminum Sulphate 5%	20 °C - Boiling	1	1	3	3	3	1
Aluminum Fluoride	at 20 °C	3	3	3	3	3	2
Aluminium Hydroxide	at 20 °C	1	1	1	1	1	1
Aluminium Sulphate 5%	65 °C	1	1	3	3	3	1
10%	at 20 °C	1	1	3	3	3	1
Saturated	at 20 °C	1	1	3	3	3	1
Aluminum-Potassium-Sulfate 2-10%	at 20 °C	1	1	3	2	2	2
10%	Boiling	2	1	3	3	3	2
Saturated	Boiling	3	2	3	3	3	2
Ammonia							
All concentrations	at 20 °C	1	1	1	1	1	1
Gas	Hot	3	3	3	3	3	
Ammonia, liquid	at 20 °C	1	1	3	3	3	3
Ammonium Bicarbonate	at 20 °C	1	1	3	3	3	2
Ammonium Bromide	at 20 °C	2	1	3	3	3	2
Ammonium Carbonate 1-5%	at 20 °C	1	1	1	3	3	3
Ammonium chloride 1%	at 20 °C	1	1	2	3	3	1
10%	Boiling	1	1		3	3	2
28%	Boiling	2	1		3	3	2
50&	Boiling	2	1		3	3	2
Ammonium Hydroxide							
All concentrations	at 20 °C	1	1	2	3	3	3
Ammonium monophosphate	at 20 °C	1	1	2	3	3	2
Ammonium nitrate							
All Concentration	at 20 °C	1	1	3	3	2	
Ammonium oxalate 5%	at 20 °C	1	1	2	3	3	
Ammonium Perchlorate 10%	Boiling	1	1	2	3	3	
Ammonium Persulphat5%		1	1	2	3	3	
Ammonium Phosphate	at 20 °C	1	1		3	3	3
Ammonium sulphate 5%	at 20 °C	1	1	2	3	3	3
10% - Saturated	Boiling	2	1	3	3	3	2
Ammonium sulfide	20 °C - Boiling	1	1	3	3	3	3
Amyl Acetate Concentration	at 20 °C	1	1	2	1	1	1
Amyl Chloride	at 20 °C	1	1	3	2	2	2
Aniline 3%	at 20 °C	1	1	2	3	3	2

Chemical Composion	Temperature °C	304, 321	304L, 316L	Carbon Steel	Brass	Bronze	Monel
Crude Concentrate	at 20 °C	1	1	1	3	3	2
Aniline hydrochloride	at 20 °C	3	3		3	3	3
Antimony trichloride	at 20 °C	3	3	3	3	3	3
Acetic Acid 50%	at 20 °C	1	1	3	3	3	3
50-80%	Boiling	3	2	3	3	3	3
80%	at 20 °C	1	1	3	3	3	1
100%	at 20 °C	1	1	3	3	3	1
100%	Boiling	3	2	3	3	3	2
10 atü 100%	200 °C	3	3	3	3	3	2
Acetic Anhydride	at 20 °C	1	1	3	3	3	2
	Boiling	1	1	3	3	3	2
Acetic acid vapor							
30°	Hot	3	2	3	3	3	3
100°	Hot	3	3	3	3	3	2
Acetone	Boiling	1	1	3	1	1	1
Acetyl chloride	Cold	2	2	3	2	2	1
	Boiling	2	2	3	2	2	3
Concentrated Acetylene	at 20 °C	1	1	1	3	3	1
Commercial purity	at 20 °C	1	1	1	3	3	1
Acid-salt mixture							
10% H2So4 and							
10% CuSo4 5H20	Boiling	1	1	3	3	3	3
10% H2So4 and							
2% FeSo4. 7H20	Boiling	1	1	3	3	3	3
Copper acetate (saturated sol.)		1	1	3			2
Copper Carbonate (Doşmuş sol)							
50% NHwas dissolved in oH		1	1		3	3	
Copper chloride 1%	at 20 °C	2	1	3	3	3	3
1%	70 °C	3	3	3	3	3	3
Mixed with air at 1%	at 20 °C	2	1	3	3	3	3
5%	at 20 °C	3	2	3	3	3	3
with 5% air	at 20 °C	3	3	3	3	3	3
Copper cyanide (Sat.sol)	Boiling	1	1		3	3	2
Copper Nitrate							
Mixed with air at 1%	at 20 °C	1	1	3	3	3	3
Mixed with air at 5%	at 20 °C	1	1	3	3	3	3
50% water solution	Hot	1	3	3	2	2	3
Copper sulphate							
5% mixed	at 20 °C	1	1	3	2	2	3
Saturated Solution	Boiling	1	1	3	2	2	3
Barium Carbonate	at 20 °C	1	1	2	1	1	2
5% barium chloride-saturated	at 20 °C	1	1	3	2	2	2
Barium Hidroaksit, solution	Hot	1	1	2	1	1	2
Barium Nitrate Solution	Hot	1	1	2			
Barium Sulphat	at 20 °C	1	1		1	1	2
Barium Sulfide, Saturated	at 20 °C	1	1	3	3	3	

Chemical Composion	Temperature °C	304, 321	304L, 316L	Carbon Steel	Brass	Bronze	Monel
Benzene (benzol) Hot	at 20 °C	1	1	2	1	1	2
Benzoic Acid	at 20 °C	1	1	1	1	1	
Benzin	at 20 °C	1	1	2	1	1	1
Borax 5%	Hot	1	1	2	1	1	2
Boraxic Acid 5%	Hot or Cold	1	1				
Boric Acid							
5% solution Hot	at 20 °C	1	1	3	1	1	2
5% solution	Boiling	1	1	3	2	1	2
Saturated Solution	at 20 °C	1	1	3	3	2	2
Saturated Solution	Boiling	1	1	3	3	3	2
Bromine	at 20 °C	3	3	3	3	3	3
Steam		1	1	3	2	1	1
Butyl Acetate		1	1	2			2
Butyric Acid 5%	20 °C -65 °C	1	1	3	2	2	2
Solution	Boiling	1	1	3	3	3	2
Zinc	Molten	3	3	3	3	3	3
Zinc chloride	at 20 °C	1	1	3	3	3	2
	Boiling	2	2	3	3	3	2
Zinc Cyanide	at 20 °C	1	1	3			
Zinc nitrate		1	1	3			
Zinc Sulphat	20 °C, Boiling	1	1	3	3	2	2
Iron Hydroxide	at 20 °C	1	1	3			
Iron Nitrate	at 20 °C	1	1	3	3	3	3
Iron Sulphat	at 20 °C	1	1	3	3	3	3
Sea water	at 20 °C	1	1	3	2	2	1
Sewage		1	1		1	1	1
Dichloroethane	Boiling	1	1	3	3	3	2
Dinitrochlorobenzene	at 20 °C	1	1	3			
Apple juice	at 20 °C	1	1	2	1	1	1
Broth	Cold	1	1	3			2
Ether	at 20 °C	1	1	2	1	1	2
Ethyl Acetate	at 20 °C	1	1	2	1	1	2
Ethyl Chloride	at 20 °C	1	1	2	2	2	1
Ethylene chloride	at 20 °C	1	1	2	2	2	1
Ethylene Glycol	at 20 °C	1	1	2	1	1	1
Ferricloride							
1% solution	at 20 °C	2	1	3	3	3	3
1% solution	Boiling	3	3	3	3	3	3
5% solution	20th	3	3	3	3	3	3
Ferrocloride	20th	3	1	3	2	2	
Flor (Gas)	at 20 °C	3	3	3	3	3	3
Formaldehyde		1	1	2	1	1	1
Formic acid	20 °C -65 °C	2	1	3	2	2	2
Phosphoric Acid 1%	at 20 °C	1	1	3	3	3	2
1%	Boiling	1	1	3	3	3	2
1% -3 atm.	140 °C	1	1	3	3	3	2
5%	at 20 °C	1	1	3	3	3	2
Phosphoric Acid 10%	at 20 °C	3	1	3	3	3	2
10-50%	Boiling	1	1	3	3	3	3
80%	at 20 °C	3	3	3	3	3	2
80%	110 °C	3	3	3	3	3	3
85%	Boiling	3	3	3	3	3	3

Chemical Composion	Temperature ºC	304, 321	304L, 316L	Carbon Steel	Brass	Bronze	Monel
Fuel-oil	Hot	1	1	2	1	1	2
Sulphuric Acid		3	2		3	3	2
Gallic acid	20 °C -100 °C	1	1	3			2
Glycerin		1	1	2	1	1	1
Silver Bromide		2	1	3	3	3	
Silver Chloride		3	3	3	3	3	3
Silver Nitrate		1	1	3	3	3	3
Hydrochloric acid	20 °C	3	3	3	3	3	3
Hydrofluoric Acid	20 °C	3	3	3	3	3	1
Hidroflosilisik Acid	20 °C	3	3	3	2	2	2
Hydrogen peroxide	20 °C	2	1	3	3	3	2
Hydrogen Sulphide	20 °C	2	1	2	1	1	3
Hypo-		1	1				
Lodine	20 °C	3	3	3	3	3	3
Lodoform	20 °C	1	1	3			2
Gelatin		1	1	3	1	1	1
Coffee	Boiling	1	3	1	1	1	1
Tin	molten	3	3	3	3	3	
Tin Chloride Solution	20 °C-Boiling	3	3	3	3	3	3
Calcium Carbonate	at 20 °C	1	1	1			1
Calcium Chlorate							
Dilute Solution	at 20 °C	1	1	2			2
Calcium Chloride							
Any solution	at 20 °C	2	1	3	2	2	3
Calcium Clorohypocloride							
(Bleaching powder) 1%	at 20 °C	3	3	3	2	2	3
5%	at 20 °C	3	3	3	2	2	3
Calcium Hypochloride 2%	at 20 °C	2	1	3	2	2	3
Calcium Sulfate, Saturated	at 20 °C	1	1	3	1	1	2
Carbonlik acid, Saturated, sol.	at 20 °C	1	1	3	3	1	3
Carboxylic acid	20 °C-Boiling	1	1	3	2	2	1
Carbonated water		1	1	3	2	2	3
Carbonbisulphite	at 20 °C	1	1	2	1	2	2
The carbon monoxide gas	760 °C -870 °C	1	1	1	3	3	1
Carbon tetrachloride	at 20 °C	1	1	2	1	1	1
Dry	Boiling	1	1	2	1	1	2
Commercial + 1% Water		3	3	3	2	2	2
Carnallite (KCl-MgCl2 6H2o)	Boiling	3	1				
Tar		1	1	2	1	1	2
Creosote	Hot	1	1	2	1	1	2
Tar	Hot	1	1	2	2	2	2
Kerosene	20 °C	1	1	2	1	1	2
Ketchup	20 °C -65 °C	1	1	3			2
Quinine Bisulphate		2	1	3			
Quinine Sulphate		1	1	3	2	2	2
Cola Syrup (pure)	20 °C	1	1	3			2
Clorasedic Acid	20 °C	3	3	3	3	2	2
Clorbenzol Sol.Pure.Dry	20 °C	1	1	2	2	2	2
Chloric acid	20 °C	3	3	3	3	3	3
Chlorine gas (dry)	20 °C	3	2	2	1	1	2
(Moist)	20 °C	3	3	3	3	3	3
Chlorinated water, saturated		3	2	3			2
Chloroform	20 °C	1	1	1	1	1	1

Chemical Composion	Temperature °C	304, 321	304L, 316L	Carbon Steel	Brass	Bronze	Monel
Chromic Acid 5%	20 °C	1	1	3	3	3	3
10%	20 °C	3	2	3	3	3	3
Commercial 50%	20 °C	3	3	3	3	3	3
Commercial 50%	Boiling	3	3	3	3	3	3
Chrome Plating Bath	20 °C	1	1	2			3
Sulphure, moist	20 °C	2	1	3	3	3	2
Molten	130 °C	1	1	3	3	3	1
Molten	445 °C	3	3	3	3	3	3
Sulfur Chloride		3	3	3	1	1	2
Sulfur Diosit, moist	20 °C	2	1	3	2	2	3
	300 °C	1	1	3	1	1	2
Lactic acid 1%	20 °C	1	1	3	2	2	2
1%	Boiling	1	1	3	3	3	2
5%	at 20 °C	1	1	3	2	2	2
5%	65 °C - Boiling	2	1	3	3	3	2
10%	at 20 °C	2	1	3	2	2	2
10%	65 °C - Boiling	3	2	3	3	3	2
Concentrated	at 20 °C	2	1	3	2	2	2
Concentrated	Boiling	3	3	3	3	3	3
Concentration smoky.	20 °C - 45 °C	1	1	3	3	3	3
Concentration smoky.	Boiling	3	3	3	3	3	3
Magnesium Sulphat		1	1	3	1	1	2
Yeast		1	1		3	3	1
Fruit Juices	at 20 °C	1	1	3	2	2	2
Ink	at 20 °C	2	1	3	3	3	1
Starch Solution		1	1				2
oxalic Acid 5-10%	20 °C - Boiling	1	1	3	3	2	2
10%	Boiling	3	3	3	3	2	2
25-50%	Boiling	3	3	3	3	2	1
oleic Acid	20 °C -200 °C	1	1	2	2	2	2
Paraffin		1	1	2	1	1	1
oil - Ether		1	1	2			2
Pitric Acid	at 20 °C	1	1	3	3	3	3
Potassium Bichromate 25%	at 20 °C	1	1		3	3	2
25%	Boiling	1	1		3	3	2
Potassium Bromide	at 20 °C	2	1	3	2	2	2
Potassium Carbonate 1%	at 20 °C	1	1	2	2	2	1
Potassium Chlorate	Boiling	1	1	2	3	3	3
Potassium chloride 1%	at 20 °C	1	1	3	3	2	1
5%	at 20 °C	1	1	3	3	2	1
Potassium Chromium Sulphate	at 20 °C	1	1	3	3	2	
Potassium Cyanide	at 20 °C	1	1	2	3	3	2
Potassium ferricyanide	at 20 °C	1	1	3			2
5% Potassium Hydroxide	at 20 °C	1	1	2	3	2	1
Potassium Hypochlorite	at 20 °C	2	2	3	3	3	3
1-50% Potassium Nitrate	at 20 °C	1	1	3	2	2	1
50%	Boiling	1	1	3			1
Molten	550 °C	1	1	3			
Potassium oxalat		1	1				
Potassium Permanganate 5%	20 °C	1	1	2			3
Potassium Sulphate		1	1	2	2	1	2
Potassium Sulphite		1	1	3			
Pirogallik Acid		1	1	2			

Chemical Composion	Temperature ºC	304, 321	304L, 316L	Carbon Steel	Brass	Bronze	Monel
Soap	20 °C	1	1	2	1	1	1
Vegetable Juice		1	1	2	3	2	2
Cellulose		1	1				1
Liquid Adhesive	20 °C	1	1	1	2	2	2
Acid Solution	20 °C -60 °C	2	1	2	3	3	2
Vinegar	20 °C	1	1	3	3	2	3
Citric acid	20 °C -65 °C	1	1	3	2	1	2
15%	20 °C	1	1	3	3	2	2
15%-concentration	Boiling	2	1	3	3	2	3
Acid Cyanide	20 °C	1	1	3	3	3	2
Cyanide Gas	20 °C	1	1				
Sodium Acetate		1	1	3			2
Sodium bicarbonate	20 °C -65 °C	1	1	3	2	2	1
Sodium bisulphate	20 °C	1	1	3	3	2	2
Saturated Solution	20 °C	3	3	3	3	2	2
Sodium Carbonate 5%	20 °C -65 °C	1	1	2	2	2	1
5-50%	Boiling	1	1	2	2	2	1
Molten	900 °C	3	3	3	3	3	1
Sodium Chlorite	20 °C-Boiling	2	1	3	3	2	1
Sodium Cyanide	at 20 °C	1	1	2	3	3	
Sodium Fluoride	at 20 °C	2	1	3	1	1	1
Sodium Hypochloride		2	1	3	3	2	3
Sodium Hyposulphite	at 20 °C	1	1	3			1
Sodium Nitrate	Molten	1	1	2	1	1	2
Sodium perchlorate	20 °C-Boiling	1	1				
Sodium Phosphate	at 20 °C	1	1	2	2	2	2
Sodium Suphate	at 20 °C	1	1	3	1	1	1
Sodium Sulphide		2	1	3	3	3	2
Sodium Sulphide	20 °C -65 °C	1	1	3	3	2	2
Sodium Triosulphate	20 °C-Boiling	1	1	3	3	3	2
Stearic Acid	at 20 °C	1	1				
Strontium Hydroxide		1	1	3			2
Strontium Nitrate Solution		1	1	2	1	1	1
Water		3	2	3	3	2	3
5-10% sulphuric acid	at 20 °C	3	3	3	3	3	3
5-10%	Boiling	3	3	3	3	3	3
50%	at 20 °C	3	3	3	3	3	3
50%	Boiling	3	3	3	3	3	3
Concentrated	at 20 °C	1	1	3	3	2	3
Concentrated	Boiling	3	3	3	3	2	3
Concentrated	150 °C	3	3	3	3	1	3
Smoky	at 20 °C	3	2	3	3	2	3
Wine		1	1	3	3	3	2
Tenenli Acid	at 20 °C	1	1	3	2	3	1
	65 °C	1	1		2	1	3
Tartaric acid	20 °C - Boiling	2	1	3	2	1	2
Trichloroacetic acid	20 °C	3	3	3	3	2	3
Trichloroethylene	20 °C	1	1	3	1	1	1
Varnish	20 °C	1	1	2	1	1	1
Whiskey		1	1	3	2	1	1
Whole Milk	20 °C	1	1	3	3	3	2
oils, crude		1	1		2	2	1
oils, mineral, vegetable		1	1		2	2	1

t	p	v'	v''	h'	h''	r	s'	s''
°C	bar	dm³/kg	m³/kg	kJ/kg		kJ/kg	kJ/kg	
0	0.006108	1.0002	206.3	-0.04	2501.6	2501.6	-0.0002	9.1577
2	0.007055	1.0001	179.9	8.39	2505.2	2469.8	0.0306	9.1047
4	0.008129	1.0000	157.3	16.80	2508.9	2492.1	0.0611	9.0526
6	0.009345	1.0000	137.8	25.21	2512.6	2487.4	0.0913	9.0015
8	0.10720	1.0001	121.0	33.60	2516.2	2482.6	0.1213	8.9513
10	0.12270	1.0003	106.4	41.99	2519.9	2477.9	0.1510	8.9020
12	0.014014	1.0004	93.84	50.38	2523.6	2473.2	0.1805	8.8536
14	0.015973	1.0007	82.90	58.75	2527.2	2468.5	0.2098	8.8060
16	0.018168	1.0010	73.98	67.13	2530.9	2463.8	0.2388	8.7593
18	0.02062	1.0013	65.09	75.50	2434.5	2459.0	0.2677	8.7135
20	0.02337	1.0017	57.84	83.86	2538.2	2454.3	0.2963	8.6684
22	0.02642	1.0022	51.49	92.23	2541.8	2449.6	0.3247	8.6241
24	0.02982	1.0026	45.93	100.59	2545.5	2444.9	0.3530	8.5806
26	0.03360	1.0032	41.03	108.95	2549.1	2440.2	0.3810	8.5379
28	0.03778	1.0037	36.73	117.31	2552.7	2435.4	0.4088	8.4959
30	0.04241	1.0043	32.93	125.66	2556.4	2430.7	0.4365	8.4546
32	0.04753	1.0049	29.57	134.02	2560.0	2425.9	0.4640	8.4140
34	0.05318	1.0056	26.60	142.38	2563.6	2421.2	0.4913	8.3740
36	0.05940	1.0063	23.97	150.74	2567.2	2416.4	0.5184	8.3348
38	0.06624	1.0070	21.63	159.09	2570.8	2411.7	0.5453	8.2962
40	0.07375	1.0078	19.55	167.45	2574.4	2406.9	0.5721	8.2583
42	0.08198	1.0086	17.69	175.81	2577.9	2402.1	0.5987	8.2209
44	0.09100	1.0094	16.04	184.17	2581.5	2397.3	0.6252	8.1842
46	0.100866	1.0103	14.56	192.53	2585.1	2392.5	0.6514	8.1481
48	0.11162	1.0112	13.23	200.89	2588.6	2387.7	0.6776	8.1842
50	0.12335	1.0121	12.05	209.26	2592.2	2382.9	0.7035	8.0776
52	0.13613	1.0131	10.98	217.62	2595.7	2378.1	0.7293	8.0432
54	0.15002	1.0140	10.02	225.98	2599.2	2372.2	0.7550	8.0093
56	0.16511	1.0150	9.159	234.35	2602.7	2368.4	0.7804	7.9759
58	0.18147	1.0161	8.381	242.72	2606.2	2363.5	0.8058	7.9431
60	0.19920	1.0171	7.679	251.09	2609.7	2358.6	0.8310	7.9108
62	0.2184	1.0182	7.044	259.46	2613.2	2353.7	0.8560	7.8790
64	0.2391	1.0193	6.948	267.84	2616.9	2348.8	0.8809	7.8477
66	0.2615	1.0205	5.476	276.21	2620.1	2343.9	0.9057	7.8168
68	0.2856	1.0217	5.046	284.59	2623.5	2338.9	0.9303	7.7864
70	0.3116	1.0228	4.656	292.97	2626.9	2334.0	0.9548	7.7565
72	0.3396	1.0241	4.300	301.35	2630.3	2329.0	0.9792	7.7270
74	0.3696	1.0253	3.976	309.74	2633.7	2324.0	1.0034	7.6979
76	0.4019	1.0266	3.680	318.13	2637.1	2318.9	1.0275	7.6693
78	0.4365	1.0279	3.409	326.52	2640.4	2313.9	1.0514	7.6410
80	0.4736	1.0292	3.162	334.92	2643.8	2308.8	1.0753	7.6132
82	0.5133	1.0305	2.162	343.31	2647.1	2303.8	1.0990	7.5858
84	0.5557	1.0319	2.935	351.71	2650.4	2298.7	1.1225	7.5588
86	0.6011	1.0333	2.927	360.12	2653.6	2293.5	1.1460	7.5321
88	0.6495	1.0347	2.536	368.53	2656.9	2288.4	1.1693	7.5058
90	0.7011	1.0361	2.361	376.94	2660.1	2283.2	1.1925	7.4799
92	0.7561	1.0376	2.200	385.36	2663.4	2278.0	1.2156	7.4543
94	0.8146	1.0391	2.052	393.78	2666.6	2272.8	1.2386	7.4291
96	0.8769	1.0406	1.915	402.20	2669.7	2267.5	1.2615	7.4042
98	0.9430	1.0421	1.789	410.63	2672.9	2262.2	1.2842	7.3796

t °C	p bar	v' dm^3/kg	v'' m^3/kg	h'	h''	r kJ/kg	s'	s''
				kJ/kg			kJ/kg	
100	1.0133	1.0437	1.673	419.06	419.06	2258.9	1.3069	7.3554
105	1.2080	1.0477	1.419	440.17	440.17	2243.6	1.3630	7.2962
110	1.4327	1.0519	1.210	461.32	461.32	2230.0	1.4185	7.2388
115	1.6909	1.0562	1.036	482.50	482.50	2216.2	1.4733	7.1832
120	1.9854	1.0606	0.8915	503.72	503.72	2202.2	1.5276	7.1293
125	2.3210	1.0652	0.7702	524.99	524.99	2188.0	1.5276	7.0769
130	2.7013	1.0700	0.6681	546.31	546.31	2173.6	1.5813	7.0261
135	3.131	1.0750	0.5818	567.68	567.68	2158.9	1.6344	6.9766
140	3.614	1.0801	0.5085	589.10	589.10	2144.0	1.6869	6.9284
145	4.155	1.0853	0.4460	610.60	610.60	2128.0	1.7390	6.8815
150	4.760	1.0908	0.3924	632.15	632.15	2113.2	1.7906	6.8358
155	5.433	1.0964	0.3464	653.78	653.78	2097.4	1.8416	6.7911
160	6.181	1.1022	0.3068	675.47	675.47	2081.3	1.8923	6.7475
165	7.008	1.1082	0.2724	697.25	697.25	2064.8	1.9425	6.7048
170	7.920	1.1145	0.2165	719.12	719.12	2047.9	1.9923	6.6630
175	8.924	1.1209	0.1938	741.07	741.07	2030.7	2.0416	6.6221
180	10.027	1.1275	0.1739	763.12	762.12	2013.1	2.0906	6.5819
185	11.233	1.1344	0.1563	785.26	785.26	1995.2	2.1393	6.5424
190	12.551	1.1415	0.1408	807.52	807.52	1976.7	2.1876	6.5036
195	13.987	1.1589	0.1272	829.88	829.88	1957.9	2.2356	6.4654
200	15.549	1.1565	0.1150	852.37	852.37	1938.6	2.2833	6.4278
205	17.243	1.1644	0.1042	874.99	874.99	1918.8	2.3307	6.3906
210	19.077	1.1726	0.0946	897.74	897.74	1898.5	2.3778	6.3539
215	21.060	1.1811	0.0860	920.63	920.63	1877.6	2.4247	6.3176
220	23.198	1.1900	0.0784	943.67	943.67	1856.2	2.4713	6.2817
225	25.501	1.1992	0.0715	966.89	966.89	1834.3	2.5178	6.2461
230	27.976	1.2087	0.0653	990.26	990.26	1811.7	2.5641	6.2107
235	30.632	1.2187	0.0597	1013.8	1013.8	1788.5	2.6102	6.1756
240	33.478	1.2291	0.0546	1097.6	1037.6	1764.6	2.6562	6.1408
245	36.523	1.2399	0.0500	1061.6	1061.6	1740.0	7020	6.1057
250	39.776	1.2513	0.0459	1085.8	1085.8	1714.6	2.7478	6.0709
255	43.246	1.2632	0.0421	1110.2	1110.2	1688.5	2.7935	6.0359
260	46.943	1.2756	0.0387	1134.9	1134.9	1661.5	2.8392	6.0010
265	50.877	1.2887	0.0356	1159.2	1159.9	1633.6	2.8848	59658
270	55.058	1.3025	0.0327	1185.2	1185.2	1604.6	2.9306	5.9304
275	59.496	1.3170	0.0301	1210.9	1210.9	1574.7	2.9763	5.8947
280	64.202	1.3324	0.0277	1236.8	1236.8	1543.6	3.0223	5.8586
285	69.186	1.3487	0.0255	1263.2	1263.2	1511.3	3.0683	5.8220
290	74.037	1.3659	0.0235	1290.0	1290.0	1477.6	3.1146	5.7848
295	80.037	1.3844	0.0217	1317.3	1317.3	1442.6	3.1611	5.7469
300	85.927	1.4041	0.0183	1345.0	1345.0	1406.0	3.2079	5.7069
310	98.700	1.4480	0.0155	1402.4	1402.4	1327.6	3.2512	5.7081
320	112.89	1.4995	0.0130	1462.6	1462.6	1241.1	3.4500	5.6278
330	128.63	1.5615	0.0130	1526.6	1526.5	1143.6	3.5528	5.4490
340	146.05	1.6387	0.0108	1595.5	1595.5	1030.7	3.6616	5.3427
350	165.35	1.7411	0.0088	1671.9	1671.9	895.7	3.7800	5.2177
360	186.75	1.8959	0.0069	1764.2	1764.2	721.3	3.9210	5.0600
370	210.54	2.2136	0.0050	1890.2	1890.2	452.6	4.1108	4.8144
374.15	221.20	3.17	0.0032	2107.4	2107.4	0.0	4.4429	4.4429

t = temperature v = specific volume of fluid h ‘= liquid enthalpy r = the heat of vaporization s’ = liquid entropy
p = pressure v” = specific volume of steam h” = gas enthalpy s” = gas entropy

t °C	p bar	v' dm³/kg	v'' m³/kg	h'	h''	r kJ/kg	s'	s''
				kJ/kg			kJ/kg	
0.010	6.9808	1.0001	129.20	29.34	2514.4	2485.0	0.1060	8.9767
0.015	13.036	1.0006	87.98	54.71	2525.5	2470.7	0.1957	8.8288
0.020	17.513	1.0012	67.01	73.46	2533.6	2460.2	0.2607	8.7246
0.025	21.096	1.0020	54.26	88.45	2540.2	2451.7	0.3119	8.6440
0.030	24.100	1.0027	45.67	101.00	2545.6	2444.6	0.3544	8.5785
0.035	26.694	1.0033	39.48	111.85	2550.4	2438.5	0.3907	8.5232
0.040	28.983	1.0040	34.80	121.41	2554.5	2433.1	0.4225	8.4755
0.045	31.035	1.0046	31.14	129.99	2558.2	2428.2	0.4507	8.4335
0.050	32.898	1.0052	28.19	137.77	2561.6	2423.8	0.4763	8.3960
0.055	34.605	1.0058	25.77	144.91	2564.7	2419.8	0.4995	8.3621
0.060	36.183	1.0064	23.74	151.50	2567.5	2416.0	0.5209	8.3312
0.065	37.651	1.0069	22.02	157.64	2570.2	2412.5	0.5407	8.3029
0.070	39.025	1.0074	20.53	163.38	2572.6	2409.2	0.5591	8.2767
0.075	40.316	1.0079	19.24	168.77	2574.9	2406.2	0.5763	8.2523
0.080	41.534	1.0084	18.10	173.86	2577.4	2403.2	0.5925	8.2296
0.085	42.689	1.0089	17.10	178.69	2579.2	2400.5	0.6079	8.2082
0.090	43.787	1.0094	16.20	183.28	2581.1	2397.9	0.6224	8.1881
0.095	44.833	1.0098	15.40	187.65	2583.0	2395.3	0.6361	8.1691
0.10	45.833	1.0102	14.67	191.83	2584.8	2392.9	0.6493	8.1511
0.12	49.446	1.0119	12.36	206.94	2591.2	2384.3	0.6963	8.0872
0.14	52.574	1.0133	10.69	220.02	2596.7	2376.7	0.7367	8.0334
0.16	55.341	1.0147	9.433	231.59	2601.6	2370.0	0.7721	7.9869
0.18	57.826	1.0160	8.445	241.99	2605.9	2363.9	0.8036	7.9460
0.20	60.086	1.0172	7.650	251.45	2609.9	2358.4	0.8321	7.9094
0.25	64.992	1.0199	6.204	271.99	2618.3	2346.4	0.8932	7.8323
0.30	69.124	1.0223	5.229	289.30	2625.4	2336.1	0.9441	7.7695
0.40	75.886	1.0265	3.993	317.65	2636.9	2319.2	1.0261	7.6709
0.45	78.743	1.0284	3.576	329.64	2641.7	2312.0	1.0603	7.6307
0.50	81.345	1.0301	3.240	340.56	2646.0	2205.4	1.0912	7.5947
0.55	83.737	1.0317	2.964	350.61	2649.9	2299.3	1.1194	7.5623
0.60	85.954	1.0333	2.732	359.93	2653.6	2293.6	1.1454	7.5327
0.65	88.021	1.0347	2.535	368.62	2656.9	2288.3	1.1696	7.5055
0.70	89.959	1.0361	2.365	376.77	2660.1	2283.3	1.1921	7.4804
0.75	91.785	1.0375	2.217	384.45	2663.0	2278.6	1.2131	7.4570
0.80	93.512	1.0387	2.087	391.72	2665.8	2274.0	1.2330	7.4352
0.85	95.152	1.0400	1.972	398.63	2668.4	2269.8	1.2518	7.4147
0.90	96.713	1.0412	1.869	405.21	2670.9	2265.6	1.2696	7.3954
1.0	99.632	1.0434	1.694	417.51	2675.4	2257.9	1.3027	7.3598
1.5	111.37	1.0530	1.159	467.13	2693.4	2226.2	1.4336	7.2234
2.0	120.23	1.0608	0.8854	504.70	2706.3	2201.6	1.5301	7.1268
2.5	127.43	1.06675	0.7184	535.34	2716.4	2181.0	1.6071	7.0520
3.0	133.54	1.0735	0.6056	561.43	2724.7	2163.2	1.6716	6.9909
3.5	138.87	1.0789	0.5240	584.27	2731.6	2147.4	1.7273	6.9392
4.0	143.62	1.0839	0.4622	604.67	2737.6	2133.0	1.7764	6.8943
4.5	147.92	1.0885	0.4138	623.16	2742.9	2119.7	1.8204	6.8547
5.0	151.84	1.0928	0.3747	640.12	2747.5	2107.4	1.8604	6.8192
6.0	158.84	1.1009	0.3155	670.42	2755.5	2085.0	1.9308	6.7575
7.0	164.96	1.1082	0.2727	697.06	2762.0	2064.9	1.9918	6.7052
8.0	170.41	1.1150	0.2403	720.94	2767.5	2046.5	2.0457	6.6596
9.0	175.36	1.1213	0.2148	742.64	2772.1	2029.5	2.0941	6.6192
10.0	179.88	1.1274	0.1943	762.61	2776.2	2013.6	2.1382	6.5828

t	p	v'	v''	h'	h''	r	s'	s''
°C	bar	dm³/kg	m³/kg	kJ/kg		kJ/kg	kJ/kg	
11	184.07	1.1331	0.1774	781.13	2779.7	1998.5	2.1786	6.5497
12	187.96	1.1386	0.1632	798.43	2782.7	1984.3	2.2161	6.5194
13	191.61	1.1438	0.1511	814.70	2785.4	1970.7	2.2510	6.4913
14	195.04	1.1489	0.1407	830.08	2787.8	1957.7	2.2837	6.4651
15	198.29	1.1539	0.1317	844.67	2789.9	1945.2	2.3145	6.4406
16	201.37	1.1586	0.1237	858.56	2731.7	1933.2	2.3436	6.4175
17	204.31	1.1633	0.1166	871.84	2739.4	1921.5	2.3713	6.3957
18	207.11	1.1678	0.1103	884.58	2794.8	1910.3	2.3976	6.3751
19	209.80	1.1723	0.1047	896.81	2796.1	1899.3	2.4228	6.3554
20	212.37	1.1766	0.09954	908.59	2791.2	1888.6	2.4469	6.3367
21	214.85	1.1809	0.09489	919.96	2798.2	1878.2	2.4700	6.3187
22	217.24	1.1850	0.09065	930.95	2799.1	1868.1	2.4922	6.3015
23	219.55	1.1892	0.08677	941.60	2799.8	1858.2	2.5136	6.2849
24	221.78	1.1932	0.08320	651.93	2800.4	1848.5	2.5343	6.2690
25	223.94	1.1972	0.07991	961.96	2800.9	1839.0	2.5543	6.2536
26	226.04	1.2011	0.07686	971.72	2801.4	1829.6	2.5736	6.2387
28	230.05	1.2088	0.07139	990.48	2802.0	1811.5	2.6106	6.2104
29	233.84	1.2163	0.06663	1008.4	2802.3	1793.9	2.6455	6.1837
30	237.45	1.2237	0.06244	1025.4	2802.3	1776.9	2.6786	6.1585
32	240.88	1.2310	0.05873	1041.8	2802.1	1760.3	2.7101	6.1344
34	244.16	1.2381	0.05541	1057.6	2802.7	1744.2	2.7401	6.11115
36	247.31	1.2451	0.05244	1072.7	2801.1	1728.4	2.7689	6.0896
38	250.33	1.2521	0.04975	1087.4	2800.3	1712.9	2.7965	6.0685
40	257.41	1.2691	0.04404	1122.1	2797.7	1675.6	2.8612	6.0191
45	263.91	1.2858	0.03943	1154.5	2794.2	1639.7	2.9206	5.9735
50	269.93	1.3023	0.035.63	1184.9	2789.9	1605.0	2.9757	5.9309
55	275.55	1.3187	0.032.44	1213.7	2785.0	1571.3	2.0273	5.8908
60	280.82	1.3350	0.02972	1241.1	2779.5	1538.4	3.0759	5.8527
65	285.79	1.3513	0.02737	1267.4	2773.5	1506.0	3.1219	5.8162
70	290.50	1.3677	0.02533	1292.7	2766.9	1474.2	3.1657	5.7811
75	294.97	1.3842	0.02353	1317.1	2759.9	14422.8	3.2076	5.7471
80	299.23	1.4009	0.02193	1340.7	2752.5	1411.7	3.2479	5.7141
85	303.31	1.4179	0.02050	1363.7	2744.6	1380.9	3.2867	5.6820
90	307.21	1.4351	0.01921	1386.1	2736.4	1350.2	3.3242	5.6506
95	310.96	1.4526	0.01804	1408.0	2727.7	1319.7	3.3605	5.6198
100	318.05	1.4887	0.01601	1450.6	2709.3	1258.7	3.4304	5.5595
110	324.65	1.5268	0.01428	1491.8	2689.2	1197.4	3.4972	5.5002
120	330.83	1.5672	0.01280	1532.0	2667.0	1135.0	3.5616	5.4408
130	336.64	1.6106	0.01150	1571.6	2642.4	1070.7	3.6242	5.3803
140	342.13	1.6579	0.01034	1611.0	2615.0	1004.0	3.6859	5.3178
150	347.33	1.7103	0.009308	1650.5	2584.9	934.3	3.7471	5.2531
160	352.26	1.7696	0.008371	1691.7	2551.6	859.9	3.8107	5.1855
170	356.96	1.8399	0.007498	1734.8	2513.9	779.1	3.8765	4.1128
180	361.43	1.9260	0.006678	1778.7	2470.6	692.0	3.9429	4.0332
190	365.70	2.0370	0.005877	1826.5	2418.4	591.9	4.0149	4.9412
200	369.78	2.2015	0.005023	1886.3	2347.6	461.3	4.1048	4.8223
210	373.69	2.6714	0.003728	2011.1	2195.6	184.5	4.2947	4.5799
220	374.15	3.17	0.00317	2107.4	2107.4	0	4.4429	4.4429
221.2								

Pipe Dimensions and Weights

Note: °C. = 5/9 (°F.-32); °F. = 9/5 °C.+32

Nominal Dia. Outer Dia. mm - inch		Type and Schedule Number			Wall Thickness mm - inch		Cross Section Area cm²	Moment of Inertia cm⁴ - inch⁴		Cross Area Module cm³ - inch³		Pipe Weight kg/m lb./ft.		Water Weight kg/m lb./ft.	
15 21.336	1/2″ 0.840	Std.	40	40S	2.769	0.109	1.96	0.7078	0.0171	0.6639	0.0407	1.265	0.851	0.196	0.132
		XS	80	80S	3.734	0.147	1.51	0.8325	0.0201	0.7809	0.0478	1.618	1.09	0.151	0.101
			160		4.750	0.187	1.10	0.9191	0.0221	0.8621	0.0527	1.949	1.30	0.110	0.074
		XXS			7.468	0.294	0.32	1.0043	0.243	0.9421	0.0577	2.551	1.72	0.032	0.022
20 26.670	3/4″ 1.050	Std.	40	40S	2.870	0.113	3.44	1.5385	0.0370	1.1541	0.0706	1.682	1.13	0.344	0.231
		XS	80	80S	3.912	0.154	2.79	1.8602	0.0448	1.3954	0.0853	2.192	1.47	0.279	0.187
			160		5.537	0.218	1.91	2.1921	0.0527	1.6444	0.100	2.887	1.94	0.191	0.128
		XXS			7.823	0.308	0.95	2.4059	0.0579	1.8048	0.110	3.631	2.44	0.095	0.064
25 33.401	1″ 1.315	Std.	40	40S	3.378	0.133	5.59	3.0274	0.0874	2.1600	0.133	2.494	1.68	0.559	0.374
		XS	80	80S	4.547	0.179	4.04	4.3894	0.106	2.6284	0.161	3.229	2.17	0.404	0.311
			160		6.350	0.250	3.36	5.2049	0.125	3.1167	0.190	4.233	2.84	0.336	0.226
		XXS			9.093	0.358	1.81	5.8424	0.141	3.4984	0.214	5.446	3.66	0.181	0.122
32 42.164	1 1/4″ 1.660	Std.	40	40S	3.556	0.140	9.64	8.0872	0.195	3.8364	0.235	3.378	2.27	0.964	0.65
		XS	80	80S	4.851	0.191	8.27	10.0535	0.242	4.7691	0.291	4.460	3.00	0.827	0.56
			160		6.350	0.250	6.81	11.8048	0.284	5.6000	0.342	5.604	3.76	0.681	0.46
		XXS			9.703	0.382	3.06	14.1836	0.341	6.7285	0.411	7.760	5.22	0.306	0.27
40 48.260	1 1/2 1.900	Std.	40	40S	3.683	0.145	13.13	12.8837	0.310	5.3392	0.326	4.043	2.72	1.313	0.88
		XS	80	80S	5.080	0.200	11.39	16.2745	0.391	6.7445	0.412	5.406	3.63	1.139	0.77
			160		7.137	0.281	9.07	20.0562	0.483	8.3117	0.508	7.228	4.87	0.907	0.61
		XXS			10.160	0.400	6.12	23.6220	0.568	9.7893	0.598	9.541	6.41	0.612	0.41
50 60.325	2″ 2.375	Std.	40	40S	3.912	0.154	21.63	27.679	0.666	9.177	0.561	5.43	3.65	2.163	1.45
		XS	80	80S	5.537	0.218	19.04	36.063	0.868	11.957	0.731	7.46	5.02	1.904	1.28
			160		8.730	0.343	14.42	48.395	1.16	16.046	0.979	11.10	7.45	1.442	0.97
		XXS			11.074	0.436	11.44	54.526	1.31	18.078	1.10	13.44	9.03	1.144	0.77
65 73.025	2 1/2″ 2.875	Std.	40	40S	5.156	0.203	30.88	63.559	1.53	17.408	1.06	8.61	5.79	3.0888	2.08
		XS	80	80S	7.010	0.276	27.32	80.030	1.93	21.920	1.34	11.40	7.66	2.732	1.84
			160		9.525	0.375	22.84	97.825	2.35	26.794	1.64	14.90	10.0	2.284	1.54
		XXS			14.021	0.552	15.89	119.398	2.87	32.702	2.00	20.38	13.7	1.589	1.07
80 88.900	3″ 3.500	Std.	40	40S	5.186	0.216	47.68	125.400	3.02	28.211	1.72	11.26	7.58	4.768	3.20
		XS	80	80S	7.020	0.300	42.59	161.012	3.90	36.448	2.23	15.26	10.3	4.259	2.86
			160		11.120	0.438	34.88	209.573	5.04	47.148	2.88	21.28	14.3	3.488	2.34
		XXS			15.240	0.600	26.79	249.300	5.99	56.085	3.43	27.67	18.6	2.679	1.80
100 114.300	4″ 4.500	Std.	40	40S	6.010	0.237	82.12	300.480	7.23	52.577	3.21	16.04	10.8	8.212	5.51
		XS	80	80S	8.550	0.337	74.16	399.460	9.61	69.896	4.27	22.28	15.3	7.416	4.98
			120		11.120	0.438	66.52	485.000	11.7	84.804	5.18	28.28	19.0	6.652	4.47
			160		13.487	0.531	59.88	551.900	13.3	96.570	5.90	33.49	22.5	5.988	4.02
		XXS			17.110	0.674	50.34	635.63	15.3	112.213	6.79	40.98	27.5	5.034	3.38
125 141.300	5″ 5.563	Std.	40	40S	6.553	0.258	129.01	630.50	15.2	89.240	5.45	21.75	14.6	12.901	8.66
		XS	80	80S	9.525	0.375	117.33	859.50	20.7	121.650	7.43	20.92	20.8	11.733	7.88
			120		12.700	0.500	105.44	1070.50	25.7	151.640	9.25	40.25	27.0	10.554	7.09
			160		15.875	0.625	94.46	1245.20	30.0	186.240	10.8	48.87	33.0	9.446	6.33
		XXS			19.050	0.750	83.60	1399.26	33.6	208.050	12.1	57.40	38.6	8.360	5.62

Pipe Dimensions and Weights

Note: °C. = 5/9 (°F.-32); °F. = 9/5 °C.+32

Nominal Dia. Outer Dia. mm - inch		Type and Schedule Number			Wall Thickness mm - inch		Cross Section Area cm^2	Moment of Inertia cm^4 - $inch^4$		Cross Area Module cm^3 - $inch^3$		Pipe Weight kg/m lb./ft.		Water Weight kg/m lb./ft.	
150 168.275	6″ 6.625	Std.	40	40S	7.112	0.280	186.20	1170.30	28.1	149.100	8.50	28.24	19.0	18.620	12.5
			80	80S	10.973	0.432	168.06	1683.60	40.5	210.110	12.1	42.53	28.6	16.806	11.3
			120		14.275	0.562	153.24	2062.70	49.6	255.180	15.0	54.16	36.4	15.324	10.3
			160		18.260	0.718	136.24	24.54.70	59.0	281.770	17.8	67.51	45.3	13.624	9.16
		XXS			21.946	0.864	121.44	2758.30	66.3	337.860	20.0	79.12	53.2	12.144	8.14
200 219.075	8″ 8.625		20		6.350	0.250	333.9	2400.8	57.7	219.19	13.4	33.29	22.4	33.390	22.5
			30		7.036	0.277	329.8	2633.0	63.4	240.39	14.7	36.74	24.7	32.980	22.2
		Std.	40	40S	8.179	0.322	322.5	3012.1	72.5	275.00	16.8	42.66	28.6	32.250	21.7
			60		10.312	0.406	309.1	3690.0	88.3	356.89	20.6	53.05	35.6	30.910	20.8
		XS	80	80S	12.700	0.500	294.4	4397.0	106	401.44	24.5	64.59	43.4	29.440	19.8
			100		15.080	0.593	280.1	5050.9	154	461.14	28.1	75.82	50.9	28.010	18.8
			120		18.260	0.718	261.5	5850.7	141	534.16	32.6	90.37	60.6	26.150	17.6
			140		20.625	0.812	248.2	6392.6	154	583.63	35.6	100.85	67.8	24.820	16.7
		XXS			22.225	0.875	239.3	6736.3	162	615.01	37.6	107.80	72.4	23.930	16.1
			160		23.012	0.906	235.0	6899.1	166	629.88	38.5	111.19	74.7	23.500	15.8
250 273.050	10″ 10.750		20		6.350	0.250	532.0	4730.2	114	346.48	21.2	41.74	28.0	53.200	35.7
			30		7.798	0.307	520.3	5711.0	138	418.30	25.6	50.93	34.2	52.030	34.9
		Std.	40	40S	9.271	0.365	508.4	6685.4	161	489.70	29.9	60.27	40.5	50.840	34.1
		XS	60		12.700	0.500	484.7	8558.8	212	626.92	39.4	78.86	54.7	48.470	32.3
			80	80S	15.080	0.593	463.0	10194.8	245	746.78	45.5	95.88	64.3	46.300	31.1
			100		18.260	0.718	439.1	11914.1	286	872.69	53.2	114.67	76.9	43.910	29.5
			120		21.430	0.843	415.9	13495.3	324	988.52	60.3	132.90	89.2	41.590	27.9
			140		25.400	1.000	387.7	15299.6	368	1120.68	68.4	155.04	104	38.770	26.0
			160		28.575	1.125	365.9	16608.0	399	1216.52	74.3	172.16	116	36.590	24.6
300 323.850	12″ 12.750		20		6.350	0.250	759.9	7979.5	192	492.80	30.0	49.69	33.4	75.990	51.1
			30		8.382	0.330	740.2	10342.8	249	638.14	39.0	65.16	43.8	74.020	49.7
		Std.		40S	9.525	0.375	729.2	11614.2	279	717.28	43.8	73.75	49.6	72.920	49.0
			40		10.312	0.406	721.7	124.85.4	300	771.08	47.1	79.67	53.5	72.170	48.5
		XS		80S	12.700	0.500	699.1	150.39.5	362	928.82	56.7	97.40	65.4	69.910	47.0
			60		14.275	0.562	684.5	16651.8	401	1028.39	62.8	108.88	73.2	68.450	46.0
			80		17.470	0.687	655.1	19782.4	475	1221.73	74.5	131.90	88.5	65.510	44.0
			100		21..430	0.843	619.7	23378.9	562	1443.85	88.1	159.74	107	61.970	41.6
			120		25.400	1.000	585.2	26691.8	642	1648.45	101	186.80	125	58.520	39.3
			140		28.575	1.125	558.3	29137.6	701	1799.50	110	207.93	140	55.830	37.5
			160		33.325	1.312	519.2	32486.8	781	2006.53	123	238.60	160	51.920	34.9

Pipe Dimensions and Weights

Note: °C. = 5/9 (°F.-32); °F. = 9/5 °C.+32

Nominal Dia. Outer Dia. mm - inch		Type and Schedule Number		Wall Thickness mm - inch		Cross Section Area cm^2	Moment of Inertia cm^4 - $inch^4$		Cross Area Module cm^3 - $inch^3$		Pipe Weight kg/m lb./ft.		Water Weight kg/m lb./ft.	
350 355.600	14" 14.00		10	6.350	0.250	923.0	11006	255	619.06	36.5	54.6	36.7	92.300	62.0
			20	7.925	0.312	906.0	13006	315	736.04	45.0	67.9	45.7	90.600	60.6
		Std.	30	9.525	0.675	889.0	15515	373	872.62	53.3	81.2	54.6	88.900	59.7
			40	11.100	0.438	872.5	17831	429	1002.09	61.4	94.2	63.4	87.250	58.6
		XS		12.700	0.500	855.9	20125	484	1131.00	69.1	107.3	72.1	85.590	57.5
			60	15.062	0.593	831.5	23456	562	1319.27	80.3	126.4	84.9	83.150	55.9
			80	19.050	0.750	791.3	28593	687	1608.20	98.2	158.0	106	79.130	53.1
			100	23.800	0.937	744.6	34298	825	1929.03	118	194.6	131	74.460	50.0
			120	27.787	1.093	706.5	38699	930	2178.55	133	224.5	151	70.650	47.5
			140	31.750	1.250	669.7	42733	1030	2403.45	147	253.4	170	66.970	45.0
			180	35.712	1.406	533.8	46461	1120	2613.13	160	281.6	189	63.380	42.6
400 406.400	16" 16.00		10	6.350	0.250	1216.7	15961	384	785.4	48.0	62.6	42.1	121.870	81.7
			20	7.925	0.312	1197.4	19676	474	968.3	59.3	77.7	52.3	119.740	80.5
		Std.	30	9.525	0.375	1177.7	23372	562	1150.1	70.3	93.1	62.6	117.770	79.7
			40	12.700	0.500	1139.5	30450	732	1498.5	91.5	123.2	82.8	113.950	73.5
		XS	60	16.662	0.656	1092.6	38782	933	1908.5	117	160.0	108	109.260	73.4
			80	21.430	0.843	1037.4	48137	1150	2368.9	145	203.3	136	130.740	69.7
			100	26.187	1.031	983.9	56750	1370	2792.8	171	245.3	165	98.390	66.14
			120	30.960	1.218	931.5	64744	1560	3186.2	195	286.5	192	93.150	62.6
			140	36.520	1.438	872.3	73243	1760	3604.4	220	332.9	224	87.230	58.6
			160	40.480	1.593	631.4	78799	1890	3877.9	237	365.1	245	63.140	55.9
450 457.200	18" 18.000		10	6.350	0.250	1551.0	22845	549	999.3	61.0	70.5	47.4	155.1	104
		Std.	20	7.925	0.312	1529.1	20200	679	1233.5	75.5	87.7	59.0	152.9	103
		XS		9.525	0.375	1507.0	33541	807	1467.2	89.6	105.0	70.6	150.7	101.4
			30	11.120	0.438	1485.1	38766	932	1695.8	104	122.2	82.2	148.5	99.7
				12.700	0.500	1403.6	43814	1050	1916.6	117	139.1	93.5	140.4	98.9
			40	14.270	0.562	1442.4	40716	1170	2131.0	130	155.7	105	144.2	96.9
			60	19.050	0.750	1378.8	63012	1520	2756.4	168	205.7	136	137.9	92.6
			80	23.850	0.937	1316.7	86330	1830	3339.0	204	254.4	171	131.7	88.5
			100	29.362	1.156	1246.4	90573	2180	3966.4	242	309.6	208	127.7	83.7
			120	34.920	1.375	1177.8	103914	2500	4545.6	278	363.4	244	117.8	79.1
			140	39.675	1.562	1129.8	114358	2750	5902.5	306	408.2	274	113.0	75.3
			160	44.230	1.781	1055.4	125622	3020	5495.2	336	459.2	309	150.5	70.9

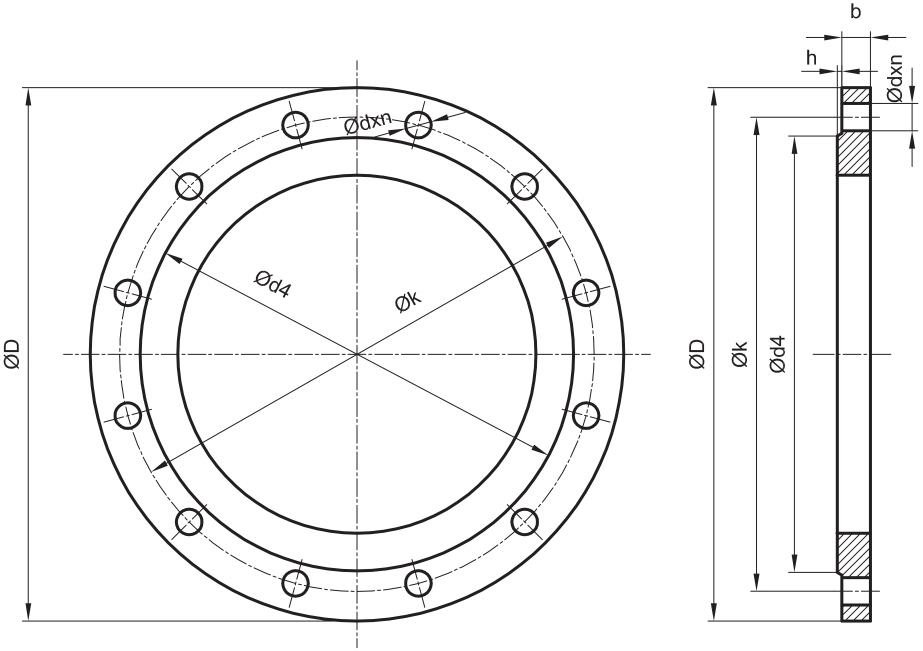
Pipe Dimensions and Weights

Note: °C. = 5/9 (°F.-32); °F. = 9/5 °C.+32

Nominal Dia. Outer Dia. mm - inch		Type and Schedule Number		Wall Thickness mm - inch		Cross Section Area cm^2	Moment of Inertia cm^4 - inch^4		Cross Area Module cm^3 - inch^3		Pipe Weight kg/m lb./ft.		Water Weight kg/m lb./ft.	
500 508.000	20" 20.000		10	0.350	0.250	1925	32469	757	1238.9	75.7	78.5	52.7	192.5	129
		Std.	20	9.525	0.375	1876	46300	1110	1822.8	111	116.9	78.6	187.6	126
		XS	30	12.700	0.500	1828	60844	1460	2595.4	146	155.3	104	182.8	123
			40	15.080	0.593	1792	70954	1700	2793.4	170	182.0	123	179.2	120
			60	20.625	0.812	1710	93688	2260	3695.5	226	247.7	166	171.0	115
			80	26.187	1.031	1629	115277	2770	4538.4	277	310.9	209	162.9	109
			100	32.537	1.281	1540	137866	3320	5428.5	323	362.0	256	154.0	103
			120	38.100	1.500	1463	158180	3760	6148.6	376	441.2	296	146.3	98.3
			140	44.450	1.750	1378	175353	4220	6904.6	422	507.8	341	137.8	92.6
			160	50.010	1.968	1306	190814	4590	7512.3	459	564.5	379	130.6	87.8
600 609.600	24" 24.000		10	6.350	0.250	2796	54720	1320	1795.2	110	94.4	63.4	279.6	188
		Std.	20	9.525	0.375	2736	81409	1940	2670.8	162	141.9	94.6	273.6	184
		XS		12.700	0.500	2679	106057	2550	6479.5	213	186.8	125	267.9	180
			30	14.275	0.562	2650	118245	2840	3879.4	237	209.4	141	265.0	178
			40	17.470	0.587	2592	142482	3420	4674.6	285	254.9	171	259.2	174
			60	24.610	0.968	2465	193715	4650	6355.4	388	354.8	238	246.5	166
			80	30.960	1.218	2354	236108	5670	7746.2	473	441.5	296	235.4	158
			100	38.880	1.531	2221	284586	6850	9336.8	571	548.0	367	222.1	149
			120	46.020	1.812	2102	325490	7820	10678.8	652	639.2	429	210.2	141
			140	52.375	2.062	2000	358793	8630	11771.4	719	719.3	483	200.0	134
			160	59.530	2.343	1888	393448	9460	12900.3	799	807.1	542	188.8	127
750 762.00	30" 30.000		10	7.92	0.312	4370	132984	3210	3490.3	214	147.45	98.9	437.0	294
		Std.		9.52	0.375	4333	158910	3830	4170.8	255	176.57	119	433.3	291
			20	12.70	0.500	4259	209766	5040	5505.6	336	234.44	157	425.9	286
			30	15.88	0.625	4185	259313	6220	6806.1	415	291.11	196	418.5	281

Flange Table

ANSI



ANSI 150

h = 1/16 (1.6 mm)

Nominal Dia (inch)	ØD		Ød4		Øk		b		Ød		n	w
	in	mm	in	mm	in	mm	in	mm	in	mm		
1/2	3 1/2	88.9	1 3/8	34.9	2 3/8	60.3	3/8	9.5	5/8	15.9	4	1/2 1/2
3/4	3 7/8	98.4	1 11/16	42.9	2 3/4	69.9	3/8	9.5	5/8	15.9	4	1/2
1	4 1/4	108.0	2	50.8	3 1/8	79.4	3/8	9.5	5/8	15.9	4	1/2
1 1/4	4 5/8	117.5	2 1/2	63.5	3 1/2	88.9	7/16	11.1	5/8	15.9	4	1/2
1 1/2	5	127.0	2 7/8	73.0	3 7/8	98.4	1/2	12.7	5/8	15.9	4	5/8
2	6	152.4	3 5/8	92.1	4 3/4	120.7	9/16	14.3	3/4	19.1	4	5/8
2 1/2	7	177.8	4 1/8	104.8	5 1/2	139.7	5/8	15.9	3/4	19.1	4	5/8
3	7 1/2	190.5	5	127.0	6	152.4	11/16	17.5	3/4	19.1	4	5/8
3 1/2	8 1/2	215.9	5 1/2	139.7	7	177.8	3/4	19.1	3/4	19.1	8	5/8
4	9	228.6	6 3/16	157.2	7 1/2	190.5	7/8	22.2	3/4	19.1	8	3/4
5	10	254.0	7 5/16	185.7	8 1/2	215.9	7/8	22.2	7/8	22.2	8	./4
6	11	279.4	8 1/2	215.9	9 1/2	241.3	15/16	23.8	7/8	22.2	8	3/4
8	13 1/2	342.9	10 5/8	269.9	11 3/4	298.5	1 1/16	27.0	7/8	22.2	8	7/8
10	16	406.4	12 3/4	323.9	14 1/4	362.0	1 1/8	28.6	1	25.4	12	7/8
12	19	482.6	15	381.0	17	431.8	1 3/16	30.2	1	25.4	12	1
14	21	533.4	16 1/4	412.8	18 3/4	476.3	1 5/16	33.3	1 1/8	28.6	12	1
16	23 1/2	596.9	18 1/2	469.9	21 1/4	539.8	1 3/8	34.9	1 1/8	28.6	16	1 1/8
18	25	635.0	21	533.4	22 3/4	577.9	1 1/2	38.1	1 1/4	31.8	16	1 1/8
20	27 1/2	698.5	23	584.2	25	635.0	1 5/8	41.3	1 1/4	31.8	20	1 1/8
24	32	812.0	27 1/4	692.2	29	749.3	1 13/16	46.0	1 3/8	34.9	20	1 1/4

ANSI 300 lb

h = 1/16" (1.6 mm)

Nominal Dia (inch)	ØD		Ød4		Øk		b		Ød		n	w
	in	mm	in	mm	in	mm	in	mm	in	mm		
1/2	3 3/4	95.3	1 3/8	34.9	2 5/8	66.7	1/2	12.7	5/8	15.9	4	1/2
3/4	4 5/8	117.5	1 11/16	42.9	3 1/4	82.6	9/16	14.3	3/4	19.1	4	5/8
1	4 7/8	123.8	2	50.8	3 1/2	88.9	5/8	15.9	3/4	19.1	4	5/8
1 1/4	5 1/4	133.4	2 1/2	63.5	3 7/8	98.4	11/16	17.5	3/4	19.1	4	5/8
1 1/2	6 1/8	155.6	2 7/8	73.0	4 1/2	114.3	3/4	19.1	7/8	22.2	4	3/4
2	6 1/2	165.1	3 5/8	92.1	5	127.0	13/16	20.6	3/4	19.1	8	5/8
2 1/2	7 1/2	190.5	4 1/8	104.8	5 7/8	149.2	15/16	23.6	7/8	22.2	8	3/4
3	8 1/4	209.6	5	127.0	6 5/8	168.3	1 1/16	27.0	7/8	22.2	8	3/4
3 1/2	9	228.6	5 1/2	139.7	7 1/4	184.2	1 1/8	28.6	7/8	22.2	8	3/4
4	10	254.0	6 3/16	157.2	7 7/8	200.0	1 3/16	30.2	7/8	22.2	8	3/4
5	11	279.4	7 5/16	185.7	9 1/4	235.0	1 5/16	33.3	7/8	22.2	8	3/4
6	12 1/2	317.5	8 1/2	215.98	10 5/8	269.9	1 3/8	34.9	7/8	22.2	12	3/4
8	15	381.0	10 5/8	269.9	13	330.2	1 9/16	39.7	1	25.4	12	7/8
10	17 1/2	444.5	12 3/4	323.9	15 1/4	387.4	1 13/16	46.0	1 1/8	28.6	16	1
12	20 1/2	520.7	15	381.0	17 3/4	450.9	1 15/16	49.2	1 1/4	31.8	16	1 1/8
14	23	584.2	16 1/4	412.8	20 1/4	514.4	2 1/16	52.4	1 1/4	31.8	20	1 1/8
16	25 1/2	647.7	18 1/2	469.9	22 1/2	571.5	2 3/16	55.6	1 3/8	34.9	20	1 1/4
18	28	711.2	21	533.4	24 3/4	628.7	2 5/16	58.7	1 3/8	34.9	24	1 1/4
20	30 1/2	774.7	23	584.2	27	685.8	2 7/16	61.9	1 3/8	34.9	24	1 1/4
24	36	914.4	27 1/4	692.2	32	812.8	2 11/16	68.3	1 5/8	41.3	24	1 1/2

ANSI 400 lb

h = 1/4" (6.4 mm)

Nominal Dia (inch)	ØD		Ød4		Øk		b		Ød		n	w
	in	mm	in	mm	in	mm	in	mm	in	mm		
1/2	3 3/4	95.3	1 3/8	34.9	2 5/8	66.7	9/16	14.3	5/8	15.9	4	1/2
3/4	4 5/8	117.5	1 11/18	42.9	3 1/4	82.6	5/8	15.9	3/4	19.1	4	5/8
1	4 7/8	123.8	2	50.8	3 1/2	88.9	11/16	17.5	3/4	19.1	4	5/8
1 1/4	5 1/4	133.4	2 1/2	63.5	3 7/8	98.4	13/16	20.6	3/4	19.1	4	5/8
1 1/2	6 1/8	155.6	2 7/8	73.0	4 1/2	114.3	7/8	22.2	7/8	22.2	8	3/4
2	6 1/2	165.1	3 5/8	92.1	5	127.0	1	25.4	3/4	19.1	8	5/8
2 1/2	7 1/2	190.5	4 1/8	104.8	5 7/8	149.2	1 1/8	28.6	7/8	22.2	8	3/4
3	8 1/4	209.6	5	127.0	6 5/8	168.3	1 1/4	31.8	7/8	22.2	8	3/4
3 1/2	9	228.6	5 1/2	139.7	7 1/4	184.2	1 3/8	34.9	1	25.4	8	7/8
4	10	254.0	6 3/16	157.2	7 7/8	200.0	1 3/8	34.9	1	25.4	8	7/8
5	11	279.4	7 5/16	185.7	9 1/4	235.0	1 1/2	38.1	1	25.4	8	7/8
6	12 1/2	317.5	8 1/2	215.9	10 5/8	269.9	1 5/8	41.1	1	25.4	12	7/8
8	15	381.0	10 5/8	269.9	13	330.2	1 7/8	47.6	1 1/8	28.6	12	1
10	17 1/2	444.5	12 3/4	323.9	15 1/4	387.4	2 1/8	54.0	1 1/4	31.8	16	1 1/8
12	20 1/2	520.7	15	381.0	17 3/4	450.9	2 1/4	57.2	1 3/8	34.9	16	1 1/4
14	23	584.2	16 1/4	412.8	20 1/4	514.4	2 3/8	60.3	1 3/8	34.9	20	1 1/4
16	25 1/2	647.7	18 1/2	469.9	22 1/2	571.5	2 1/2	63.5	1 1/2	38.1	20	1 3/8
18	28	711.2	21	533.4	24 3/4	628.7	2 5/8	66.7	1 1/2	38.1	24	1 3/8
20	30 1/2	774.7	23	584.2	27	685.2	2 3/4	69.9	1 5/8	41.3	24	1 1/2
24	36	914.4	27 1/4	692.2	32	812.8	3	76.2	1 7/8	47.6	24	1 3/4

ANSI 600 lb

h = 1/4" (6.4 mm)

Nominal Dia (inch)	ØD		Ød4		Øk		b		Ød		n	w
	in	mm	in	mm	in	mm	in	mm	in	mm		
1/2	3 3/4	95.3	1 3/8	34.9	2 5/8	66.7	9/16	14.3	5/8	15.9	4	1/2
3/4	4 5/8	117.5	1 11/18	42.9	3 1/4	82.6	5/8	15.9	3/4	19.1	4	5/8
1	4 7/8	123.8	2	50.8	3 1/2	88.9	11/16	17.5	3/4	19.1	4	5/8
1 1/4	5 1/4	133.4	2 1/2	63.5	3 7/8	98.4	13/16	20.6	3/4	19.14	4	5/8
1 1/2	6 1/8	155.6	2 7/8	73.0	4 1/2	114.3	7/8	22.2	7/8	22.2	4	3/4
2	6 1/2	165.1	3 5/8	92.1	5	127.0	1	25.4	3/4	19.1	8	5/8
2 1/2	7 1/2	190.5	4 1/8	104.8	5 7/8	149.2	1 1/8	28.6	7/8	22.2	8	3/4
3	8 1/4	209.6	5	127.0	6 5/8	168.3	1 1/4	31.8	7/8	22.2	8	3/4
3 1/2	9	228.6	5 1/2	139.7	7 1/4	184.2	1 3/8	34.9	1	25.4	8	7/8
4	10 3/4	273.1	6 3/16	157.2	8 1/2	215.9	1 1/2	38.1	1	25.4	8	7/8
5	13	330.2	7 5/16	185.7	10 1/2	266.7	1 3/4	44.5	1 1/8	28.6	8	1
6	14	355.6	8 1/2	215.9	11 1/2	292.1	1 7/8	47.6	1 1/8	28.6	12	1
8	16 1/2	419.1	10 5/8	269.9	13 3/4	349.3	2 3/16	55.6	1 1/4	31.8	12	1 1/8
10	20	508.0	12 3/4	323.9	17	431.8	2 1/2	63.5	1 3/8	34.9	16	1 1/4
12	22	558.8	15	381.0	19 1/4	489.0	2 5/8	66.7	1 3/8	34.9	20	1 1/4
14	23 3/4	603.3	16 1/4	412.8	20 3/4	527.1	2 3/4	69.9	1 1/2	38.1	20	1 3/8
16	27	685.8	18 1/2	469.9	23 3/4	603.3	3	76.2	1 5/8	41.3	20	1 1/2
18	29 1/4	743.0	21	533.4	25 3/4	654.1	3 1/4	82.6	1 3/4	44.5	20	1 5/8
20	32	812.8	23	584.4	28 1/2	723.9	3 1/2	88.9	1 3/4	44.5	24	1 5/8
24	37	938.8	27 1/4	692.2	33	832.2	4	101.6	2	50.8	24	1 7/8

ANSI 900 lb

h = 1/4" (6.4 mm)

Nominal Dia (inch)	ØD		Ød4		Øk		b		Ød		n	w
	in	mm	in	mm	in	mm	in	mm	in	mm		
1/2	4 3/4	120.7	1 3/8	34.9	3 1/4	82.6	7/8	22.2	7/8	22.2	4	3/4
3/4	5 1/8	130.2	1 11/16	42.9	3 1/2	88.9	1	25.4	7/8	22.2	4	3/4
1	5 7/8	149.2	2	50.8	4	101.6	1 1/8	28.6	1	25.4	4	7/8
1 1/4	6 1/4	158.8	2 1/2	63.5	4 3/8	111.1	1 1/8	28.6	1	25.4	4	7/8
1 1/2	7	177.8	2 7/8	73.0	4 7/8	123.8	1 1/4	31.8	1 1/8	28.6	4	1
2	8 1/2	215.9	3 5/8	92.1	6 1/2	165.1	1 1/2	38.1	1	25.4	8	7/8
2 1/2	9 5/8	244.5	4 1/8	104.8	7 1/2	190.5	1 5/8	41.3	1 1/8	28.6	8	1
3	9 1/2	241.3	5	127.0	7 1/2	190.5	1 1/2	38.1	1	25.4	8	7/8
4	11 1/2	292.1	6 3/16	157.2	9 1/4	235.0	1 3/4	44.5	1 1/4	31.8	8	1 1/8
5	13 3/4	349.3	7 5/16	185.7	11	279.4	2	50.8	1 3/8	34.9	8	1 1/4
6	15	381.0	8 1/2	215.9	12 1/2	317.5	2 3/16	55.6	1 1/4	31.8	12	1 1/8
8	18 1/2	469.9	10 5/8	269.9	15 1/2	393.7	2 1/2	63.5	1 1/2	38.1	12	1 3/4
10	21 1/2	546.1	12 3/4	323.9	18 1/2	469.9	2 3/4	69.9	1 1/2	38.1	16	1 3/8
12	24	609.6	15	381.0	21	533.4	3 1/8	79.4	1 1/2	38.1	20	1 3/8
14	25 1/4	641.4	16 1/4	412.8	22	558.8	3 3/8	85.7	1 5/8	41.3	20	1 1/2
16	27 3/4	704.9	18 1/2	469.9	24 1/4	616.0	3 1/2	88.9	1 3/4	44.5	20	1 5/8
18	31	787.4	21	533.4	27	685.8	4	101.6	2	50.8	20	1 7/8
20	33 3/4	857.3	23	584.2	29 1/2	749.3	4 1/4	108.0	2 1/8	54.0	20	2
24	41	1041.4	27 1/4	692.2	35 1/2	901.7	5 1/2	139.7	2 5/8	66.7	20	2 1/2

ANSI1500 lb

h = 1/4" (6.4 mm)

Nominal Dia (inch)	ØD		Ød4		Øk		b		Ød		n	w
	in	mm	in	mm	in	mm	in	mm	in	mm		
1/2	4 3/4	120.7	1 3/4	34.9	3 1/4	82.6	7/8	22.2	7/8	22.2	4	3/4
3/4	5 1/8	130.2	1 11/16	42.9	3 1/2	88.9	1	25.4	7/8	22.2	4	3/4
1	5 7/8	149.2	2	50.8	4	101.6	1 1/8	28.6	1	25.4	4	7/8
1 1/4	6 1/4	158.8	2 1/2	63.5	4 3/8	111.1	1 1/8	28.6	1	25.4	4	7/8
1 1/2	7	177.8	2 7/8	73.0	4 7/8	123.8	1 1/4	31.8	1 1/8	28.6	4	1
2	8 1/2	215.9	3 5/8	92.1	6 1/2	165.1	1 1/2	38.1	1	25.4	8	7/8
2 1/2	9 5/8	244.5	4 1/8	104.8	7 1/2	190.5	1 5/8	41.3	1/8	28.6	8	1
3	10 1/2	266.7	5	127.0	8	203.2	1 7/8	47.6	1 1/4	31.8	8	1 1/8
4	12 1/4	311.2	6 3/16	157.2	9 1/2	241.3	2 1/8	54.0	1 3/8	34.9	8	1 1/4
5	14 3/4	374.7	7 5/16	185.7	11 1/2	292.1	2 7/8	73.0	1 5/8	41.3	8	1 1/2
6	15 1/2	393.7	8 1/2	215.9	12 1/2	317.5	3 1/4	82.6	1 1/2	38.1	12	1 3/8
2	19	482.6	10 5/8	269.9	15 1/2	393.7	3 5/8	92.1	1 3/4	44.5	12	1 5/8
10	23	584.2	12 3/4	323.9	19	482.6	4 1/4	108.0	2	50.8	12	1 7/8
12	26 1/2	673.1	15	381.0	22 1/2	571.5	4 7/8	123.8	2 1/8	54.0	16	2
14	29 1/2	749.3	16 1/4	412.8	25	635.0	5 1/4	133.4	2 3/8	60.3	16	2 1/4
16	32 1/2	825.5	18 1/2	469.9	27 3/4	704.9	5 3/4	146.1	2 5/8	66.7	16	2 1/2
18	36	914.4	21	533.4	30 1/2	774.7	6 3/8	161.9	2 7/8	73.0	16	2 3/4
20	38 3/4	984.3	23	584.2	32 3/4	831.9	7	177.8	3 1/8	79.4	16	3
24	46	1168.4	27 1/4	692.2	39	990.6	8	203.2	3 5/8	92.1	16	3 1/2

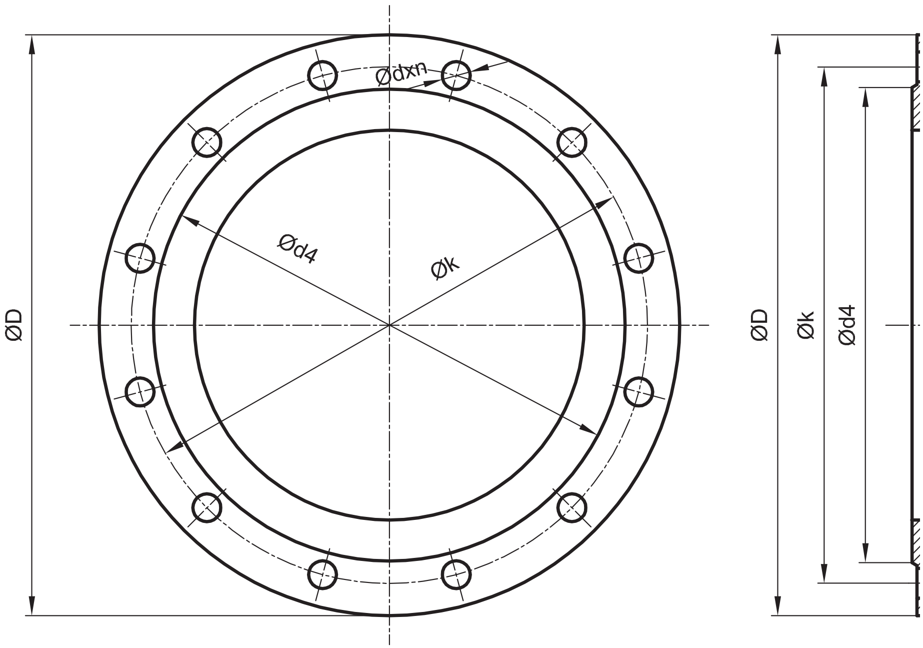
ANSI 2500 lb

h = 1/4" (6.4 mm)

Nominal Dia (inch)	ØD		Ød4		Øk		b		Ød		n	w
	in	mm	in	mm	in	mm	in	mm	in	mm		
1/2	5 1/4	133.4	1 3/8	34.9	3 1/2	88.9	1 3/16	30.2	7/8	22.2	4	3/4
3/4	5 1/2	139.7	1 11 /16	42.9	3 3/4	95.3	1 1/4	31.8	7/8	22.2	4	3/4
1	6 1/4	158.8	2	50.8	4 1/4	108.0	1 3/8	34.9	1	25.4	4	7/8
1 1/4	7 1/4	184.2	2 1/2	63.5	5 1/8	130.2	1 1/2	38.1	1 1/8	28.6	4	1
1 1/2	8	203.2	2 7/8	73.0	5 3/4	146.1	1 3/4	44.5	1 1/4	31.8	4	1 1/8
2	9 1/4	235.0	3 5/8	92.1	6 3/4	171.5	2	50.8	1 1/8	28.6	8	1
2 1/2	10 1/2	266.7	4 1/8	104.8	7 3/4	196.9	2 1/4	57.2	1 1/4	31.8	8	1 1/8
3	12	304.8	5	127.0	9	228.6	2 5/8	66.7	1 3/8	34.9	8	1 1/4
4	14	355.6	6 3/16	157.2	10 3/4	273.1	3	76.2	1 5/8	41.3	8	1 1/2
5	16 1/2	419.1	7 5/16	185.7	12 3/4	323.9	3 5/8	92.1	1 7/8	47.4	8	1 3/4
6	19	482.6	8 1/2	215.9	1 4 1/2	368.3	4 1/4	108.0	2 1/8	54.0	8	2
8	21 3/4	552.5	10 5/8	269.9	17 1/4	438.2	5	127.0	2 1/8	54.0	12	2
10	26 1/2	673.1	12 3/4	323.9	21 1/4	539.8	6 1/2	165.1	2 5/8	66.7	12	2 1/2
12	30	762.0	15	381.0	24 3/8	619.2	7 1/4	184.2	2 7/8	73.0	12	2 3/4

Flange Table

DIN



DIN 2501

1 ve 2.5 atü All dimensions given (mm)

Nominal Ø	ØD	Ød4	Øk	n	w	Ød
6	65	25	40	4	M10	11
8	70	30	45	4	M10	11
10	75	35	50	4	M10	11
15	80	40	55	4	M10	11
20	90	50	65	4	M10	11
25	100	60	75	4	M10	11
32	120	70	90	4	M12	14
40	130	80	100	4	M12	14
50	140	90	110	4	M12	14
65	160	110	130	4	M12	14
80	190	128	150	4	M12	18
100	210	148	170	4	M16	18
125	240	178	200	8	M16	18
150	265	202	225	8	M16	18
200	320	258	280	8	M16	18
250	375	312	335	12	M16	18
300	440	365	395	12	M20	22
350	490	415	445	12	M20	22
400	540	465	495	16	M20	22
450	595	520	550	16	M20	22
500	645	570	600	20	M20	22
600	755	670	705	20	M24	26
700	860	775	810	24	M24	26
800	975	880	920	24	M27	30
900	1075	980	1020	24	M27	30
1000	1175	1080	1120	28	M27	30
1200	1375	1280	1320	32	M27	30
1400	1575	1480	1520	36	M27	30
1600	1790	1690	1730	40	M27	30
1800	1990	1890	1930	44	M27	30
2000	2190	2090	2130	48	M27	30
2200	2405	2295	2340	52	M30	33
2400	2605	2495	2540	56	M30	33
2600	2805	2695	2740	60	M30	33
2800	3030	2910	2960	64	M33	36
3000	3230	3110	3160	68	M33	36
3200	3430	3310	3360	72	M33	36
3400	3630	3510	3560	76	M33	36
3600	3840	3720	3770	80	M33	36
3800	4045	3920	3970	80	M36	39
4000	4245	4120	4170	84	M36	39

DIN 2501

6 atü All dimensions given (mm)

Nominal Ø	ØD	Ød4	Øk	n	w	Ød
6	65	25	40	4	M10	11
8	70	30	45	4	M10	11
10	75	35	50	4	M10	11
15	80	40	55	4	M10	11
20	90	50	65	4	M10	11
25	100	60	75	4	M10	11
32	120	70	90	4	M12	14
40	130	80	100	4	M12	14
50	140	90	110	4	M12	14
65	160	110	130	4	M12	14
80	190	128	150	4	M16	18
100	210	148	170	4	M16	18
125	140	178	200	8	M16	18
150	165	202	225	8	M16	18
20	320	258	280	8	M16	18
250	375	312	335	12	M16	18
300	440	365	395	12	M20	22
350	490	415	445	12	M20	22
400	540	465	495	16	M20	22
450	595	520	550	16	M20	22
500	645	570	600	20	M20	22
600	755	670	705	20	M24	26
700	860	775	810	24	M24	26
800	975	880	920	24	M27	30
900	1075	980	1020	24	M27	30
1000	1175	1080	1120	28	M27	30
1200	1405	1295	1340	32	M30	33
1400	1630	1510	1560	36	M33	36
1600	1830	1710	1760	40	M33	36
1800	2045	1920	1970	44	M36	39
2000	2265	2115	2180	48	M39	42
2200	2475	2335	2390	52	M39	42
2400	2685	2545	2600	56	M39	42
2600	2905	2750	2810	60	M45	48
2800	3115	2960	3020	64	M45	48
3000	3315	3160	3220	68	M45	48
3200	3525	3370	3430	72	M45	48
3400	3725	3580	3640	76	M45	48
3600	3970	3790	3860	80	M52	56

AYVAZ

DIN 2501

10 atü

Nominal Ø	ØD	Ød4	Øk	n	w	Ød
6	75	32	50	4	M10	11
8	80	38	55	4	M10	11
10	90	40	60	4	M12	14
15	95	45	65	4	M12	14
20	105	58	75	4	M12	14
25	115	68	85	4	M12	14
32	140	78	100	4	M16	18
40	150	88	110	4	M16	18
50	165	102	125	4	M16	18
65	185	122	145	4	M16	18
80	200	138	160	8	M16	18
100	220	158	180	8	M16	18
125	250	188	210	8	M16	18
150	285	212	240	8	M20	22
175	315	242	270	8	M20	22
200	340	268	295	8	M20	22
250	395	320	350	12	M20	22
300	445	370	400	12	M20	22
350	505	430	460	16	M20	22
400	565	482	515	16	M24	26
450	615	532	585	20	M24	26
500	675	585	620	20	M24	26
600	780	685	725	20	M27	30
700	895	800	840	24	M27	30
800	1015	905	950	24	M30	33
900	1115	1005	1050	28	M30	33
1000	1230	1110	1160	28	M33	36
1200	1455	1330	1380	32	M36	39
1400	1675	1535	1590	36	M39	42
1600	1915	1760	1820	40	M45	48
1800	2115	1960	2020	44	M45	48
2000	2325	2170	2230	42	M45	48
2200	2550	2370	2440	52	M52	56
2400	2760	2570	2650	56	M52	56
2600	2960	2780	2850	60	M52	56
2800	3180	3000	3070	64	M52	56
3000	3405	3210	3290	68	M56	62

DIN 2501

16 atü

All dimensions given (mm)

Nominal Ø	ØD	Ød4	Øk	n	w	Ød
6	75	32	50	4	M10	11
8	80	38	55	4	M10	11
10	90	40	60	4	M12	14
15	95	45	65	4	M12	14
20	105	58	75	4	M12	14
25	115	68	85	4	M12	14
32	140	78	100	4	M16	18
40	150	88	110	4	M16	18
50	165	102	125	4	M16	18
65	185	122	145	4	M16	18
80	200	138	160	8	M16	18
100	220	158	180	8	M16	18
125	250	188	210	8	M16	18
150	285	212	240	8	M20	22
175	315	242	270	8	M20	22
200	340	268	295	12	M20	22
250	405	320	355	12	M24	26
300	460	378	410	12	M24	26
350	520	438	470	16	M24	26
400	580	490	525	16	M27	30
450	640	550	585	20	M27	30
500	715	610	650	20	M30	33
600	840	725	770	20	M33	36
700	910	795	840	24	M33	36
800	1025	900	950	24	M36	39
900	1125	1000	1050	28	M36	39
1000	1255	1115	1170	28	M39	42
1200	1485	1330	1390	32	M45	48
1400	1685	1530	1590	36	M56	48
1600	1930	1750	1820	40	M52	56
1800	2130	1950	2020	44	M52	56
2000	2345	2150	2230	48	M56	62
2200	2555	2360	2440	52	M56	62

DIN 2501

25 atü

Nominal Ø	ØD	Ød4	Øk	n	w	Ød
6	75	32	50	4	M10	11
8	80	38	55	4	M10	11
10	90	40	60	4	M12	14
15	95	45	65	4	M12	14
20	105	58	75	4	M12	14
25	115	68	85	4	M12	14
32	140	78	100	4	M16	18
40	150	88	110	4	M16	18
50	165	102	125	4	M16	18
65	185	122	145	8	M16	18
80	200	138	160	8	M16	18
100	235	162	190	8	M20	22
125	270	188	220	8	M24	26
150	300	218	250	8	M24	26
175	330	248	280	12	M24	26
200	360	278	310	12	M24	26
250	425	335	370	12	M27	30
300	485	395	430	16	M27	30
350	555	450	490	16	M30	33
400	620	505	550	16	M33	36
500	730	615	660	20	M33	36
600	845	720	770	20	M36	39
700	960	820	875	24	M39	42
800	1085	930	990	24	M45	48
900	1185	1030	1090	28	M45	48
1000	1320	1140	1210	28	M52	56
1200	1530	1350	1420	32	M52	56
1400	1755	1560	1640	36	M56	62
1600	1975	1780	1860	40	M56	62
1800	2195	1985	2070	44	M64	70
2000	2425	2210	2300	48	M64	70

DIN 2501

40 atü

Nominal Ø	ØD	Ød4	Øk	n	w	Ød
6	75	32	50	4	M10	11
8	80	38	55	4	M10	11
10	90	40	60	4	M12	14
15	95	45	65	4	M12	14
20	105	58	75	4	M12	14
25	115	68	85	4	M12	14
32	140	78	100	4	M16	18
40	150	88	110	4	M16	18
50	165	102	125	4	M16	18
65	185	122	145	8	M16	18
80	200	138	160	8	M16	18
100	235	162	190	8	M20	22
125	270	188	220	8	M24	26
150	300	218	250	8	M24	26
175	350	248	295	12	M27	30
200	375	285	320	12	M27	30
250	450	345	385	12	M30	33
300	515	410	450	16	M30	33
350	580	465	510	16	M33	36
400	660	535	585	16	M36	39
450	685	560	610	20	M36	39
500	755	615	670	20	M39	42
600	890	735	795	20	M45	48
700	995	740	900	24	M45	48
800	1140	960	1030	24	M52	56
900	1250	1070	1140	28	M52	56
1000	1360	1180	1250	28	M52	56
1200	1575	1380	1460	32	M56	62
1400	1795	1600	1680	36	M56	62
1600	2025	1815	1900	40	M64	70

DIN 2501

64 atü

Nominal Ø	ØD	Ød4	Øk	n	w	Ød
6						
8						
10	100	40	70	4	M12	14
15	105	45	75	4	M12	14
20						
25	140	68	100	4	M16	18
32						
40	170	88	125	4	M20	22
50	180	102	135	4	M20	22
65	205	122	160	8	M20	22
80	215	138	170	8	M20	22
100	250	162	200	8	M24	26
125	295	188	240	8	M27	30
150	345	218	280	8	M30	33
175	375	260	310	12	M30	33
200	415	285	345	12	M33	36
250	170	345	400	12	M33	36
300	530	410	460	16	M33	36
350	600	465	525	16	M36	39
400	670	535	585	16	M39	42
500	800	615	705	20	M45	48
600	930	735	820	20	M52	56
700	1045	840	935	24	M52	56
800	1165	960	1050	24	M56	62
900	1285	1070	1170	28	M56	62
1000	1415	1180	1290	28	M64	70
1200	1665	1380	1530	32	M72	78