KEYSER®
TECHNOLOGIES

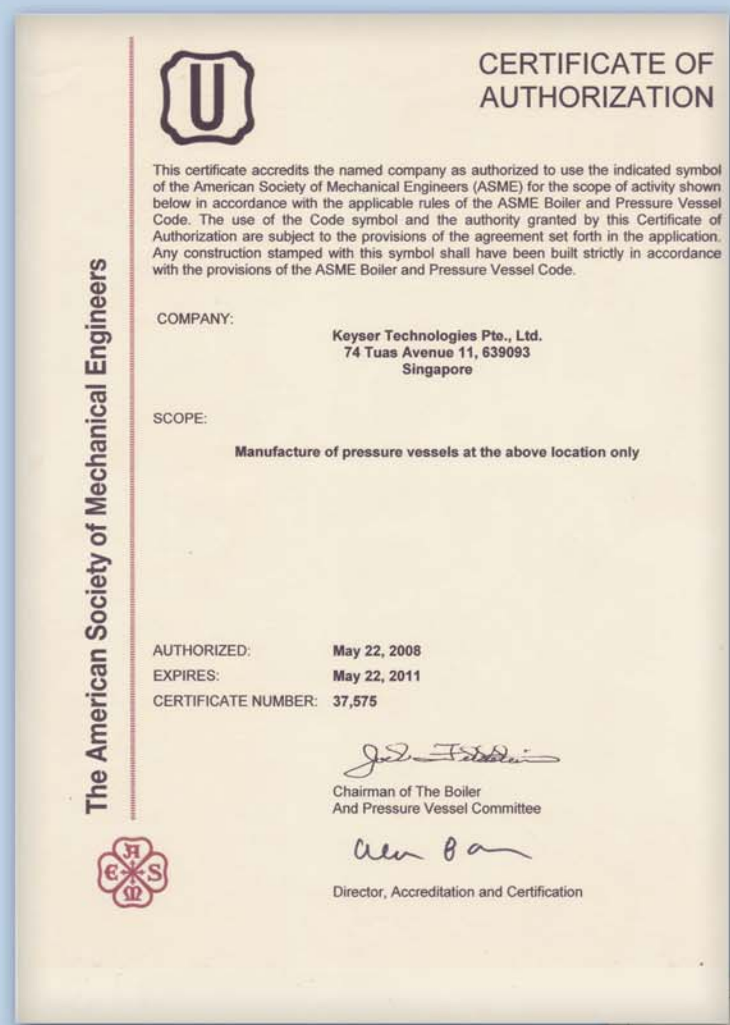
METAL
Expansion Joints Catalogue

American Society of Mechanical Engineers
"U" Stamp Accredited

DNV
UKAS
QUALITY MANAGEMENT
013

KEYSER TECHNOLOGIES PTE LTD
(DESIGN, MANUFACTURE OF EXPANSION JOINTS & ASSOCIATED STEEL FABRICATION WORKS)

Catalogue compiled and printed in 2009



The American Society of Mechanical Engineers

CERTIFICATE OF AUTHORIZATION

This certificate accredits the named company as authorized to use the indicated symbol of the American Society of Mechanical Engineers (ASME) for the scope of activity shown below in accordance with the applicable rules of the ASME Boiler and Pressure Vessel Code. The use of the Code symbol and the authority granted by this Certificate of Authorization are subject to the provisions of the agreement set forth in the application. Any construction stamped with this symbol shall have been built strictly in accordance with the provisions of the ASME Boiler and Pressure Vessel Code.

COMPANY:

Keyser Technologies Pte., Ltd.
74 Tuas Avenue 11, 639093
Singapore

SCOPE:

Manufacture of pressure vessels at the above location only

AUTHORIZED: May 22, 2008
EXPIRES: May 22, 2011
CERTIFICATE NUMBER: 37,575

Chairman of The Boiler
And Pressure Vessel Committee

Director, Accreditation and Certification

The ***American Society of Mechanical Engineers (ASME)*** is a professional society focused on mechanical engineering known for setting codes and standards for mechanical devices. The ASME was founded in 1880 by Alexander Lyman Holley, Henry Rossiter Worthington, John Edison Sweet and Matthias N. Forney in response to numerous steam boiler pressure vessel failures. The ASME conducts one of the world's largest technical publishing operations through its ASME Press, holds numerous technical conferences and hundreds of professional development courses each year, and sponsors numerous outreach and educational programs.

As of 2006, the ASME has 120,000 members.

Stiftelsen Det Norske Veritas or DNV, established in 1864 in Norway, is a classification society organized as a foundation, with the objective of "Safeguarding life, property, and the environment". It was established in Norway to inspect and evaluate the technical condition of Norwegian merchant vessels.Together with Lloyd's Register and American Bureau of Shipping, DNV is one of the three major companies in the classification society business. DNV has its headquarters in Norway and has 300 offices in 100 countries, with 8,400 employees.

Important industries where the company operates include ship transport, energy, aviation, automotive, finance, food, heath care and information technology. It also conducts research in several fields where it operates.

DNV

DET NORSKE VERITAS

MANAGEMENT SYSTEM CERTIFICATE

Certificate No. 43360-2008-AQ-SNG-UKAS

This is to certify that the Management System of

KEYSER TECHNOLOGIES PTE LTD

At

No. 74 Tuas Avenue 11
Singapore 639093

has been found to conform to

ISO 9001:2000

This Certificate is valid for the following product or service ranges:

DESIGN, MANUFACTURE AND SALES OF EXPANSION JOINTS AND ASSOCIATED STEEL FABRICATION WORKS.

Initial Certification date: 16 December 2002

This Certificate is valid until: 15 November 2010

The audit has been performed under the supervision of Chui Heng Tak, *Lead Auditor*

UKAS QUALITY MANAGEMENT 013

Place and date: Singapore, 19 January 2009

for the Accredited Unit: DNV CERTIFICATION B.V., THE NETHERLANDS

Peter D. Dombey, *Management Representative*

Lack of fulfilment of conditions as set out in the Certification Agreement may render this Certificate invalid.

KEYSER®
TECHNOLOGIES

VISION STATEMENT

Together, we will be the recognised leader in our industry for quality, service and responsiveness to customer needs.

MISSION STATEMENT

Our mission is to provide the highest quality products and services to our customers. We will do this through investments in technology, product innovations, production processes, and the people, who are our asset to growth and profitability. Keyser Technologies shall continually improve the effectiveness of the company’s quality management system.

OUR VALUES

- Respect for individuals
- Superior Customer Service
- Pride in craftmanship
- Honesty and Integrity
- Teamwork
- Strong Work Ethic
- Simplicity
- An atmosphere of open communications





INTRODUCTION

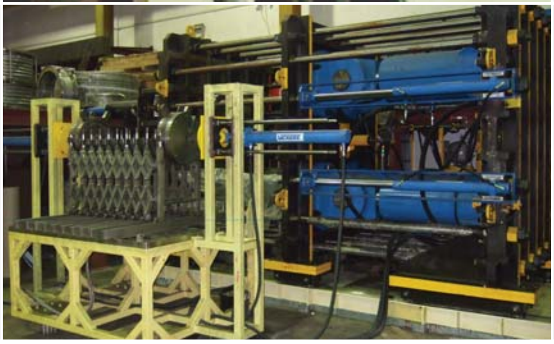
Keyser Technologies Pte Ltd specializes in the Manufacturing of Thermal Expansion Joints in Singapore. Keyser was established in Year 1995, solely as a Trading Service Company in various products. In Year 1999, Keyser entered into the Metal Expansion Joints Industry and ventured with full steam into the Manufacturing of Metal Expansion Joints. This is where the first KEYFLEX bellow was produced. Since then, Keyser has progressively grown and expanded into many sectors of industry in Singapore, Asia and Pacific regions.

Keyser Technologies Pte Ltd is a diversified company where our main activity is to supply Expansion Joints in Metal, Rubber and Fabric types. We also provide a wide range of services, such as fabrication work and trading services. For Quality ASSURANCE - Keyser obtained the Quality System Standard, as an ISO 9001:2000 Company in Singapore, certified by Det Norske Veritas (DNV). We are also accredited to ASME Stamp by Association of Mechancial Engineers (ASME). With respect to ISO 9001:2000 certification and America Society of Mechanical Engineering (ASME) U Symbol Stamp, Keyser is recognized in Designing, Manufacturing and Sales of Thermal Expansion Joints and Associated Steel Fabrication Works. From achieving of ISO 9001:2000 certification, Keyser holds a very strong stand in:

- Supplying high quality products;
- Prompt & efficient delivery;
- Providing premium services to our customers.








Keyser Technologies Pte Ltd works to an approved Q.A./Q.C. procedure manual. This dedication to quality is reflected in the performance of KEYFLEX products. We design and manufacture KEYFLEX Expansion Joints in accordance to the Code and Engineering Standards of Expansion Joints Manufacturers Association (EJMA) and ISO 9001:2000 certification together with Welding Procedure Specifications (WPS) qualified to the American Society of Mechanical Engineers (ASME) Standards.

Keyser leads the industry in the design, manufacture and supply with a comprehensive range of metal expansion joints that can be fully customized to fit different industries with different applications. Keyser Technologies ensures top quality control and innovative designs with constant investments in its staff and equipments. Keyser’s metal expansion joints are used widely to cater for a variety of industries ranging from Marine Industries to Power Plants to many other industrial applications.

KEYSER METAL EXPANSION JOINTS DESIGN

In order to evaluate the loads upon piping, supports or equipment, the determination of the forces and movements required is essential in order to move an Expansion Joint. Due to this reason, the catalogs of most Expansion Joint manufacturers will contain force data to move a convolution to the rated axial movement established by the manufacturer. For convenience, it desirable to divide this force by the rated movement to obtain a bellows resistance factor or working spring rate, fw. in pounds per inch of movement per convolution. Once this factor has been determined, the movements and forces required to move an Expansion Joint may be calculated as follows:

(Formulas from the EJMA Handbook Eighth Edition 2003 & Ninth Edition 2008)

$$F_a = f_w e_x$$

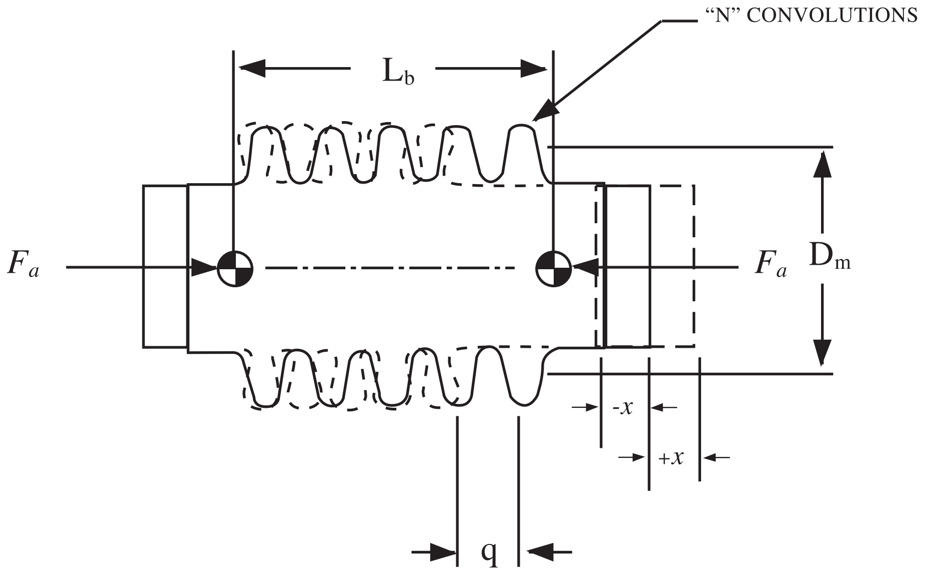
$$M_l = \frac{f_w D_m e_y}{4}$$ for lateral movement

$$M_\theta = \frac{f_w D_m e_\theta}{4}$$ for angular movement

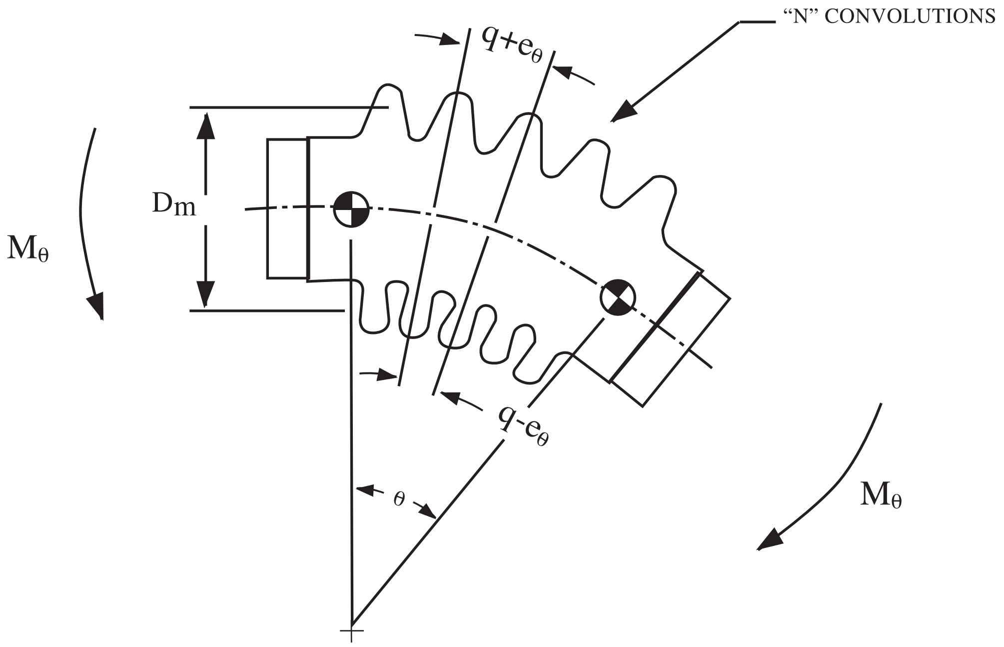
$$V_l = \frac{f_w D_m e_y}{2(L_b \pm x)}$$ for lateral movement of a single bellow

$$V_l = \frac{f_w D_m e_y}{2(L_u \pm x)}$$ for lateral movement of a universal bellow

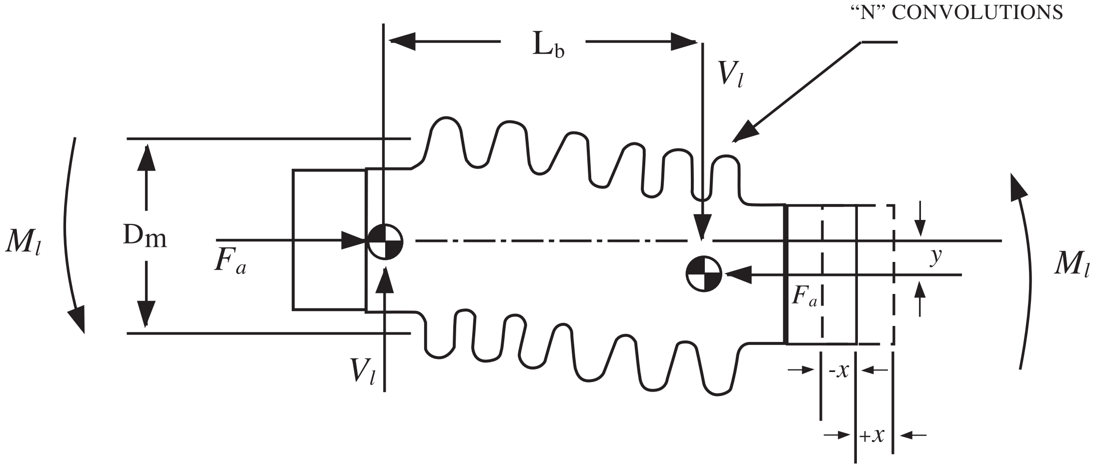
The preceding relationships are applicable in all Expansion Joints. It should be noted that every equation is dependent upon data which must be supplied by the Expansion Joint manufacturer. For standard designs, all necessary data is available in the catalogs of the individual manufacturer. UNDER NO CIRCUMSTANCES SHOULD THE DATA OF ONE MANUFACTURER BE APPLIED TO THE PRODUCT OF ANOTHER DUE TO FUNDAMENTAL DESIGN DIFFERENCES.



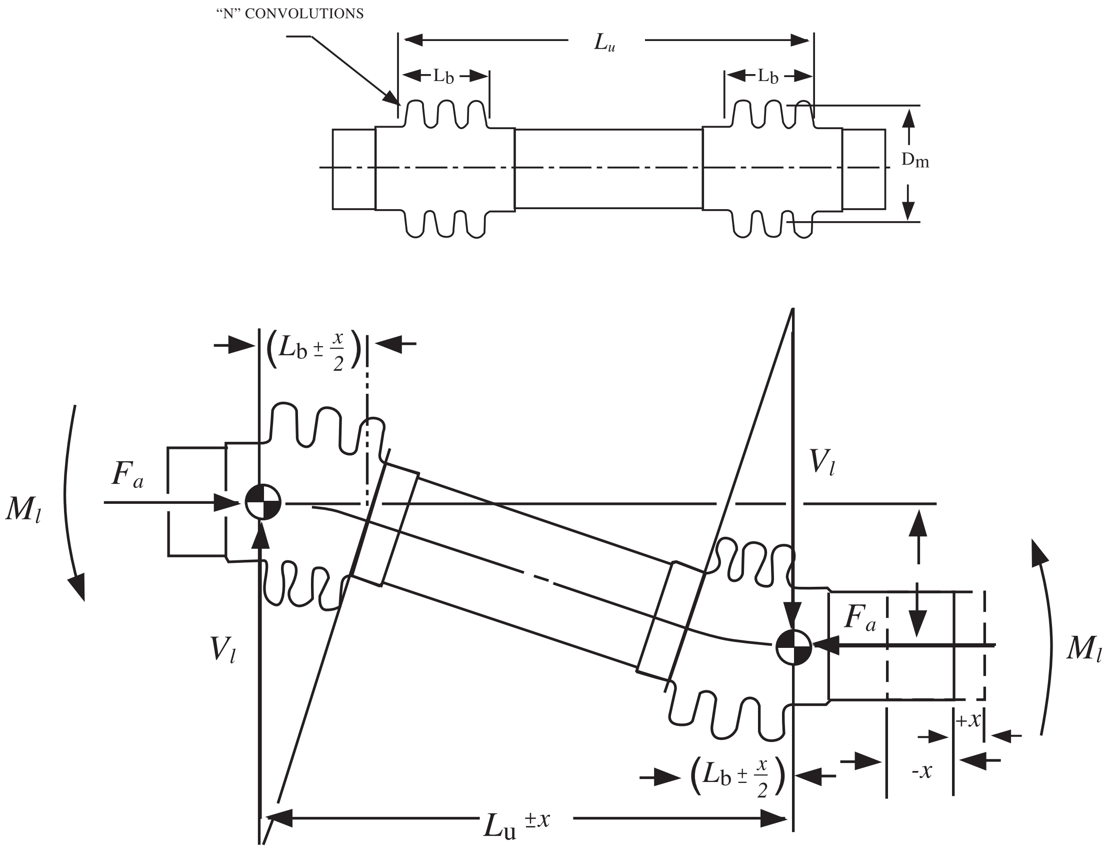
Axial Movement (Single Expansion Joint)



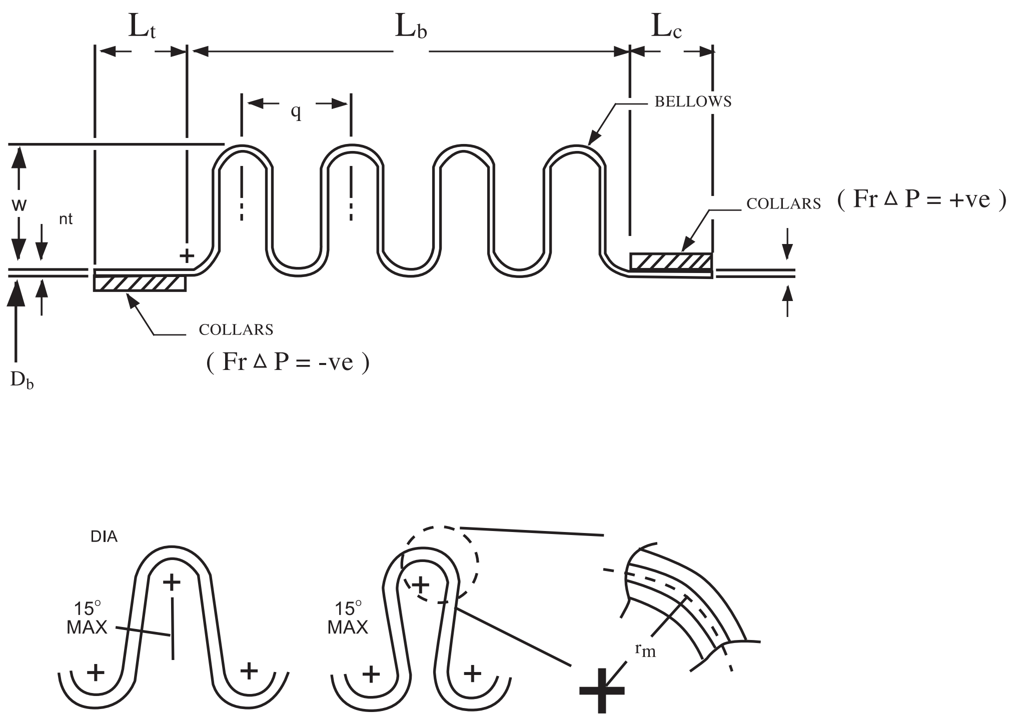
Angular Movement (Single Expansion Joint)



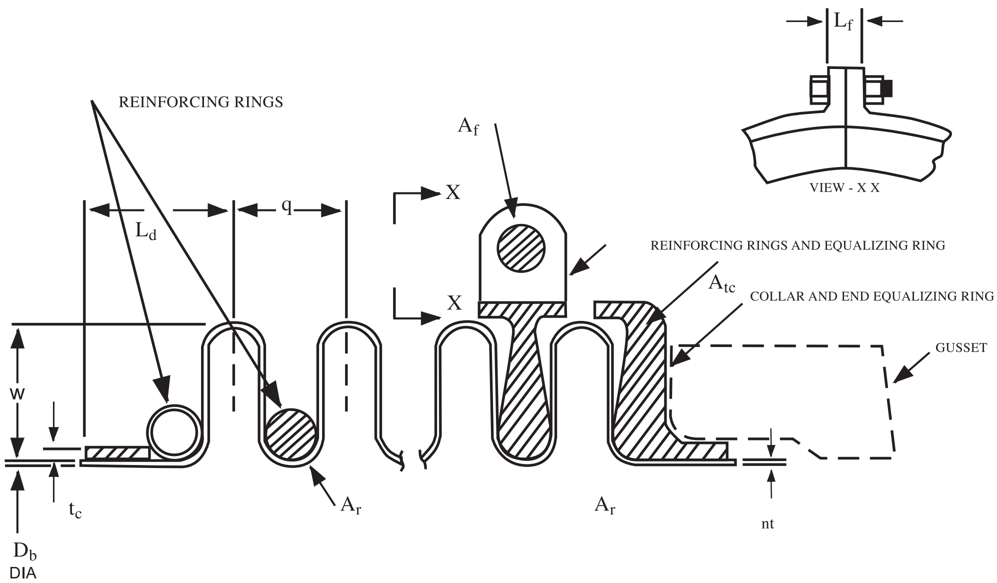
Lateral Movement (Single Expansion Joint)



Lateral Deflection (Universal Expansion Joint)



Unreinforced Bellows



Optional: Reinforced Bellows

APPLICATIONS FOR AXIAL MOVEMENT

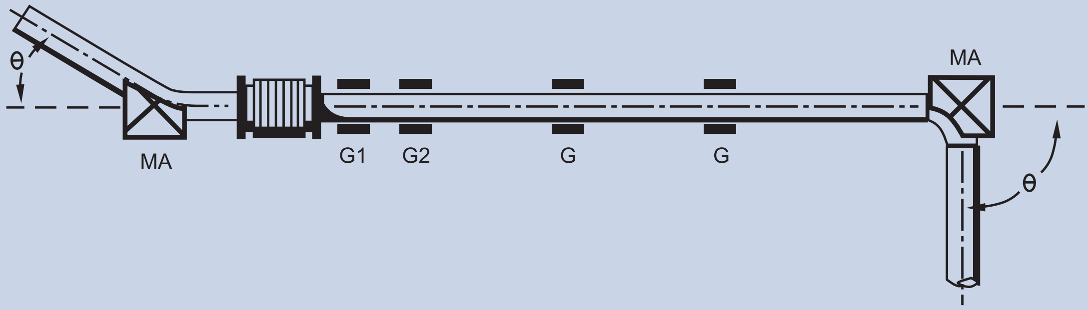


Diagram A

Diagram A displays the use of a single Expansion Joint to absorb axial pipe line expansion. One Expansion Joint is used between two main anchors (MA).

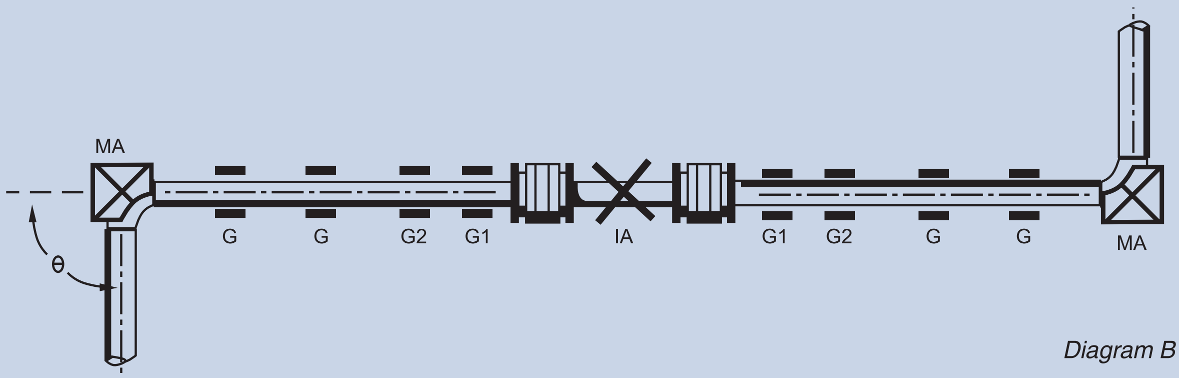


Diagram B

Diagram B displays the use of a double Expansion Joint to absorb axial pipe line expansion. There is a additional intermediate anchor (IA) dividing the pipe line into individual expanding sections with two main anchors, thus there is only one Expansion Joint between any two anchors.

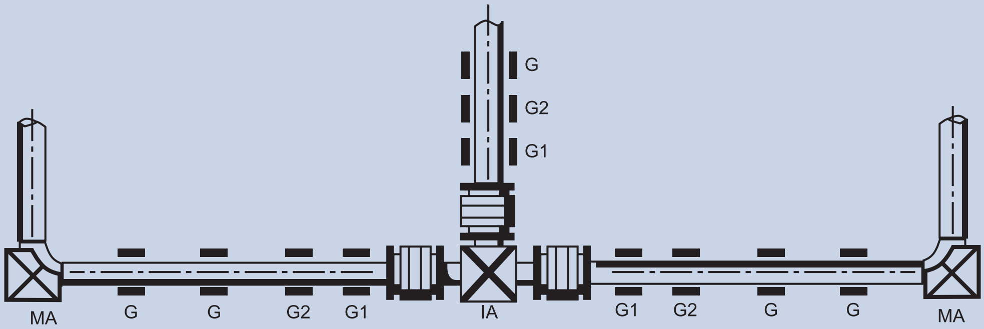


Diagram C

Diagram C displays the use of a Expansion Joints to absorb axial pipe line expansion in a pipe which a branch connection. The anchor at the junction (a tee) is a main anchor (MA) that is designed to absorb the thrust from the Expansion Joint in the branch line.

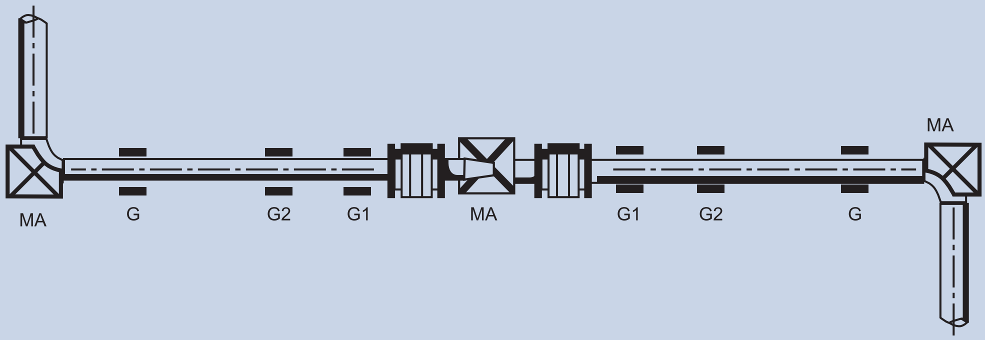


Diagram D

Diagram D displays the use of a Expansion Joints to absorb axial pipe line expansion in a pipe which a reducer. The anchor at the junction, which in this case is a tee, is a main anchor (MA) designed to absorb the thrust from the Expansion Joint in the branch line.

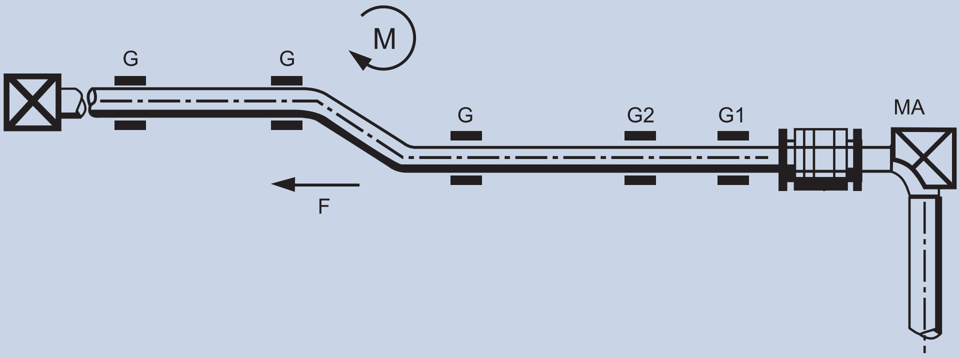


Diagram E

Diagram E displays the use of a single Expansion Joint to a pipe line containing an offset. Applications of this nature are not usually reccomended. There will only be satisfactory performance within certain limits. At each ends, the line is provided with main anchors. This is to absorb the pressure, movement loading, and guide friction. Where the line contains an offset, this load must be transmitted through the offset leg, resulting in a moment on the piping. In cases where the line size is small, the offset appreciable, or where the pressure and movement forces are relatively high, this configuration may result in over-stressing, or distortion of the piping and guides.

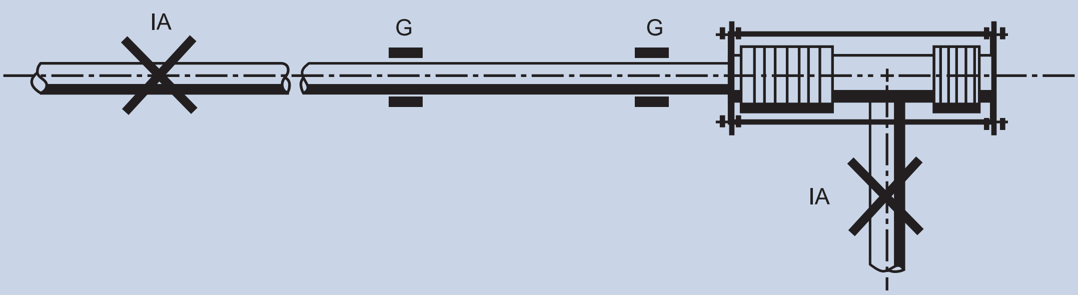


Diagram F

Diagram F displays the use of pressure balanced Expansion Joint to absorb axial line expansion. Take note that the Expansion Joint is located at the position where there is a change in direction of the piping, and that the elbow and the end of the pipe line are secured by intermediate achors. A minimum of guiding is required since the pressure thrust is absorbed by the Expansion Joint itself, and only the forces required to deflect the Expansion Joint are imposed on the piping. Often, directional guiding adjacent to the Expansion Joint, as shown, may suffice. In cases where there are long, small-diameter pipe lines, additional guiding might be needed.

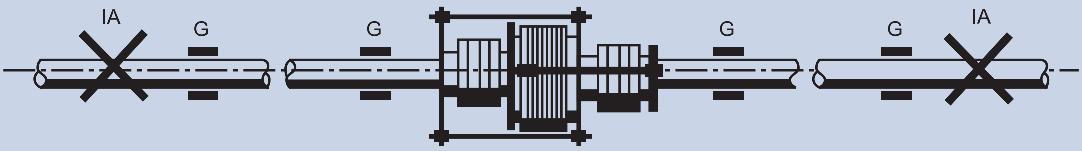


Diagram G

Diagram G displays the use of an in-line pressure balanced Expansion Joints to absorb axial pipe line movements in a long, straight piping run. With this arrangement, the two anchors shown are relieved of pressure loading and are designed as intermediate anchors. A minimum of guiding is requried in this arrangement, primarily to direct the thermal expansion of the piping into the Expansion Joints in an axial direction as the piping is relieved of compressive pressure loading.

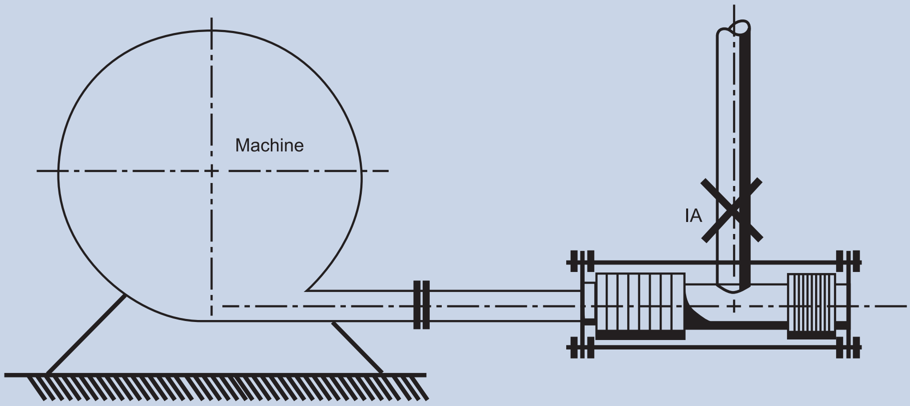


Diagram H

Diagram H displays the use of a pressure balanced Expansion Joint to absorb the thermal expansion of equipment such as turbines & compressors. The Expansion Joint is used primarily to minimize loading upon the equipment casing. Take note that only an intermediate anchor is required at the change of piping direction. However, no guiding is necessary if the Expansion Joint is located immediately adjacent to the machine. Extra care & effort must be taken to provide sufficient flexibility in both the flow bellows and the balancing bellows to ensure that the forces required to compress the Expansion Joint do not exceed loading limits for the equipment as established by the equipment manufacturer.

APPLICATIONS FOR LATERAL DEFLECTION, ANGULAR ROTATION AND COMBINED MOVEMENT

The selection and proper application of Expansion Joints for lateral deflection, angular rotation and combined movements is dependent on a number of considerations, which includes load limitations upon piping and equipment, the surrounding conditions, the piping configuration, the targetted cyclic life, and available supporting structure etc. There will also be cases where two or more types of Expansion Joints are required for a particular application. In this case, the selection then becomes purely an economic one. Often, one or the other of the available designs will carry certain unique characteristics which make it particularly suitable for a given application.

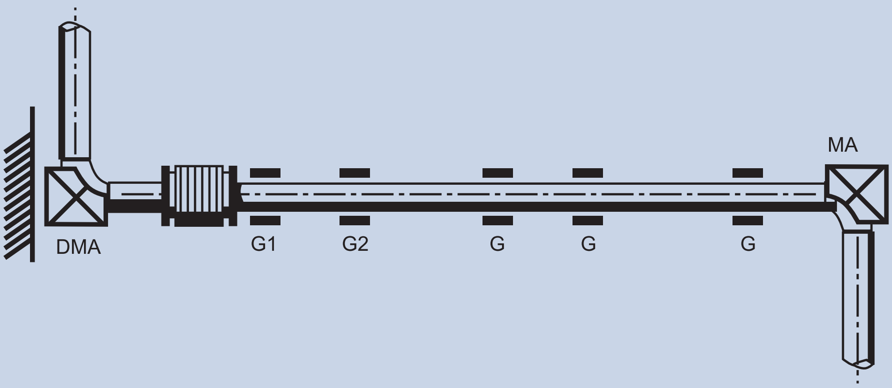


Diagram I

SINGLE EXPANSION JOINTS

The Single Expansion Joint is considered first for any application mainly because of its low cost. Diagram I shows the application of a single Expansion Joint absorbing combined axial movement and lateral deflection. The system closely follows the arrangements shown for axial movement only in the preceding section. The Expansion Joint is located at one end of the long piping control and protection of the piping against buckling. The anchor at the left end of the line is a directional main anchor (DMA). The anchor permits thermal expansion of the short piping leg to act upon the Expansion Joint as lateral deflection while it absorbs the main anchor loading in the direction of the Expansion Joint axis. The anchor at the end of the shorter piping leg is an intermediate anchor as this main anchor loading exists only in the piping segment containing the expansion joint.

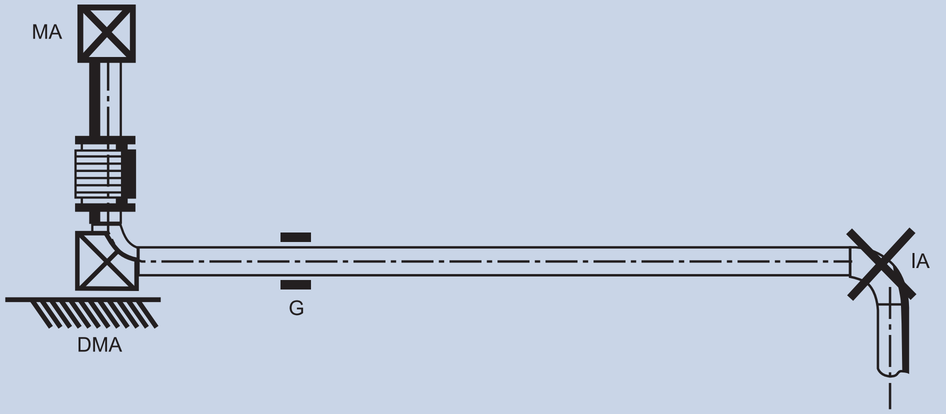


Diagram J

Diagram J displays an alternative arrangement where the Expansion Joint is installed in the short piping leg and the principal expansion is absorbed as lateral deflection. The longer the piping length is free of compressive pressure loading requires only an intermediate anchor and directional guiding. The functions of the directional main anchor and the pipe guide can combined in a single device.

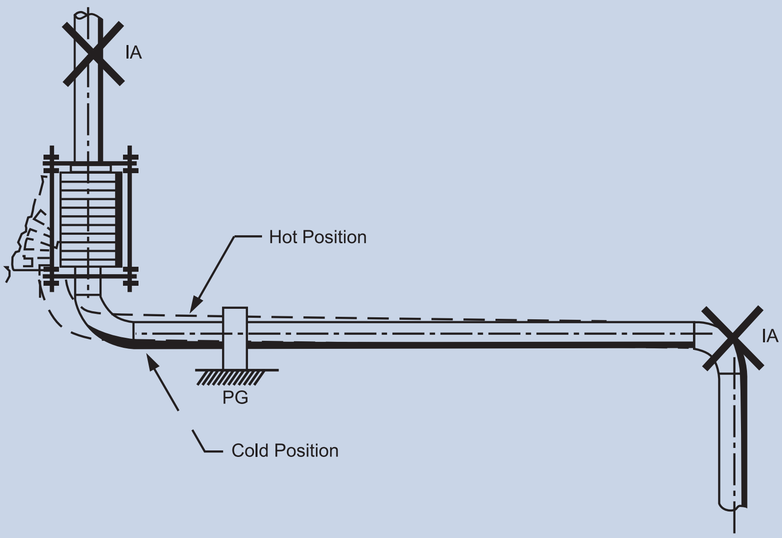


Diagram K

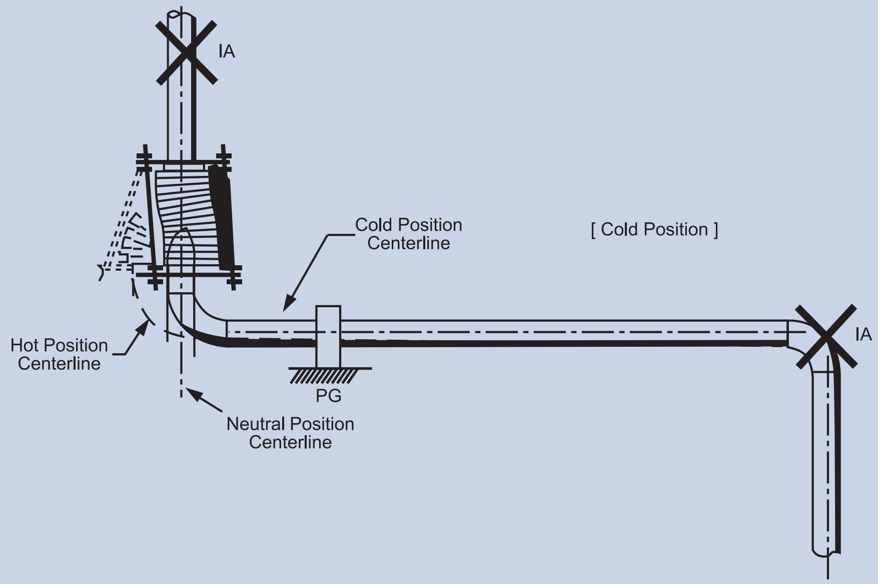


Diagram L

Diagram K & L illustrates modifications on Diagram J where the main anchors at either end of the Expansion Joint are replaced by tie rods. When applicable, the use of tie rods adjusted to prevent axial movement usually eases installation and lowers cost. However, because of these tie rods, the Expansion Joint is unable of absorbing any axial movement other than its own thermal expansion. As a result, the deflection of the piping in the shorter leg imposes deflection on the longer piping leg. In cases where the longer piping leg is not sufficiently flexible or where the shorter leg is dimensionally unsuitable, tie rods can be installed spanning the entire short leg to ensure no deflection is imposed.

Shortening of the Expansion Joint can result from the displacement of the tie rods when certain amounts of lateral deflection are imposed upon the Expansion Joints (as shown in Diagram K). Extra effort and care must be taken to ensure that sufficient piping flexibility exists to absorb this deflection of the piping. Minimizing the amount of this deflection is possible by cold springing the Expansion Joint in the lateral direction.

The limited amout of lateral deflection which such an Expansion Joint can absorb is the main restriction upon the use of single Expansion Joints for lateral deflection or combined axial movement and lateral deflection. The allowable lateral deflection is directly proportional to the ratio of convoluted length to diameter which, in turn, is restricted by considerations of stability and manufacturing limitations.

UNIVERSAL EXPANSION JOINTS

The universal Expansion Joint is ideal for the absorption of lateral deflection. This design may also be used to absorb axial movement, angular rotation or any combination of the three. Using the universal Expansion Joint is its use as a tied Expansion Joint in a 90 degree piping offset with the tie rods adjusted to prevent external axial movement is one of the most typical application used.

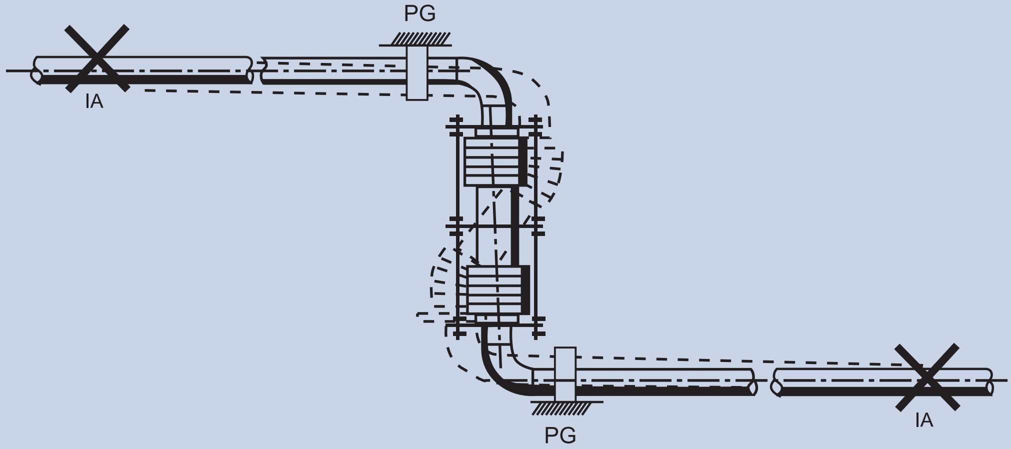


Diagram M

Diagram M illustrates a tied universal Expansion Joint being used to absorb lateral deflection in a single plane “Z” bend. Where dimensionally feasible, the Expansion Joint is designed to fill the entire offset leg to ensure that its expansion is absorbed within the tie rods as axial movement. The tie rod should also be extended to the elbow center line whenever practical. The thermal movement of the horizontal lines is absorbed as lateral deflection by the Expansion Joint.

Since the pressure loading is absorbed by the tie-rods, both anchors are considered intermediate anchors. As the compressive load on the pipe consists only of the force necessary to deflect the Expansion Joint, only directional guiding is needed. Any thermal expansion of the offset leg external to the tie-rods, i.e. the elbows at either end, must be absorbed by bending of the horizontal pipe legs. Considerations must be taken in the design of the guides to allow for both this deflection and the reduced length of the Expansion Joint in its deflected position. For long universal Expansion Joints under high pressure particularly, additional allowance might be necessary to compensate for stretching of the tie rods under load. Consulting the Expansion Joint manufacturer for recommended minimum guide clearances is strongly advised.

MATERIAL EVALUATION FOR HYDRO-FORMING PROCESS

By Singapore Institute of Manufacturing Technology (Project Code: S08-F-09)

Keyser Technologies Pte Ltd developed the Hydro-forming process for the manufacturing of steam bellow components and has engaged SIMTech to evaluate the materials that could be used in this process. The materials that have been studied are stainless steel type 321, 316L and SUS304. The study aims to determine the flow stress data of these materials and to examine whether the influence of material direction is significant. Please note that while the test was conducted on 3 different stainless steel types, this report only includes the logarithmic plot of stress-strain data and tensile strength results of stainless steel type 316L (612663 0.6mm). Please contact Keyser Technologies for more detailed test results.

There are two main objectives in this study:
1) To determine the flow stress curves of the materials used for hydro-forming process from tensile testing.
2) To evaluate whether there is any significant influence of material direction on material properties.

Methodology
The materials evaluated for hydro-forming process are stainless steel Type 316L. Below is a summary of the materials used in this study and their chemical composition.

Stainless Steel Type 321

Batch No.	Material Thickness (mm)	Chemical Composition								
		C%	SI%	Mn%	P%	S%	Cr%	Ni%	Ti%	N%
661853	0.6	0.04	0.42	1.26	0.034	0.002	17.2	9.1	0.37	0.011
658851	0.8	0.04	0.41	1.29	0,03	<.001	17.3	9.1	0.28	0.015
658834	1.0	0.04	0.43	1.27	0.030	0.002	17.1	9.1	0.31	0.014
653074	1.5	0.05	0.41	1.27	0.037	0.001	17.1	9.1	0.34	0.012

Stainless Steel Type 316L

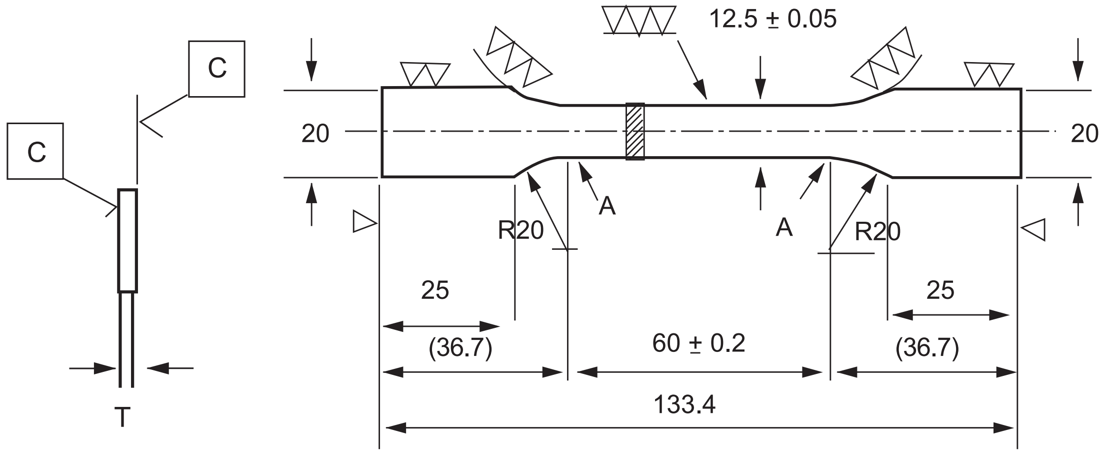
Batch No.	Material Thickness (mm)	Chemical Composition								
		C%	SI%	Mn%	P%	S%	Cr%	Ni%	Ti%	N%
612663	0.6	0.02	0.4	1.05	0.027	0.002	16.6	10.2	2.04	0.03
619743	0.8	0.02	0.4	1.1	0.029	0.001	16.7	10.2	2.03	0.029
612622	1.5	0.023	0.37	1.1	0.03	0.002	16.7	10.1	2.02	0.029

Stainless Steel SUS304

Batch No.	Material Thickness (mm)	Chemical Composition						
		C%	SI%	Mn%	P%	S%	Ni%	Cr%
7N1378D	1.5	0.06	0.66	1.02	0.024	0.005	8.04	18.08

Tensile Test

The tensile specimens are machined from sheets according to the dimensions as shown in the diagram below. In addition, specimens along the rolling, transverse and 45^{o} direction are prepared and will be compared in the flow stress measurement.



1. No machining of surface C
   - Roughness of Surface C is same as raw material surface
   - Thickness T is same as raw material thickness
2. Surface are connected smoothly at A. (Non step at A)
3. All dimensions are in mm

OUTO KUMPU

INSPECTION CERTIFICATE 3.1
SFS-EN 10204 3.1

Certificate No. / Zeugnis Nr. / N° du certificat: 452553/001
Page / Seite / Page: 1(01)
Date / Datum / Date: 18.06.07

Delivery address, Empfänger, Lieu de livraison	
KEYSER TECHNOLOGIES PTE. LTD. 74 TUAS AVENUE 11 SINGAPORE 639093 SINGAPORE	KEYSER TECHNOLOGIES PTE. LTD. 74 TUAS AVENUE 11 SINGAPORE 639093 SINGAPORE

Requirements, Anforderungen, Exigences	Our Order No., Unser Auftrag Nr., Notre commande n°	Your order, Ihre Bestellung, Votre commande
ASTM A240/A240M -06 ASME 2004 SEC. II PART A SA-240 A05	14011	P/4038/APR/07/JL

Product, Erzeugnisform, Produit	Mark of Manufacturer, Zeichen des Lieferwerkes, Signe de producteur	Process, Erschmelzungsart, Mode de fusion	Inspector's stamp, Zeichen d. Sachverst., Poicon de l'expert
COIL , STAINLESS STEEL	OUTO KUMPU	AOD	

Grade, Werkstoff, Nuance	Tolerances, Toleranzen, Tolérances
TYPE 316L	

Marking, Kennzeichnung, Marquage	Marks, Versandzeichen, Marques
A/SA-240 316L 2B	KEYSER TECHNOLOGIES

Line, Reihe, Ligne	Item, Position, Poste	Charge-test No., Schmelze-Probe Nr., Coulée n°	Size, Abmessungen, Dimensions	Quantity, Stückzahl, Nombre	Weight, Gewicht, Poids	Finish, Ausführung, Fini
1	1	61266 3	0,6MM X 4'		5240 KG	2B
2	3	61974 3	0,8MM X 4'		5520 KG	2B
3	4	61262 2	1,5MM X 4'		4880 KG	2B

Chemical composition, Chemische Zusammensetzung, Composition chimiques

Charge no., Schmelze Nr., Coulée n°	C %	Si %	Mn %	P %	S %	Cr %	Ni %	MO %	N %
61266	0,020	0,40	1,05	0,027	0,002	16,6	10,2	2,04	0,030
61974	0,020	0,40	1,10	0,029	0.001	16,7	10,2	2,03	0.029
61262	0,023	0,37	1,10	0,030	0.002	16,7	10,1	2,02	0.029

Mechanical properties, Mechanische Eigenschaften, Caracteristiques mecaniques

Line, Reihe, Ligne	Location, Ort, Lieu	Rp0.2 N/mm²	Rp1.0 N/mm²	Rm N/mm²	A5 %	A50 %	%	Hardness, Härte, Duraté HB30
1	E	299	324	628	70	60		163
	A	277	306	625	67	60		158
2	E	294	330	613	70	60		164
	E	294	330	613	70	60		164
3	E	284	316	582	70	62		151
	A	289	319	592	69	60		155

TENSILE TEST IN ACC TO EN 10002-1 AT ROOM TEMP. IN DELIVERY CONDITION

RP0.2 PROOF STRENGTH
RP1.0 PROOF STRENGTH
RM TENSILE STRENGTH
A50 ELONGATION GL 50 MM
A5 ELONGAT. GL PROPORT.
SAMPLES PERPENDICULAR TO THE ROLLING DIRECTION

Identity test, Verwechslungsprüfung, Controle d'identification
Sizes, Abmessungen, Dimensions
Surface, Oberfläche, Surface
Test of intergran. corros. Prüfung auf interkrist. Korros. Test de corros. intercrist.
ASTM A262-02AE3 PRACTICE E : OK

A = Beginning / Anfang / Début
E = End / Ende / Fin

We certify that the above mentioned products comply with the terms of the order contract.
Wir bestätigen, dass die Lieferung den Vereinbarungen der Bestellannahme entspricht.
Nous certifions ques les produits énumérés ci-dessus sont conformes aux prescriptions de la commande.

This test certificate is made by controlled ADP-system and is valid without signature.
Dieses Zeugnis wurde von einem überprüften Datenverarbeitungssystem erstellt und is ohne Unterschrift gültig.
Ce certificat a été établi par un systeme informatique controlé et est valide sans signature.

Outokumpu Stainless Oy

Anne-Maria Kuusela

Authorized inspector / Werkssachverständiger / Inspecteur autorisé: A-M KUUSELA

FIN-95400 Tornio, Finland
Tel. +358 16 4521,Fax +358 16 452 350.
www.outokumpu.com
Domicile: Tornio, Finland, Business Identity Code 0823315-9

Uniaxial Tensile Test

Instron 4505 mechanical testing machine is used in this tensile testing to determine the flow stress data of the stainless steel materials. The extension speed was set at a constant speed of 5mm/min for all the material used. True strain (ε) and true stress were calculated from the measured values of tensile load and stroke by the following equation:

$$\varepsilon_e = \ln\left(\frac{L_i}{L_0}\right) = \ln\left(\frac{L_i + \Delta L}{L_0}\right)$$

$$\sigma_e = \sigma_e\left(1 + \varepsilon_e\right) = \frac{F}{A_0}\left(1 + \frac{\Delta L}{L_0}\right)$$

where, L_i is instantaneous length, L_0 is the initial strength, ΔL is change in length (or machine stroke), σ_e is the engineering stress, ε_e is the engineering strain, A_0 is the initial area of the test specimen and F is the measured values of tensile load.

Result & Discussion

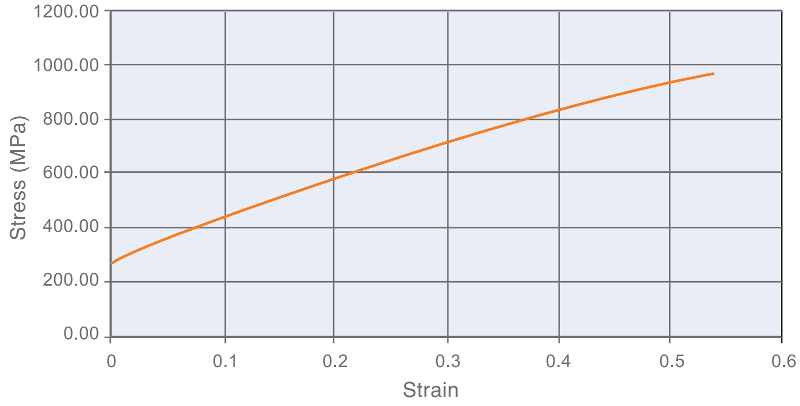
Tensile Testing of 316L Stainless Steel
Flow Stress Plot

The table below shows the yield strength and ultimate tensile strength for Stainless Steel 316L. The figures on the next page shows the stress-strain curves of Stainless Steel Type 316L determined from the tensile test for specimen thickness 0.6 mm in transverse, rolling and 45º direction. From the combined plots of the stress-strain curves in the 3 direction, the maximum differences in stress are approximately 4%. The highest differences will be on the flow stress along the 45º of the rolling directions for the wall thickness of 0.6mm.

Yield strength and ultimate tensile strength for Stainless Steel Type 316L

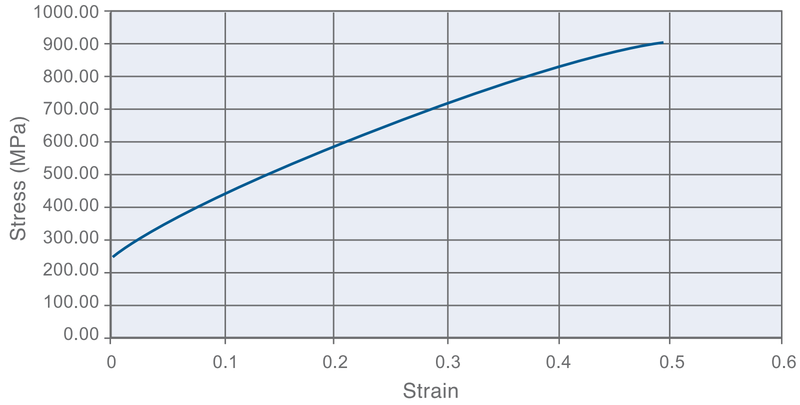
Material Batch	Specimen Direction	Yield Strength (MPa)	Ultimate Tensile Strength (MPa)
612663 (t=0.6mm)	Transverse	269	573
	Rolling	247	560
	45º	232	548
	Average	249	560

Stainless Steel Type 316L, Transverse Direction (612663)

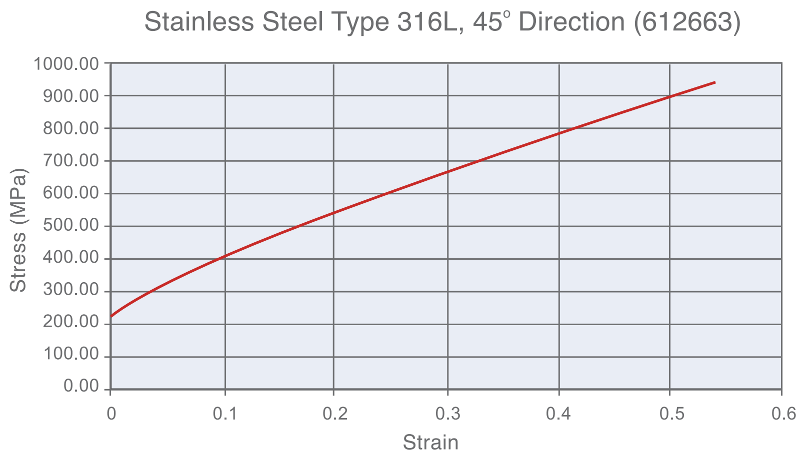


Transverse Direction

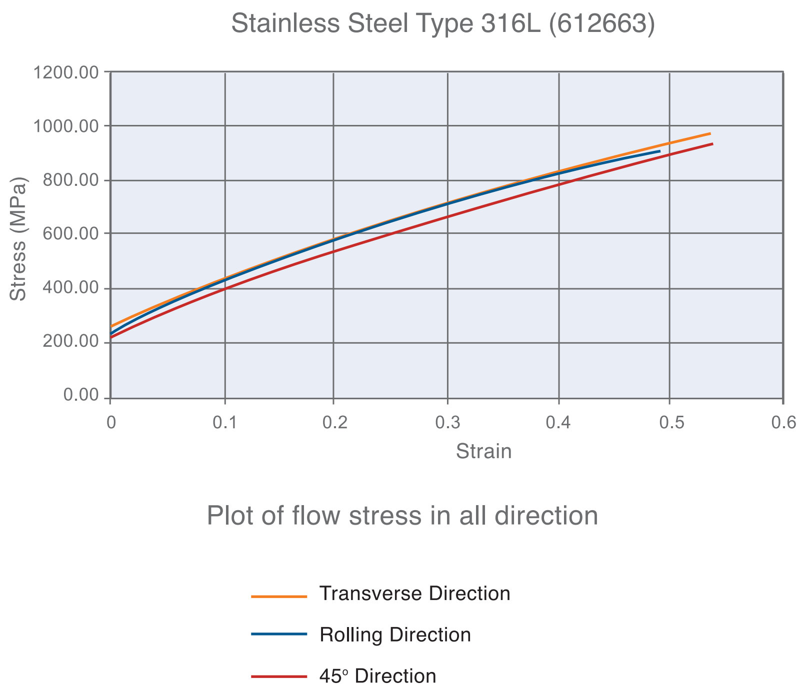
Stainless Steel Type 316L, Rolling Direction (612663)



Rolling Direction



45° Direction

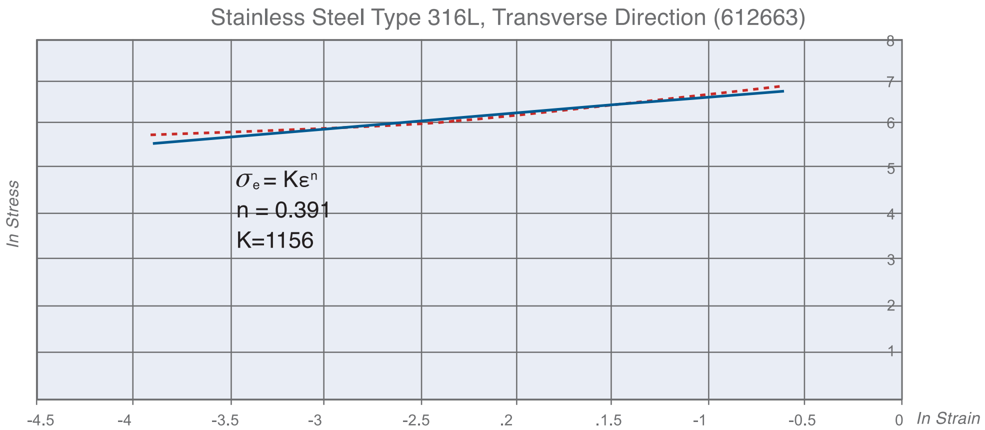


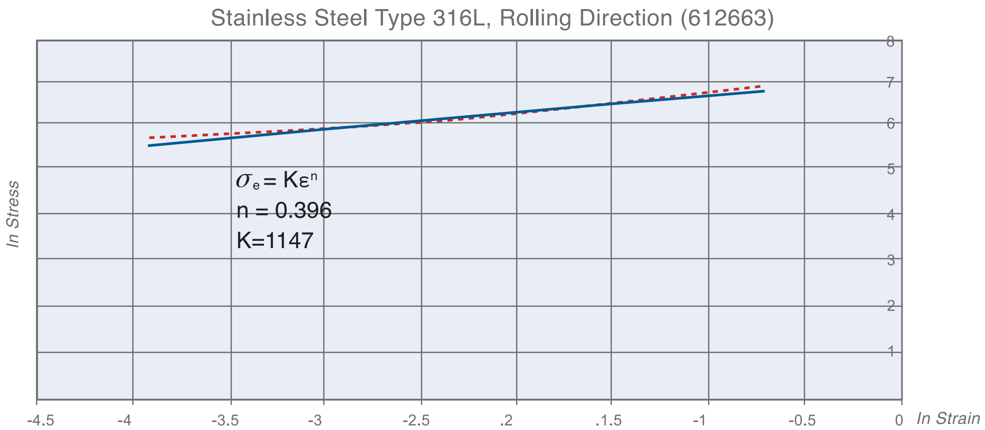
Plot of flow stress in all direction

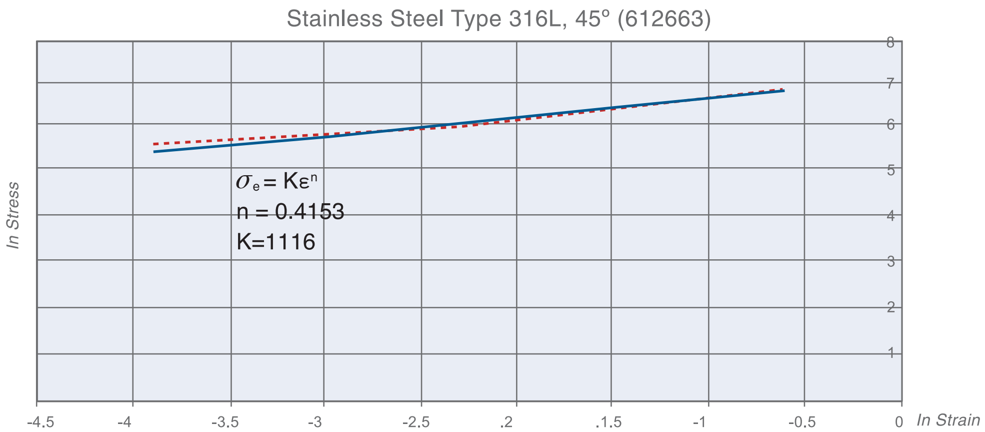
Logarithmic Plot of Stress-strain data

The figures below shows the logarithmic plot of stress-strain data. The values of work hardening exponent (n) and K in the expression of $\sigma = K\varepsilon^n$ were determined from the equation of straight line obtained by least square fitting.

Logarithmic Plot of Flow Stress Date of Stainless Steel Type 316L (t = 0.6mm)







Summary and Conclusion

From the tensile tests, important material properties such as Yield Strength and Ultimate Tensile Strength are determined from the stress-strain curves and are summarized in the table below.

Summary of the average yield strength (0.2% strain) and ultimate tensile stength

Material Type	Material Batch No.	Yield Strength (MPa)	Ultimate Tensile Strength (MPa)
Type 316L	612663	230	580
	(t=0.6mm)		

From the logarithmic plot of stress-strain data, the average values of work hardening exponent (n) and K in the expression of material flow stress equation ($\sigma = K\varepsilon^n$) are determined and summarized at the table below.

Summary of the average work hardening coefficient (n) and K constant values

Material Type	Material Batch No.	Hardening Coefficient (n)	K Constant
Type 316L	612663	0.4	1140
	(t=0.6mm)		

It is also concluded that the influence of material direction on flow stress is somewhat significant since the differences in stress are approximately 8% in all the materials tested. The difference in stress along different directions will determine the resistance of sheet along the thickness direction. In other words, the material tends to form without significantly changing in the wall thickness.

TYPES OF EXPANSION JOINTS

K-WA

Features

This Expansion Joint comprises of one single bellows accompanied with welding ends. While this model will absorbs all of the movements in any one length of piping, absorbing **axial movements** remains its primary role.

K-TE

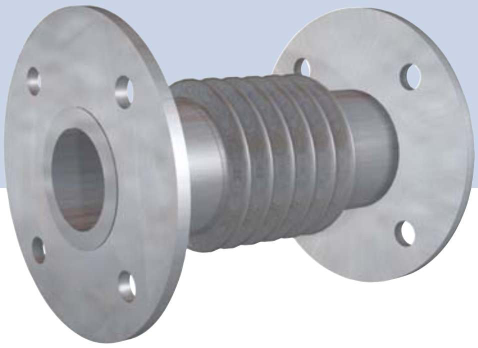
Features

This model is similar to the K-WA model except that is fitted with BSP or NPT threads instead of welding ends. The threads are external.

K-TI

Features

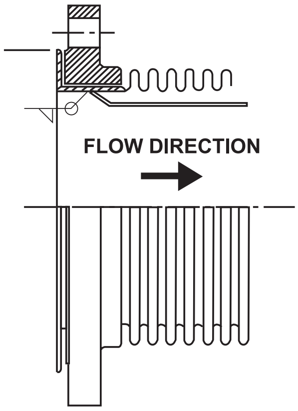
This model is similar to the K-WA model except that is fitted with BSP or NPT threads instead of welding ends. The threads are internal.

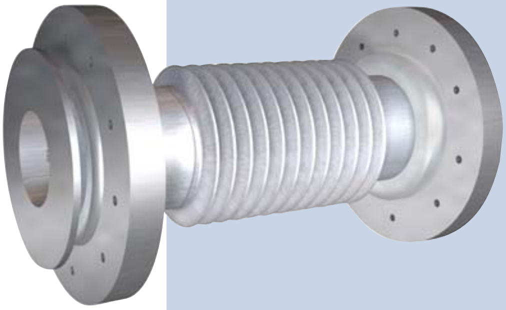


K-FA

Features

This model comprises of a single bellows equipped with fixed flanges. While this model will absorbs all of the movements in any one length of piping, absorbing **axial movements remains** its primary role.

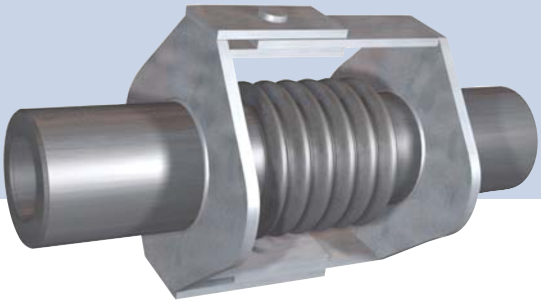




K-FF

Features

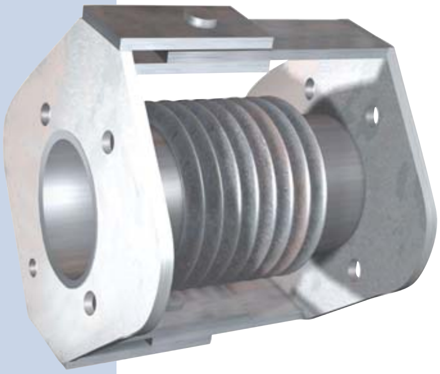
This Expansion Joint is the same as K-FA except that it comes with floating flanges instead of fixed flanges.



K-WH

Features

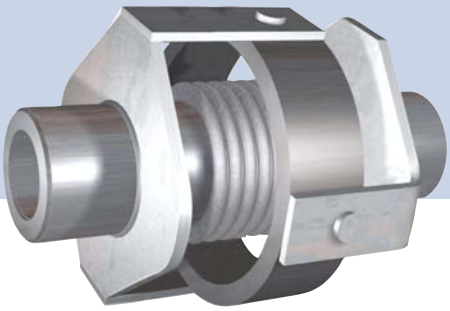
Known as **Hinged Expansion Joint with Welding Ends**, this model comprises of a bellows fitted with welding ends and a system of articulated supports that allow **Angular Movements in One Plane Only.**



K-FH

Features

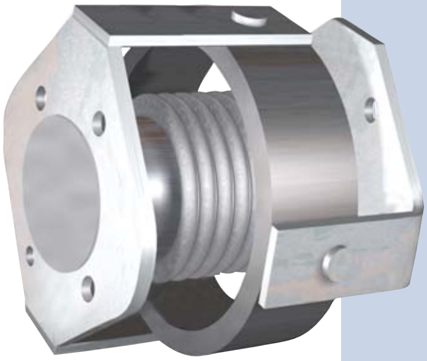
Known as **Hinged Expansion Joint with Flanges**, this model comprises of a bellow fitted with flanges and a system of articulated supports that allow **Angular Movements in One Plane Only.**



K-WG

Features

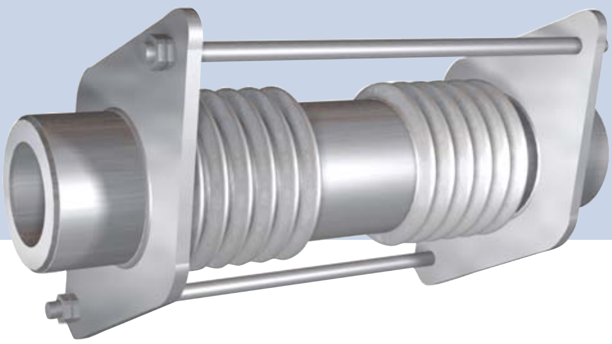
Known as **Gimbal or Cardan Expansion Joint with Welding Ends**, this model comprises of a bellow with welding ends together with two pairs of articulations linked up to a common floating ring. It absorbs **Angular Movements in One Plane Only.**



K-FG

Features

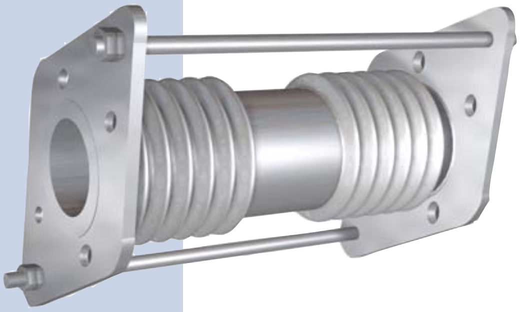
Known as **Gimbal or Cardan Expansion Joint with Welding Ends**, this model resembles K-WG except it comes with flanges instead of welding ends.



K-WL

Features

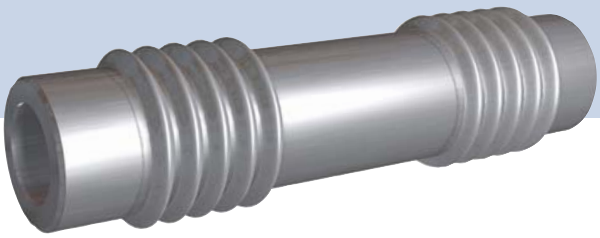
Known as **Hinged Expansion Joint with Welding Ends**, this model comprises of a bellows fitted with welding ends and a system of articulated supports that allow **Angular Movements in One Plane Only.**



K-FL

Features

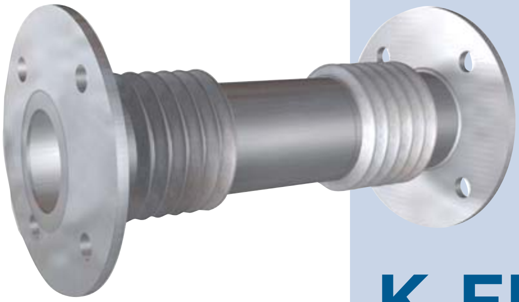
The model resembles K-WL except that it comes with flanges.



K-WD

Features

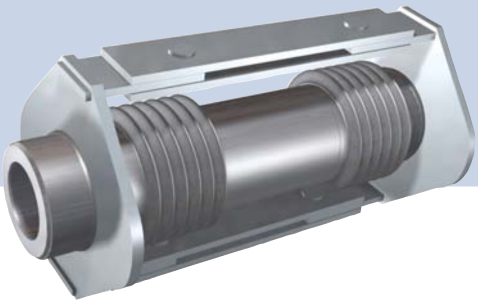
Known as **Universal Expansion Joint with Welding Ends**, this model comprises of two bellows joined together by a central pipe and fitted with welding joints. While this model can be used to absorb any combination of the three basic movements, absorbing **lateral movements** remains its primary role.



K-FD

Features

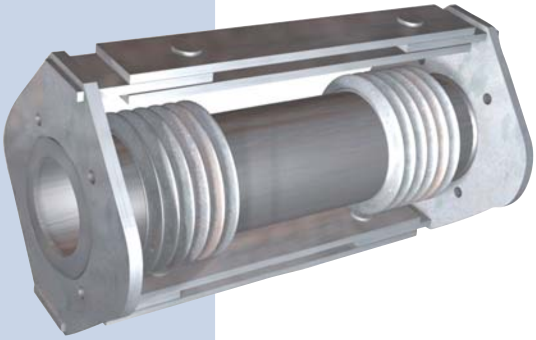
Known as **Universal Expanion Joint with Flanges**, this model comprises of two bellows joined together by a central pipe and fitted with flanges. While this model can be used to absorb any combination of the three basic movements, absorbing **lateral movements** remains its primary role.



K-WY

Features

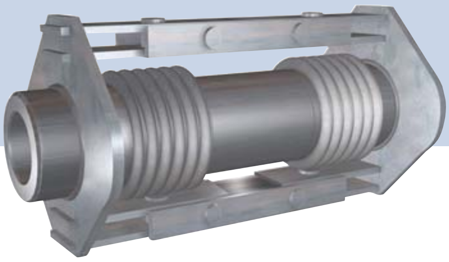
Known as **Hinged Expanion Joint with Welding Ends**, this model comprises of a bellows fitted with welding ends and a system of articulated supports that allow **Angular Movements in One Plane Only.**



K-FY

Features

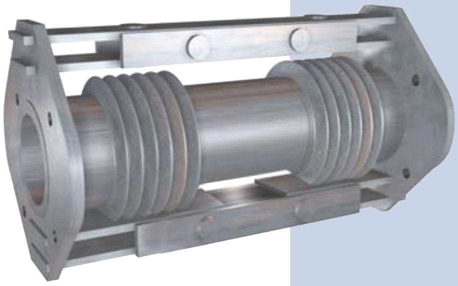
The model resembles K-WY except that it comes with flanges instead of welding ends.



K-WK

Features

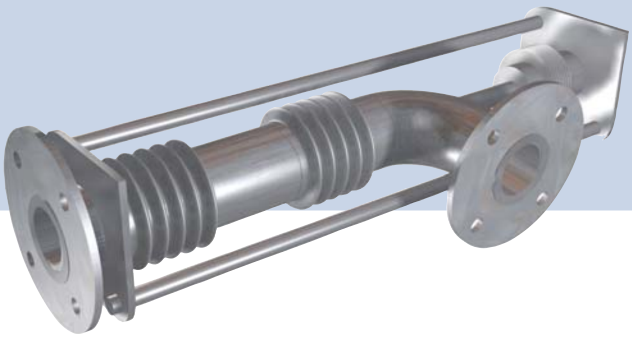
This model is designed to absorb Lateral and Angular Movements in all directions. It is made up of two bellows joined together by a linking pipe and comes fitted with welding ends and a universal system of double articulated supports.



K-FK

Features

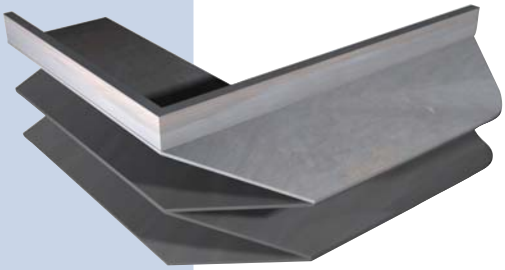
This model resembles K-WK except that it comes with flanges instead of welding ends.



K-PB

Features

Pressure Balanced - This Expansion Joint is specially designed for very specific situations. It is designed to absorb **Lateral and/or Axial Movements Eliminating The Thrust caused by The Internal Pressure**.



K-RW

Features

Camera Corner - Rectangular Expansion Joint With V-shaped Convolutions and Camera CORNER.

The applications of this model is exactly the same as the Circular Expansion Joints, and is characterised by the shape of its corner camera type and the V-shaped convolution. The connection elements are available with both flanges or welding ends.

K-UX

Features

This Expansion Joint is used to absorb axial movements. Generally, it is made up of a single carbon steel or stainless steel convolution comprising of one thick ply. They are mainly used in heat exchangers etc.

K-RU

Features

Rounded Corner - Rectangular Expansion Joint With U-shaped Convolutions and Rounded Corner.

This Expansion Joint are used in the same applications as the Circular Expansion Joints, and the corner is rounded and the convolution is U-shaped.

K-RVV

Features

Double Miter Corner

This is similar to the K-RV and the key characteristics of this model is by the shape of its miter type corner and its V-shaped or U-shaped convolution. The advantage of this is that the stress is more spread out resulting in a longer life cycle.

K-RV

Features

Single Miter Corner - Rectangular Expansion Joint With V-shaped Or U-shaped Convolutions And Miter Corner.

The key characteristics of this model is by the shape of its miter type corner and its V-shaped or U-shaped convolution. The corner can be either single or double and the connection elements are available with both flanges or welding ends.

Sample of Specification Data Sheet for Rectangular Metal Expansion Joint

KEYSER TECHNOLOGIES PTE LTD
Company Reg No.: 199001238N GST REG. NO.: 19-9001238-N
(Design, Manufacture of KEYFLEX Expansion Joints & Associated Steel Fabrication Works)

This Expansion Joint Design Analysis was calculated based on Standards of the Expansion Joint Manufacturer's Association, EJMA, 9th Edition 2008

Rectangular Expansion Joint Design Analysis

Calculation & Rev	KEY-12009181, Rev-0	Calculation Date	12/6/2009
Client	BS	Drawing Number & Rev	4122, Rev-A
Project Desc	P-012343202	Calculation by	Keyser Technologies Pte Ltd

Design Data

Design Temperature	400.00 C	Axial Movement*	45.00 mm	Angu Rotation L Side	0.00 radian
Design Pressure	0.10 MPa	Lateral Movmt L side*	7.00 mm	Angu Rotation S Side	0.00 radian
Req. Fatigue Cycles	3000.00	Lateral Movmt S side*	7.00 mm		

** Based on Concurrent Moment*

Dimensions

Inside Length L side	1370.00 mm	No of Layers	1.00	Convolution Pitch	80.00 mm
Inside Length S side	510.00 mm	No of Convolutions	5.00	Tangent Length	10.00 mm
Layer Thickness	1.50 mm	Convolution Height	100.00 mm	Total Bellow Length	1400.00 mm

Material

Bellow Material	SS316	Duct Material	SS316	Duct Collar Material	SS316
Modulus Elasticity	157187.00 MPa	Modulus Elasticity	157187.00 MPa	Modulus Elasticity	157187.00 MPa
Allowable Stress	115.40 MPa	Allowable Stress	115.40 MPa	Allowable Stress	115.40 MPa

Calculation Results (Stress)

S7L	6.62 MPa	Allowed Cycles	3272.99	Axial Spring Rate	206.80 kN/mm2
S7s	15.95 MPa	Bellows Length Le	420.00 mm	Equ. Axial movement e_e	115.40 mm
S8la	183.43 MPa	Bellows Length Lb	400.00 mm	Equivalent Thrust Force	0.05 kN
S8lb	3920.00 MPa	Bellows Length Lu	1400.00 mm	Axial Thrust Force	0.13 kN
S8l	183.43 MPa	Bellows Length L side	1470.00 mm	Moment of Inertia	1963440.00 MPa
S8sa	31.59 MPa	Bellows Length S side	610.00 mm	Bellow Yield at Des Tem	206.8 MPa
S8sb	3920.00 MPa	Effecti. Length L side	777.40 mm	Allowable Stress	115.4 MPa
S8s	31.59 MPa	Effecti. Length S side	574.81 mm	Bellow E at Rm Tem	157187.00 MPa
S9	164.44 MPa	Cross Sectional Ac	368.57 mm2	Bellow E at Des Tem	207847.00 MPa
S10	648.19 MPa	Radius of Convol	20.00 mm	Factor Ku	1.33
S11	4.17 MPa	Force Due to Press	0.04 kN	Factor Ks	1.37

Evaluation: ______________________________

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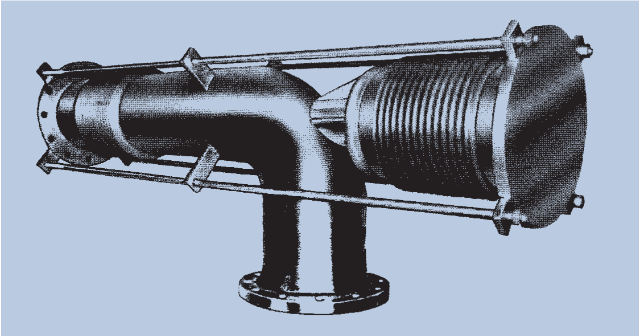
PRESSURE BALANCED EXPANSION JOINT



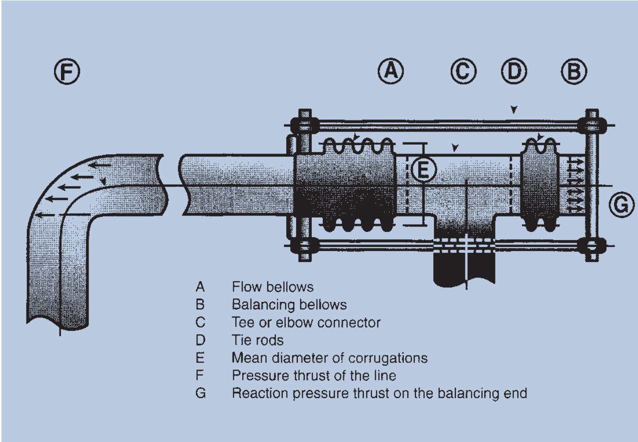
Keyser Pressure Balanced Expansion Joints are pressure balanced elbow or tee expansion joint systems specifically designed to overcome the reaction load caused by internal pressure acting, against turbine casings, pumps and other equipments. In situations where a main anchor cannot be installed to absorb axial and lateral motion, pressure balanced expansion joints are installed.

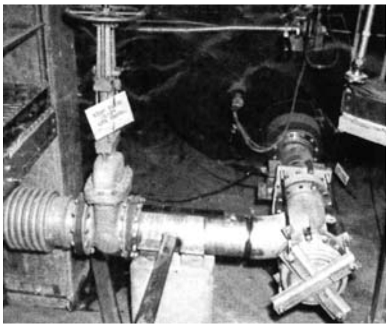
Keyser Pressure Balanced Expansion Joint design uses flow and balancing bellows inter-connected by using tie rods. The balancing bellows are subjected to the same line pressure as the flow bellows. When the flow bellow pressurizes, the tie rods extends the balancing bellows by an equal amount. There is no change in the volume, thus the pressure force remain in balance. Do note that there is no volume change when the flow bellows deflect laterally. The balancing bellows need only to contain the proper number of convolutions required to absorb the axial movements of the system. The axial force, however, is the total of the force required to move the line bellows and balancing bellows.

Key Features:
- *Absorbs axial and lateral movements while restraining pressure thrust*
- *Eliminates main anchors*
- *Minimum guiding required*

How Does Keyser's Axial Pressure Balance Work

Internal pressure that have been built up causes a pressure thrust on flow bellows (A) and against the side outlet (elbow or tee) (C). This thrust is balanced by the identical internal pressure thrust (G) pushing on balancing bellows (B) that is transmitted back through the tie rods (D) counteracting the line pressure thrust (F). The force remaining is the axial spring force required to compress line bellows (A) and extend balancing bellows (B), plus whatever friction load is gnerated by the piping moving through the alignment guides.

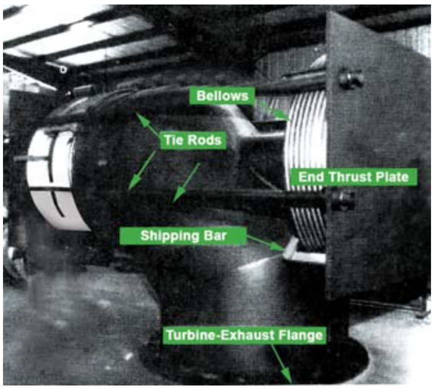




Applications

Keyser Pressure Balanced Expansion Joints are used when there is a change in the direction of the pipe line, and most commonly used is adjacent to equipment such as pump or valves where allowable nozzle loads necessitate the elimination of pressure thrust.

Shown is a typical pressure balanced elbow used where there is a change in the direction of the piping.

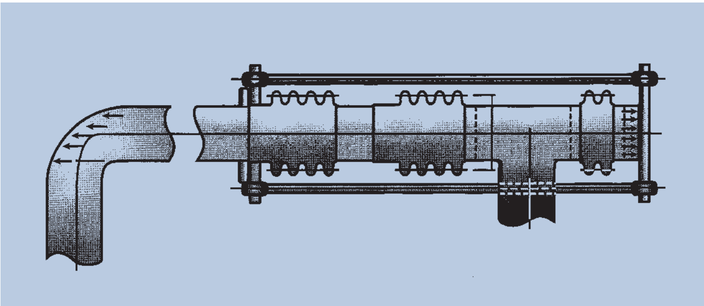


Elbow Or Tee Dual-flex And Universal Series

PBEU

Keyser Pressure Balanced elbow model PBEU, functions on the same principle as the PBES model, with the exception that it has a universal flow bellow design. Commonly used when large amount of lateral movements are required or when the lateral force must be held to a minimum. In this design, two bellows are used in the flow end of the expansion joint and single bellows in the balancing end.

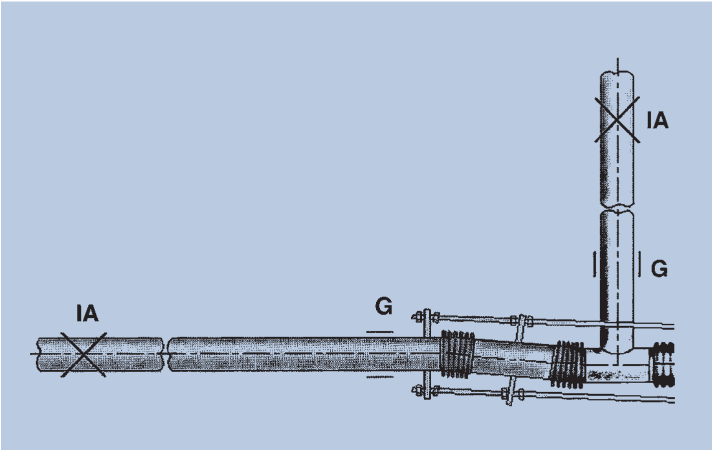
The use of the connecting pipe from the elbow/tee for the balancing bellows must be large enough to assure rapid equalitation of the pressure from balanced bellows with the pressure of the universal flow bellows.



Pressure balanced joint has lateral pipe connection that can move easily between two bellows.

Keyser PBEU series is used to absorb external lateral movement without impairing loading on the system when a pressure line that connects to a component is subjected to a large amount of lateral deflection. A universal bellow is placed at the flow end with a single bellow in the balancing end, joint by 4 tie rods. These tie rods pivot at their attachment joints. The lateral movements is taken by the flow bellow in the same manner as a tired universal expansion joint.

The diagram at the side shows a typical application of a pressure balanced expansion joint for combined axial movement and lateral deflection. The anchor on the piping run and that on the turbine are intermediate anchors and only directional guiding is required. By proper design, the guide directly above the turbine can be made to absorb the axial movement forces of the expansion joint without transmitting these to the turbine. The only force imposed on the turbine is that which is required to deflect the expansion joint laterally.



Guilding and anchoring construction in a Keyser PBEU universal pressure balanced expansion joint system

Sample of Specification Data Sheet for Circular Metal Expansion Joint

KEYSER® TECHNOLOGIES

KEYSER TECHNOLOGIES PTE LTD

Company Reg No.: 199001238N GST REG. NO.:19-9001238-N

(Design, Manufacture of KEYFLEX Expansion Joints & Associated Steel Fabrication Works)

This Expansion Joint Design Analysis was calculated based on Standards of the Expansion Joint Manufacturer's Association, EJMA,8th Edition 2003

Calculation: /2007/3267 Revision: 0

Supplied by: Keyser Technologies Pte Ltd

Client:		Drawing Number:	1752	Calculation Date:	1/9/2007
Project No:		Drawing Revision:	F	Calculated By:	Keyser Technologies
Project Desc:	KEY-800-2.5-6LX6LT	Item Number:			

Design Data

Design Temp:	410	C	Axial Compression:	-90.0	mm	Req. Fatigue Cycles:	1000
Design Press:	0.250	MPa (g)	Lateral Movement:	50.0	mm	Addit. Fatigue Safety Factor:	1
			Angular Rotation:	0.0	degr	Annealed Bellow:	No
			Angular Rotation Max:	0.0	degr	Weld Factor:	0.7

Dimensions

Nominal Diameter:	800		Tool Radius:	11.70	mm	Nipple Length:	200	mm
Bellows ID:	815.0	mm	Pitch:	50.0	mm	Nipple Mass:	37.8	kg
Bellows OD:	908.2	mm	Tangent End ID:	815.0	mm	Nipple Angle:	0.0	degr
No of Convol:	6		Tangent Length:	30.0	mm	Pipe End Length:	0	mm
No of Layers:	2		Collar Length:	0.0	mm	Pipe End Thickness:	0.0	mm
Layer Thickness:	0.80	mm	Collar Thickness:	0.00	mm	Bellows Type:	Unspecified	

Materials

Bellows:	ASME SA-240 Grade 316 1998 ed	Pipe Ends:		Bellows material's Yield:	206.8 MPa
Nipple:	ASME SA 516 Gr 70 1998ed	Collar:		Bellows in Creep Range:	No

Calculation Results

Cd:	1.98		Rated Max Axial Movement:	140	mm	Allowed Cycles:	8,148	
Cf:	1.42		Tot Equivalent Axial Movement:	112.6	mm	Convol Depth w:	45.0	mm
Cp:	0.57		Bellows Allowed Stress:	110.5	MPa	Bellows Length Le:	360	mm
S1:	50.0	MPa	Bellows E at Temperature:	167,612	MPa	Bellows Length Lb:	300	mm
S'1:	0.0	MPa	Bellows Yield at Temp by EJMA:	246.4	MPa	Bellows Length Lu:	800	mm
S2:	29.2	MPa	Axial Spring Rate:	149	N/mm	Total Length:	800	mm
S3:	3.6	MPa	Lateral Spring Rate:	198	N/mm	Thickness tp:	0.78	mm
S4:	119.9	MPa	Bending Spring Rate:	242	Nm/degr	Effective Area Ae:	583,044	mm^2
S5:	8.6	MPa	Limiting Column Instability:	0.271	MPa	Factor Ku:	1.43	
S6:	1,184.5	MPa	Limiting Inplane Instability:	0.422	MPa	Thrust Force:	146	kN

Evaluation

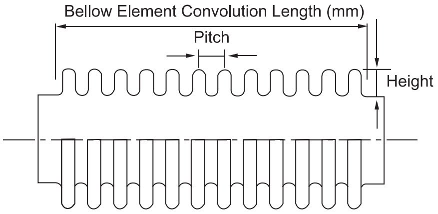
All stresses and values are acceptable if not otherwise stated below.

Address: 74 Tuas Avenue 11 Singapore 639093 Tel : 6262 0718 Fax : 6262 0836
Email: keyser@singnet.com.sg Website: http://www.keyser.com.sg

ISO: 9001-2000

Materials used to manufacture Bellows	
1	304
2	304H
3	304L
4	309S
5	310S
6	316
7	316H
8	316L
9	316ti
10	321
11	Hastelloy C276
12	Incoloy 800 HT
13	Incoloy 825
14	Inconel 600
15	Inconel 625
16	Inconel 625 LCF
17	Monel 400
18	HASTELLOY B-2 alloy
19	HASTELLOY B-3 alloy
20	HASTELLOY C-4 alloy
21	HASTELLOY C-22 alloy
22	HASTELLOY C-2000 alloy

Materials used to manufacture Reinforcing Rings	
1	304
2	304H
3	105
4	106B
5	304
6	304H
7	304L
8	309S
9	310S
10	316
11	316H
12	316L
13	321
14	516 Gr70
15	B7
16	Hastelloy C276
17	Incoloy 800HT
18	Incoloy 825
19	Inconel 600
20	Inconel 625
21	Inconel 625 LCF
22	P11
23	P22
24	SA36
25	SA53



NO OF CON;	BELLOW ELEMENT CONVOLUTION LENGTH (mm)
4	120
6	180
8	240
10	300
12	360

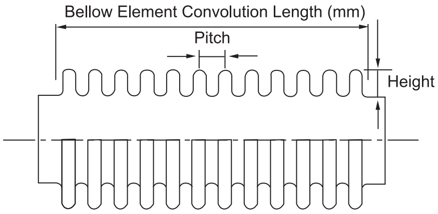
* The No. of Con is fully customizable.

Sample Datasheet for (Ø)25 with 0.4mm thickness

Size (Ø)	Temp (C°)	Pressure (Bar)	Pitch / Height (mm)	Thickness (mm)	No. of Ply	No. of Convol	Axial Movement (mm)	Lateral Movement (mm)	Angular Movement (°)	Tot Equivalent Axial Movement (mm)	Axial Spring Rate (N/mm)	Lateral Spring Rate (N/mm)	Bending Spring Rate (Nm/degr)	Allowed Cycles	Approx Weight (KG)
25	425	1	15	0.4	1	4	-9	5	28	11.5	51	38	0	6702	0.07
						6	-16	13	33	17.7	34	11	0	5912	0.1
						8	-26	23	32	24.3	25	5	0	5191	0.12
						10	-28	34	27	29	20	2	0	6382	0.15
						12	-35	50	22	35.9	17	1	0	5589	0.17
25	425	1	15	0.4	2	4	-9	5	29	11.5	100	77	0	7236	0.14
						6	-16	12	39	17.7	67	23	0	6403	0.19
						8	-23	23	42	24.3	50	10	0	5619	0.24
						10	-30	36	40	31.1	40	5	0	5089	0.29
						12	-36	49	34	36.9	33	3	0	5341	0.34
25	425	1	15	0.4	3	4	-10	6	32	12.6	149	116	1	5030	0.22
						6	-16	12	41	17.8	100	34	0	6704	0.29
						8	-23	23	46	24.3	75	15	0	5889	0.36
						10	-30	36	46	31.1	60	7	0	5334	0.44
						12	-36	51	43	36.9	50	4	0	5602	0.51
25	425	1	15	0.4	4	4	-10	5	32	12.6	198	157	1	5190	0.29
						6	-20	13	42	21.9	132	46	1	5608	0.39
						8	-23	22	49	24.3	99	20	0	6120	0.48
						10	-30	36	50	31.1	79	10	0	5545	0.58
						12	-36	51	49	36.9	66	6	0	5829	0.67
25	425	1	15	0.4	5	4	-10	13	45	12.6	245	198	1	5337	0.36
						6	-17	13	45	18.8	164	59	1	5538	0.48
						8	-24	23	52	25.4	123	25	1	5245	0.61
						10	-30	36	53	31.1	98	13	0	5745	0.73
						12	-36	50	51	36.9	82	7	0	6043	0.85

Axial spring rate, Lateral spring rate, bending spring rate and allowed cycles can be customized according to customer requirements.The calculation was based on Standards of the Expansion Joint Manufacturer's Association, EJMA, 8th edition 2005, 9th edition 2008 and ASME VIII division 1 standards.

Allowed cycles are dependent on the 3 different movements, Axial, Lateral & Angular movement. Any increase in the different movements will decrease the no. of allowed cycles and vice versa. Different combinations of the 3 movements will result in different no. of allowed cycles to suit customers' needs.



NO OF CON;	BELLOW ELEMENT CONVOLUTION LENGTH (mm)
4	120
6	180
8	240
10	300
12	360

* The No. of Con is fully customizable.

Sample Datasheet for (Ø)25 with 0.6mm thickness

Size (Ø)	Temp (C°)	Pressure (Bar)	Pitch / Height (mm)	Thickness (mm)	No. of Ply	No. of Convol	Axial Movement (mm)	Lateral Movement (mm)	Angular Movement (°)	Tot Equivalent Axial Movement (mm)	Axial Spring Rate (N/mm)	Lateral Spring Rate (N/mm)	Bending Spring Rate (Nm/degr)	Allowed Cycles	Approx Weight (KG)
25	425	1	15	0.6	1	4	-6	4	30	8.4	134	101	1	7097	0.11
						6	-11	10	34	12.6	89	30	0	6940	0.14
						8	-15	16	40	16.2	67	13	0	8091	0.18
						10	-21	25	46	22	54	6	0	5767	0.22
						12	-26	38	46	26.8	45	4	0	5386	0.26
25	425	1	15	0.6	2	4	-7	4	24	9.4	264	206	1	7521	0.22
						6	-12	9	34	13.7	176	61	1	8947	0.29
						8	-18	18	43	19.3	132	26	1	6847	0.36
						10	-23	29	46	25	106	13	0	5714	0.44
						12	-29	42	46	30.7	88	8	0	5164	0.51
25	425	1	15	0.6	3	4	-5	5	25	9.8	349	285	1	8926	0.32
						6	-13	11	40	16.5	233	85	1	5336	0.43
						8	-19	20	49	21.6	175	36	1	5692	0.54
						10	-24	29	50	26.1	140	18	1	6702	0.66
						12	-4	42	51	6.2	1315	917	5	6721	0.77
25	425	1	15	0.6	4	4	-4	3	17	6.2	1315	917	5	6721	0.43
						6	-8	7	27	9.5	877	272	3	6053	0.58
						8	-12	13	35	13.1	658	115	2	5103	0.73
						10	-14	18	38	14.9	526	59	2	8045	0.87
						12	-19	28	48	19.8	438	34	2	5035	1.02
25	425	1	15	0.6	5	4	-8	4	25	10.6	638	539	3	5211	1.54
						6	-13	10	37	14.8	426	160	2	7383	0.72
						8	-20	19	49	21.4	319	67	1	5036	0.91
						10	-24	28	52	25.1	255	34	1	6735	1.09
						12	-30	42	58	31.8	213	20	1	5203	1.28

Axial spring rate, Lateral spring rate, bending spring rate and allowed cycles can be customized according to customer requirements.The calculation was based on Standards of the Expansion Joint Manufacturer's Association, EJMA, 8th edition 2005, 9th edition 2008 and ASME VIII division 1 standards.

Allowed cycles are dependent on the 3 different movements, Axial, Lateral & Angular movement. Any increase in the different movements will decrease the no. of allowed cycles and vice versa. Different combinations of the 3 movements will result in different no. of allowed cycles to suit customers' needs.

ANALYSIS OF UNIVERSAL LPG EXPANSION BELLOW

Author:
Keyser Technologies Pte Ltd
Software:
Autodesk Inventor Professional 11.0 ANSYS Technology

Introduction

Autodesk Inventor Professional Stress Analysis was used to simulate the behavior of a mechanical part under structural loading conditions. ANSYS technology generated the results presented in this report.

Do not accept or reject a design based solely on the data presented in this report. Evaluate designs by considering this information in conjunction with experimental test data and the practical experience of design engineers and analysts. A quality approach to engineering design usually mandates physical testing as the final means of validating structural integrity to a measured precision.

Additional information on AIP Stress Analysis and ANSYS products for Autodesk Inventor is available at http://www.ansys.com/autodesk.

Geometry and Mesh

The Relevance setting listed below controlled the fineness of the mesh used in this analysis. For reference, a setting of -100 produces a coarse mesh, fast solutions and results that may include significant uncertainty. A setting of +100 generates a fine mesh, longer solution times and the least uncertainty in results. Zero is the dafault Relevance setting.

Table 1
Statistics

Bounding Box Dimensions	1532 mm 460.0 mm 552.0 mm
Part Mass	766.0 kg
Part Volume	9.483e+007 mm^3
Mesh Relevance Setting	-95
Nodes	66113
Elements	33628

Bounding box dimensions represent lengths in the global X, Y and Z directions.

Material Data

The following material behavior assumptions apply to this analysis:

- Linear - stress is directly proportional to strain.
- Constant - all properties temperature-independent.
- Homogeneous - properties do not change throughout the volume of the part.
- Isotropic - material properties are identical in all directions.

Table 2
SS304 – Stainless Steel

Young's Modulus	1.93e+005 MPa
Poisson's Ratio	0.3
Mass Density	8.08e-006 kg/mm^3
Tensile Yield Strength	276.0 MPa
Tensile Ultimate Strength	609 MPa (average)

Loads and Constraints

The following loads and constraints act on specific regions of the part. Regions were defined by selecting surfaces, cylinders, edges or vertices.

Table 3
Load and Constraint Definitions

Name	Type	Magnitude	Vector
Pressure 1	Surface Pressure	1.02 MPa	N/A
Fixed Constraint 1	Surface Fixed Constraint	105.0 mm	0.0 mm -105.0 mm -2.0 mm
Fixed Constraint 2	Surface Fixed Constraint	0.0 mm	0.0 mm 0.0 mm 0.0 mm
Fixed Constraint 3	Surface Fixed Constraint	0.0 mm	0.0 mm 0.0 mm 0.0 mm
Fixed Constraint 4	Surface Fixed Constraint	105.0 mm	0.0 mm 105.0 mm 2.0 mm

Table 4
Constraint Reactions

Name	Force	Vector	Moment	Moment Vector
Fixed Constraint 1	1.717e+004 N	1.717e+004 N 1.066 N -0.8305 N	3581 N.mm	649.1 N.mm -3426 N.mm 812.0 N.mm
Fixed Constraint 2	1.717e+004 N	1.717e+004 N 1.066 N -0.8305 N	3581 N.mm	-649.1 N.mm -3426 N.mm 812.0 N.mm
Fixed Constraint 3	1.631e+004 N	-1.631e+004 N -1.066 N 0.8305 N	6.641e+004 N.mm	-649.1 N.mm 5.465e+004 N.mm 3.772e+004 N.mm
Fixed Constraint 4	1.631e+004 N	-1.631e+004 N -1.066 N 0.8305 N	6.641e+004 N.mm	-649.1 N.mm 5.465e+004 N.mm 3.772e+004 N.mm

Note: vector data corresponds to global X, Y and Z components.

Results

The table below lists all structural results generated by the analysis. The following section provides figures showing each result contoured over the surface of the part.

Safety factor was calculated by using the maximum equivalent stress failure theory for ductile materials. The stress limit was specified by the tensile yield strength of the material.

Table 5
Structural Results

Name	Minimum	Maximum
Equivalent Stress	1.088e-003 MPa	4.548 MPa
Maximum Principal Stress	-1.52 MPa	3.987 MPa
Minimum Principal Stress	-4.678 MPa	0.6154 MPa
Deformation	0.0 mm	12.72e-003 mm
Safety Factor	N/A	15.0

Figures

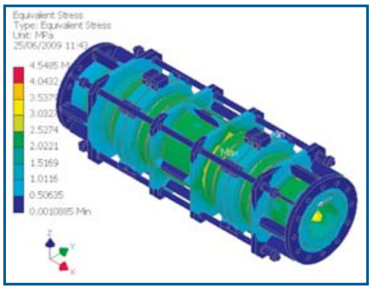


Figure 1: Equivalent Stress

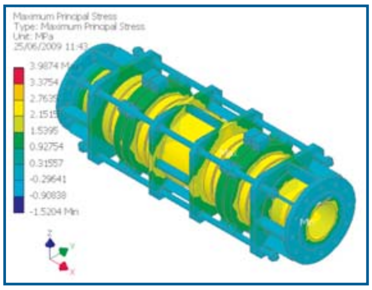


Figure 2: Maximum Principal Stress

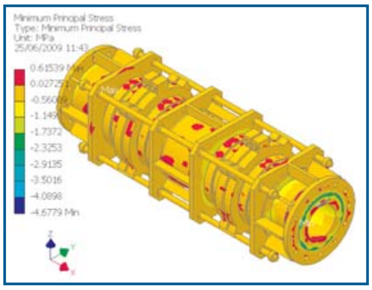


Figure 3: Minimum Principal Stress

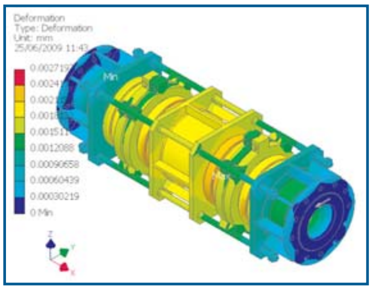


Figure 4: Deformation

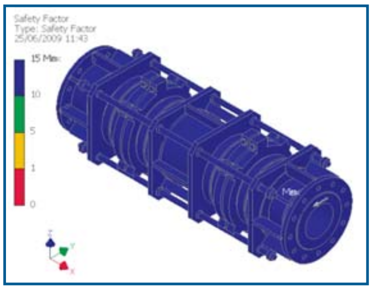
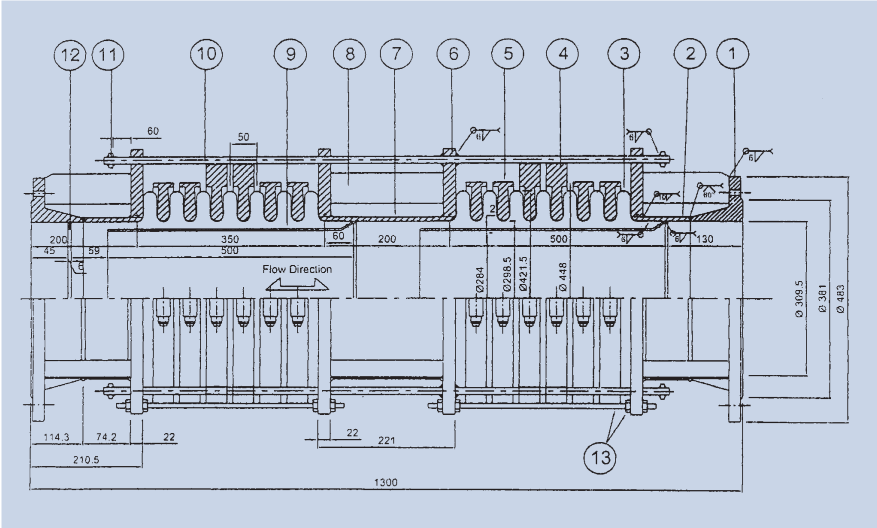
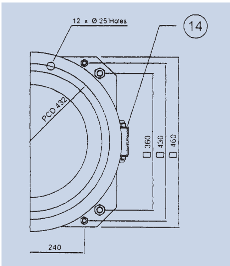


Figure 5: Safety Factor

Universal LPG Expansion Bellow





Design Pressure : 10.2 bar
Design Temperature : -45 to 80ºC

Item	Qty	Description	Material
1	2	Flange Ansi 150# W N	SUS 304L
2	2	PIPE End SCH - 40	SUS 304L
3	2	Bellows Element Thk= 1.5mm	SUS 316L
4	4	Equalizing Ring (A)	AC 7A
5	4	Equalizing Ring (B)	AC 7A
6	4	Stopper Flance	SUS 304
7	4	PIPE Spool SCH - 40	SUS 304
8	12	Lib Support Thk= 15 Width=51	SUS 304
9	2	Flow Liner Thk= 2mm	SUS 316/316L
10	4	TIE ROD Ø 28.5	SUS 304
11	8	Stopper Ring	SUS 304
12	1	Stopper Ring Thk= 6mm	SUS 304
13	8 Set	Setting Bolts & Nuts	SS 41
14	24	Bracket	SUS 304

ANALYSIS OF SLEEVE TYPE EXPANSION JOINT

Author:
Keyser Technologies Pte Ltd
Software:
Autodesk Inventor Professional 11.0 ANSYS Technology

Introduction

Autodesk Inventor Professional Stress Analysis was used to simulate the behavior of a mechanical part under structural loading conditions. ANSYS technology generated the results presented in this report.

Do not accept or reject a design based solely on the data presented in this report. Evaluate designs by considering this information in conjunction with experimental test data and the practical experience of design engineers and analysts. A quality approach to engineering design usually mandates physical testing as the final means of validating structural integrity to a measured precision.

Additional information on AIP Stress Analysis and ANSYS products for Autodesk Inventor is available at http://www.ansys.com/autodesk.

Geometry and Mesh

The Relevance setting listed below controlled the fineness of the mesh used in this analysis. For reference, a setting of -100 produces a coarse mesh, fast solutions and results that may include significant uncertainty. A setting of +100 generates a fine mesh, longer solution times and the least uncertainty in results. Zero is the default Relevance setting.

Table 1
Statistics

Bounding Box Dimensions	350.0 mm
	324.0 mm
	324.0 mm
Part Mass	39.64 kg
Part Volume	5.037e+006 mm≥
Mesh Relevance Setting	100
Nodes	27203
Elements	15694

Bounding box dimensions represent lengths in the global X, Y and Z directions.

Material Data

The following material behavior assumptions apply to this analysis:

- Linear - stress is directly proportional to strain.
- Constant - all properties temperature-independent.
- Homogeneous - properties do not change throughout the volume of the part.
- Isotropic - material properties are identical in all directions.

Table 2
Carbon Steel A106

Young's Modulus	2.e+005 MPa
Poisson's Ratio	0.29
Mass Density	7.87e-006 kg/mm≥
Tensile Yield Strength	241.0 MPa
Tensile Ultimate Strength	414.0 MPa

Loads and Constraints

The following loads and constraints act on specific regions of the part. Regions were defined by selecting surfaces, cylinders, edges or vertices.

Table 3
Load and Constraint Definitions

Name	Type	Magnitude	Vector
Pressure 1	Surface Pressure	1.6 MPa	N/A
Pressure 2	Surface Pressure	1.6 MPa	N/A
Pressure 3	Surface Pressure	1.6 MPa	N/A
Pressure 4	Surface Pressure	1.6 MPa	N/A
Fixed Constraint 1	Surface Fixed Constraint	0.0 mm	0.0 mm 0.0 mm 0.0 mm
Fixed Constraint 2	Surface Fixed Constraint	0.0 mm	0.0 mm 0.0 mm 0.0 mm

Table 4
Constraint Reactions

Name	Force	Vector	Moment	Moment Vector
Fixed Constraint 1	2.029e+004 N	2.029e+004 N	6509 N.mm	49.07 N.mm
		4.476 N		-4443 N.mm
		-2.978 N		-4756 N.mm
Fixed Constraint 2	3.71e+004 N	-3.71e+004 N	4664 N.mm	-49.1 N.mm
		-4.476 N		3404 N.mm
		2.978 N		3189 N.mm

Note: vector data corresponds to global X, Y and Z components.

Results

The table below lists all structural results generated by the analysis. The following section provides figures showing each result contoured over the surface of the part.

Safety factor was calculated by using the maximum equivalent stress failure theory for ductile materials. The stress limit was specified by the tensile yield strength of the material.

Table 5
Structural Results

Name	Minimum	Maximum
Equivalent Stress	0.3122 MPa	19.34 MPa
Maximum Principal Stress	-7.358 MPa	26.37 MPa
Minimum Principal Stress	-23.64 MPa	7.475 MPa
Deformation	0.0 mm	1.331e-002 mm
Safety Factor	N/A	12.46

Figures

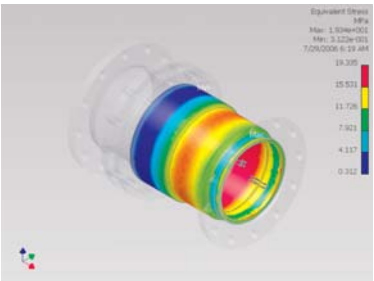


Figure 1: Equivalent Stress

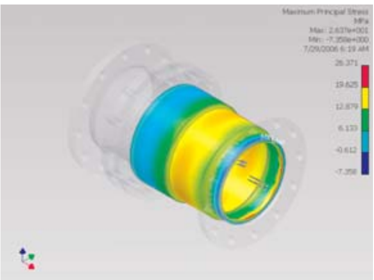


Figure 2: Maximum Principal Stress

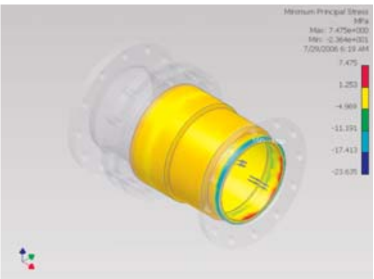


Figure 3: Minimum Principal Stress

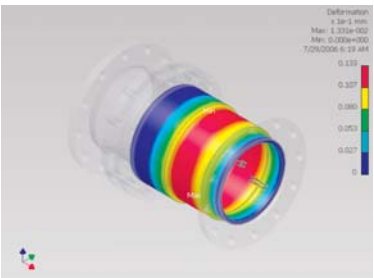


Figure 4: Deformation

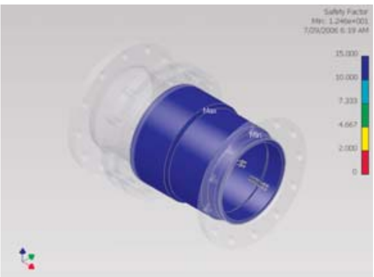
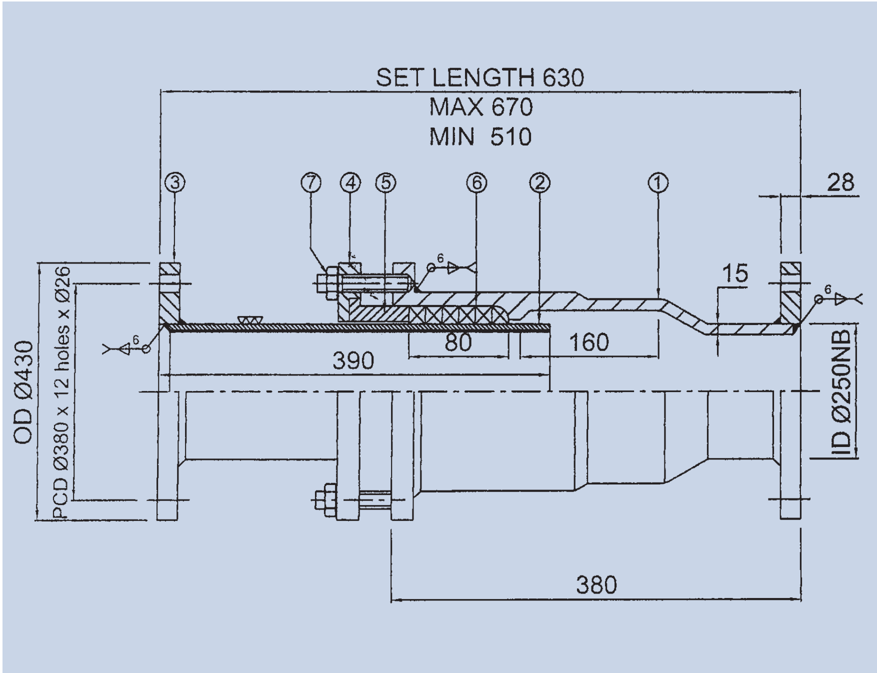


Figure 5: Safety Factor

Sleeve Type Expansion Joint



Design Pressure : 16 bar
Design Temperature : 350ºC

Item	Qty	Description	Material
1	1	Body (Seamless PIPE)	Carbon Steel A -106
2	1	Sleeve Thk= 9 mm	Stainless Steel 304
3	2	JIS 16k Flanges	SS400
4	1	Gland	Mild Steel A 36
5	1	Gland Bush	Bronze
6	6~7	Packing	Sepco ML 6402
7	8	Stud Bolt & Lock Nuts	Stainless Steel 304

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