UNDERSTANDING THE USE OF EXPANSION JOINT IN PIPING SYSTEM

By Khairul Fahmi
Piping Engineer

What is an Expansion Joint ?

Expansion Joint is piping accessories that has function to absorb force and excessive stress occurred to the piping system during operation. It has same function as piping expansion loop, where expansion loop utilized pipe as its leg to create flexibility, meanwhile expansion joint has own flexiblity on its component which is called as **"Bellows".**

Bellows

Image 1. Bellows Cross Section Area

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Piping Engineer

Expansion Joint Bellows

A Bellows contain convolution shape which made up from steel material (commonly stainless steel), rubber material, and plastic material. It was designed with flexible enough to accommodate movement that occure to the piping due to thermal growth and internal pressure.
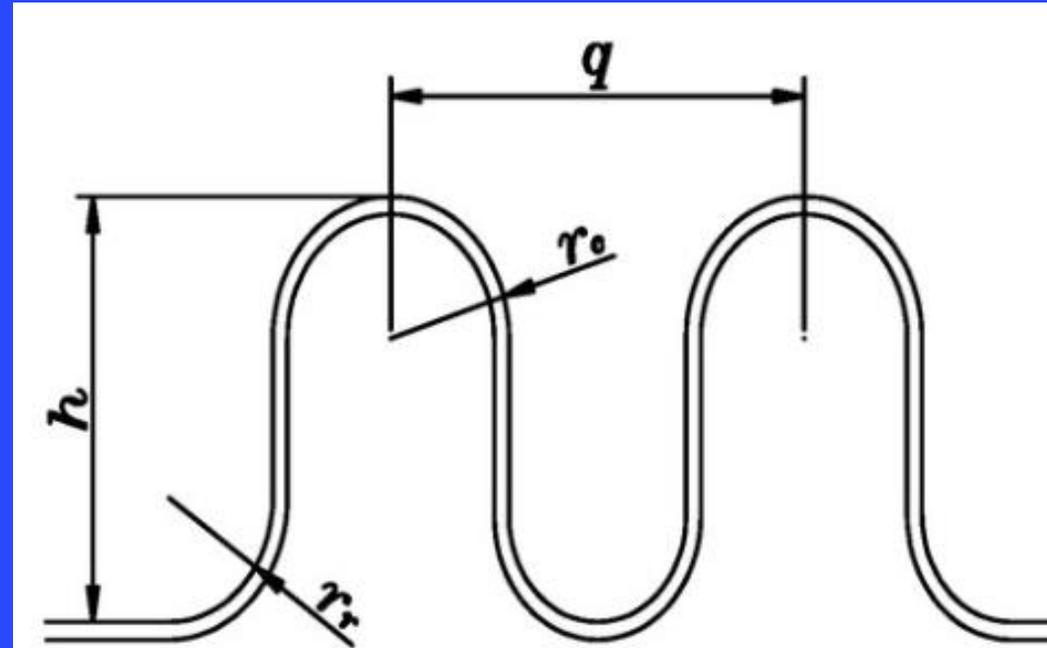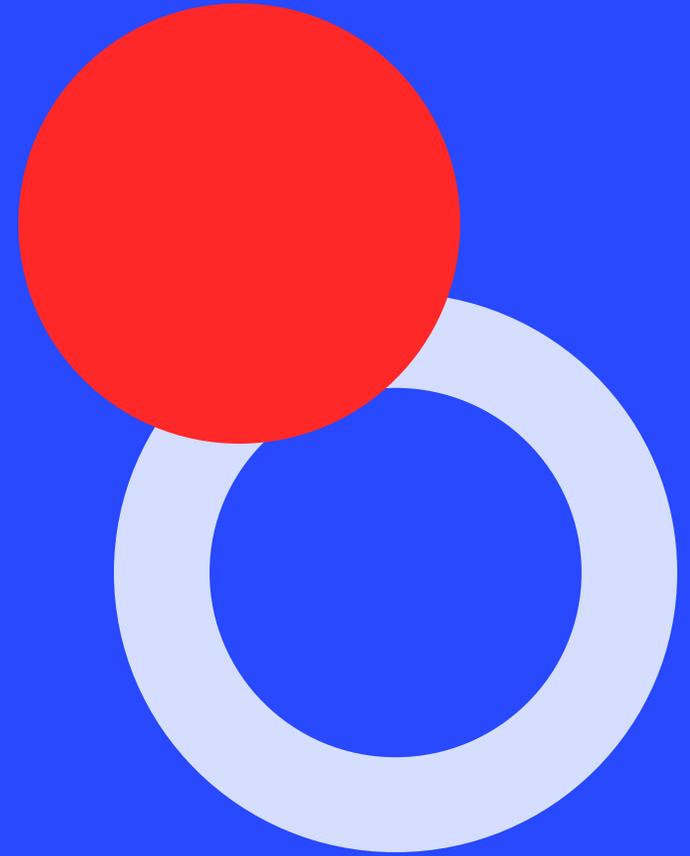

Image 2. Bellows Cross Section Area

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Piping Engineer

One of Chalenges When Decide To Use Bellows Expansion Joint is Pressure Thrust

Pressure Thrust

Pressure Thrust is the force created by pressure acting on bellows, the pressure thrust force is the effective thrust area recommended by the manufacture times the pressure.

- Pessure Thrust Force
  $F = P \times Aeff$
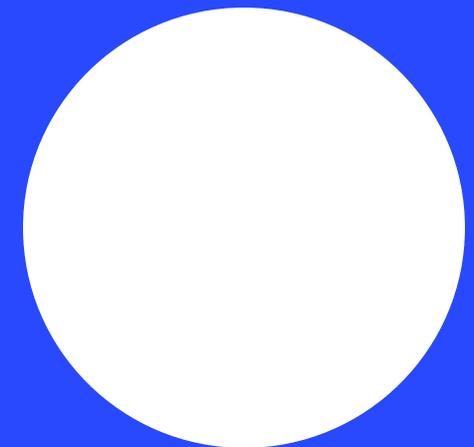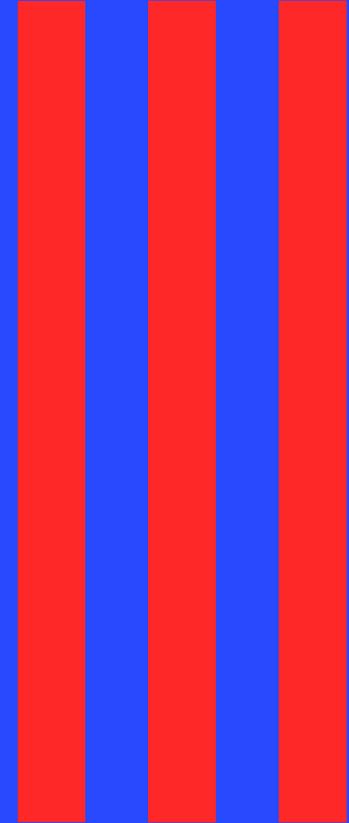
- Effective Area
  $Aeff = \pi/4 \times Dm^2$

Where :

F = Thrust Force

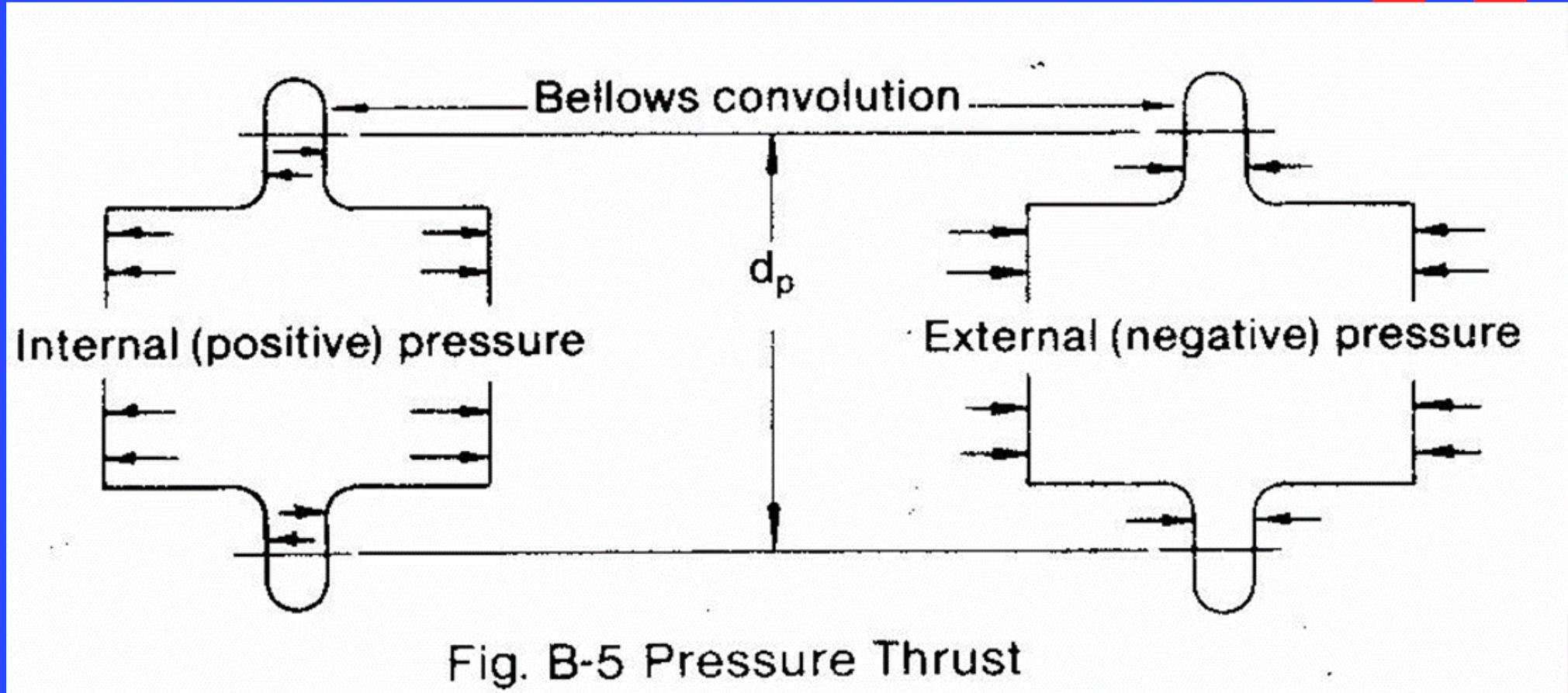$Aeff$ = Bellows efective area (Vendor recommendation)

Dm^2 = Mean diameter of bellow (note : in pipe stress analysis software mean diameter is as input to carryout analysis, it can be obtined from efective area)

P = Internal Pressure

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Piping Engineer

Pressure Thrust

Fig. B-5 Pressure Thrust

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Piping Engineer

Common Basic Type of Expansion Joint

o Untied expansion joint

o Tied expansion joint

o Hinge expansion joint

o Gimbal expansion joint

Untied
Expansion Joint

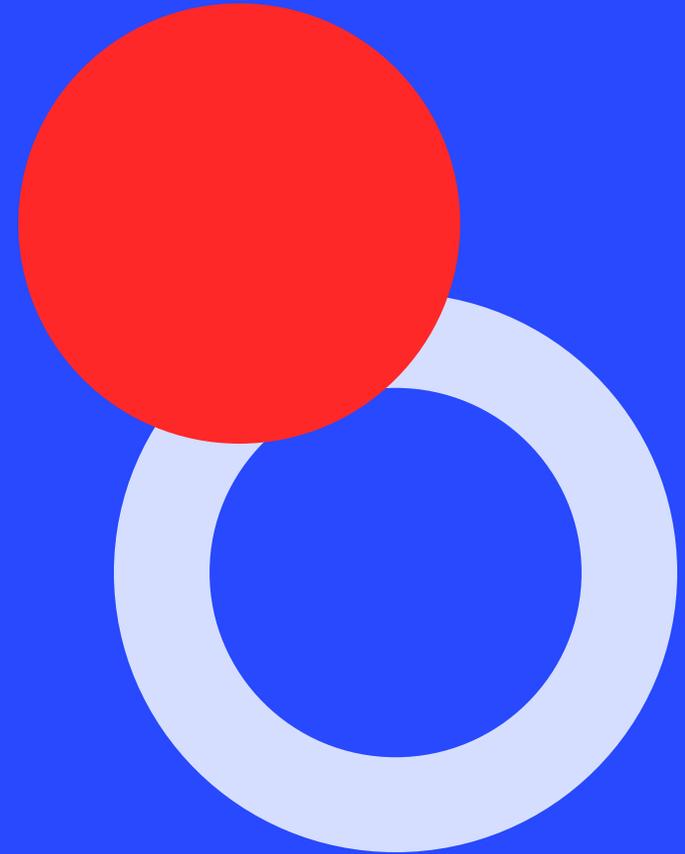Tied Expansion
Joint

Hinged
Expansion Joint

Gimbal
Expansion Joint

Advantage and Disadvantage From Each Type of Expansion Joint

No	Type of Expansion Joint	Ability of Expansion Joint					
		Able to resist pressure thrusts effect	Able to absorb axial movement	Able to absorb lateral deflection	Able to absorb angular single plane rotational movement	Able to absorb in plane and out plane angular movement	Note
1	Untied Expansion Joint	No	Yes	Yes	Yes	Yes	-
2	Tied Expansion Joint	Yes	No	Yes	No	No	-
3	Hinged Expansion Joint	Yes	No	(Yes)	Yes	No	Hinged expansion joints are usually used in set two or three, to absorb lateral deflection
4	Gimbal Expansion Joint	Yes	No	(Yes)	Yes	Yes	Gimbal expansion joints are usually used in set two or three, to absorb lateral deflection

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Piping Engineer

Inappropriate Selection Of Expansion Joint Can Cause an optimal Design Even Leading To Failure Of The System !

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Piping Engineer

Expansion Joint Stiffness

Sitfness of expansion joint can be calcluated as follows :

- Lateral Stiffness
  $$K_L = 3/2 \times (K_{Ax}) \times (D_{eff}/L)^2$$

- Bending Stiffnes
  $$K_b = \pi/360 \times K_{Ax} \times D_{eff}^2$$
  Or
  $$K_b = \pi/540 \times K_L \times L^2$$

Note :
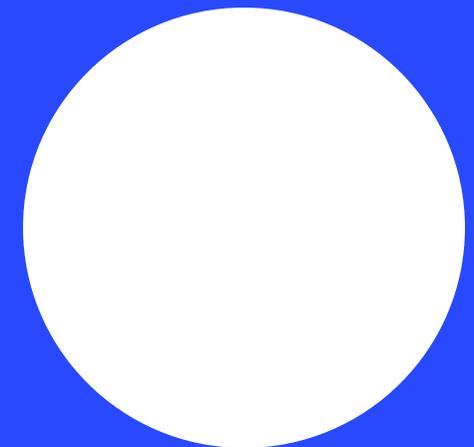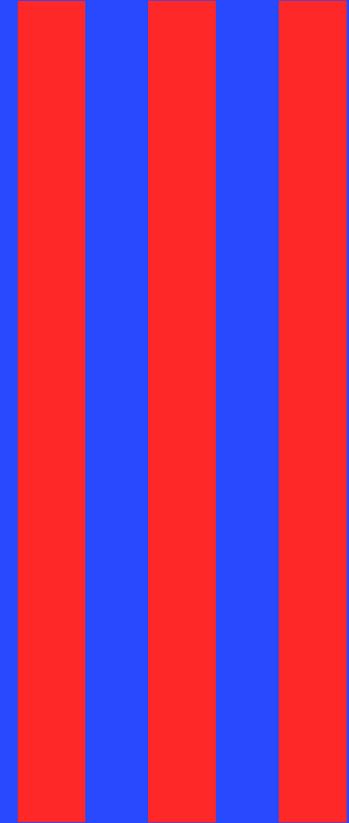This Equation applicable
for non-zero length

Where :

KL   = Lateral Stiffness

Kb   = Bending Stiffness

KAx   = Axial Stifness (From Manufacture)

L   = Bellows Convolution length (From Manufacture)

Deff   = Effective Diameter (From Manufacture)

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Piping Engineer

Sample Case

The 24" steam line, operating at a temperature of 550°F and a pressure of 650 psi, experienced significant expansion during its operating conditions. To absorb the thermal movement and reduce the stress on the pipe, a simple axial (untied) expansion joint was used, considering its low cost and ease of maintenance and installation. However, during the analysis, a failure occurred in the piping system because the large thrust force caused the expansion joint to expand excessively, which in turn forced the piping system to fail. In this case, a tied or hinged expansion joint is recommended, as it can withstand the pressure thrust effect by redirecting the movement from the axial direction to the lateral direction.

Expansion Joint Location

Expansion joint expand due to pressure thrust effect
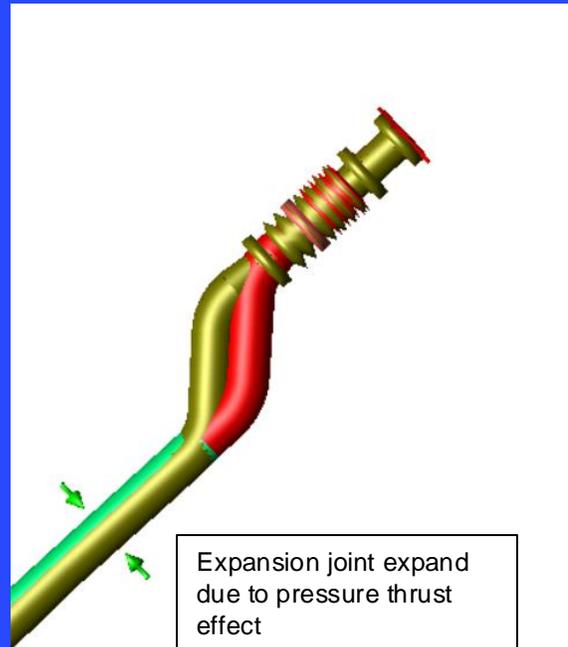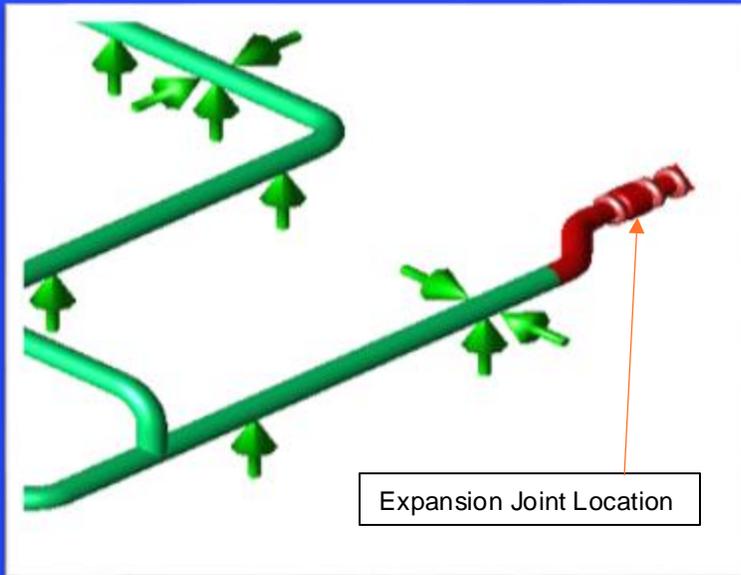
LOAD CASE DEFINITION KEY

CODE STRESS CHECK FAILED   : LOADCASE 1 (HYD) WW+HP

Highest Stresses: (N./sq.mm.) LOADCASE 1 (HYD) WW+HP			
Ratio (%):	863.3	@Node	59
Code Stress:	2083.3	Allowable Stress:	241.3
Axial Stress:	131.0	@Node	28
Bending Stress:	2685.1	@Node	59
Torsion Stress:	688.4	@Node	40
Hoop Stress:	284.0	@Node	23380
Max Stress Intensity:	2762.9	@Node	59

CODE STRESS CHECK FAILED   : LOADCASE 7 (SUS) W+P1

Highest Stresses: (N./sq.mm.) LOADCASE 7 (SUS) W+P1			
Ratio (%):	655.0	@Node	59
Code Stress:	836.1	Allowable Stress:	127.7
Axial Stress:	58.5	@Node	28
Bending Stress:	1074.3	@Node	59
Torsion Stress:	290.1	@Node	40
Hoop Stress:	144.8	@Node	23380
Max Stress Intensity:	1112.0	@Node	59

CODE STRESS CHECK FAILED   : LOADCASE 8 (SUS) W+P2

Thank you

Khairul Fahmi

Khairul.fahmi0599@gmail.com

linkedin.com/in/khairul-fahmi-92099a1b3