What are expansion joints?

Expansion joints
Compensators
Pipe connectors

Flexible piping parts that are stable enough to avoid buckling.

Hoses
“long expansion joints”
Application of expansion joints

- Temperature elongation
- Avoiding pipe stress
- Ground movement
- Vibrations
Application of expansion joints

Temperature elongation

Ground movement
Avoiding pipe damage

Vibrations
Application of expansion joints

Temperature elongation

Ground movement

Vibrations
Protect pipes and equipment.
Reduce sound level.
Why use expansion joints?

DSM engineering practices for expansion joints:

“Bellows expansion joints are allowed to be used only if there is no reasonable alternative for accommodating displacements”

Why not?:
- Engineering problems
- Weak member in the system
- Too little knowledge
Why use expansion joints?

Alternatives:

- Bends
- Loops
- Stronger materials
Why use expansion joints?

Advantages of using expansion joints:
- Less pipe and space needed.
  (less supports)
Why use expansion joints?

Advantages of using expansion joints:
- Stress can be reduced, relieving the pipe and connected equipment.

- Stress: 564 N/mm²
  Allowable stress: 196 N/mm²
  Force: $F = 1306\; kN$

- Force: $F = 27,3\; kN$
  $\Delta L = 27\; mm$

DN 150
10 barg
-10 / +200°C
2000 cycles
Pipe: St 35.8
Pipe length: 10 m
Why use expansion joints?

Advantages of using expansion joints:
- Less pipe and space needed.
- Stress can be reduced, relieving the pipe and connected equipment.
- In case of malfunctioning or operational errors the expansion joint probably will be damaged, saving more expensive equipment.
## Types of expansion joints

<table>
<thead>
<tr>
<th>Type</th>
<th>medium</th>
<th>temperature</th>
<th>pressure</th>
<th>range</th>
<th>standard or tailor made</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stainless steel</td>
<td>Fluid Gas</td>
<td>up to 1100°C</td>
<td>100 barg</td>
<td>DN 10.000 rectangular</td>
<td>tailor made</td>
</tr>
<tr>
<td>Rubber</td>
<td>Fluid Gas</td>
<td>up to 110°C, up to 90°C</td>
<td>25 barg</td>
<td>DN 3600</td>
<td>standard</td>
</tr>
<tr>
<td>PTFE</td>
<td>Fluid Gas</td>
<td>up to 200°C, low pressure</td>
<td>10 barg</td>
<td>DN 500</td>
<td>standard</td>
</tr>
<tr>
<td>Fabric</td>
<td>Gas</td>
<td>up to 1100°C</td>
<td>0.3 barg</td>
<td>unlimited</td>
<td>tailor made</td>
</tr>
</tbody>
</table>
Types of expansion joints

Selection case.
DN 200, Flanged PN 10
Cooling water
max. 60°C
max. 6 barg
movement: axial: 20 mm

Possibilities

<table>
<thead>
<tr>
<th>Fluid</th>
<th>PN 16</th>
<th>90°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluid</td>
<td>PN 10</td>
<td>200°C</td>
</tr>
<tr>
<td>Fluid</td>
<td>PN 100</td>
<td>1100°C</td>
</tr>
<tr>
<td>Gas only</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

[Diagram showing different types of expansion joints with icons]
Types of expansion joints

Rubber

- Excellent chemical resistance.
- No fatigue due to vibrations or life cycles.
- Elastic material, extra safety.
- Excellent wear resistance.
- Excellent sound reduction.

Special attention:
Life cycle is mainly influenced by the temperature.
Up to 60°C – 25 to 30 years
Up to 90°C – approx. 10 years
Up to 110°C – approx. 5 Years

Old and worn-out expansion joints can burst.
Types of expansion joints

PTFE

Excellent chemical resistance.
No fatigue due to vibrations or life cycles.
Good sound reduction.
Relative high temperatures possible.

Special attention:
Vacuum condition is not always possible.
Low pressure resistance decreasing at higher temperatures.

Old and worn-out expansion joints can burst.
Types of expansion joints

Stainless steel

Chemical resistance depending of the chosen material.
High temperature possible.
High pressure possible.
Unlimited number of variations and sizes possible.
Multiply bellows will normally not burst. (but start to leak)

Special attention:
Fatigue due to vibrations or life cycles.
More critical with respect to correct installation.
Corrosion (Pit corrosion)
Types of expansion joints

Fabric

- Chemical resistance depending on the chosen material.
- High temperature possible.
- Large number of variations and sizes possible.
- Low spring forces

Special attention:
- Only for gas. (dew point and cleaning)
- For low pressure only
- Heating from outside.
Types of expansion joints

Stainless steel

Axial movement per convolution.

Lateral and angular movement of a bellow
Types of expansion joints

Stainless steel, selection criteria

Medium → Material
Temperature and pressure → Material thickness
Movements → Type, No. convolutions, No. layers
Types of expansion joints

Stainless steel

The principle of multi ply bellows.

2 plies:

\[ \sigma = \frac{1}{2} \sigma \text{ single ply} \]

\[ F = \frac{1}{4} F \text{ single ply} \]
Forces

Reaction force

Reaction force: \( F_r = A \times p \times 10 \)

\( F_r = N \)
\( A = \text{cm}^3 \)
\( p = \text{barg} \)
Forces

Reaction force $F_r$

Spring force

Friction force – tie-rods, hinges

Unrestraint

Restraint
Example: DN 1000, 10 barg, ΔL: 90 mm

Forces on fixed point
Fr: 861 kN
Fax: 30 x 0.3: 9 kN
F: 870 kN

Flat: 90 x 0.2: 18 kN
Ffric: 4 kN
F: 24 kN
Rubber joint DN 1200, 5 barg, axial: 5 mm, lateral: 15 mm, EL= 1745, BL= 4486 mm

- $F_{\text{ax}}$: 623 kN \quad (F_{\text{reaction}} + F_{\text{axial}})$
- $F_{\text{lat}}$: 45 kN

- $F_{\text{ax}}$: axial movement not possible
- $F_{\text{lat}}$: 82 kN \quad (45 \text{ kN} + 37 \text{ kN})

- $F_{\text{ax}}$: axial movement not possible
- $F_{\text{lat}}$: 13 kN \quad (7 \text{ kN} + 6 \text{ kN})
Rubber joint DN 1200, 5 barg, axial: 5 mm, lateral: 15 mm, EL= 1745, BL= 4486 mm

- \( F_{ax} \): 16 kN  
  (8 kN per bellow)
- \( F_{lat} \): 10 kN  
  (7 kN + 3 kN)

Pressure balanced system

Single expansion joint:
- \( F_{ax} \): 623 kN
- \( F_{lat} \): 45 kN
Questions
Het Gebruik van Bellows

Rotterdam, 11-12-2008
Installatie van Expansion Bellows

“Correct ontworpen en geïnstalleerde Bellows werken vele jaren zonder problemen”
Waardoor Kunnen Bellows Falen?

- Schade kan ontstaan tijdens: vervoer, opslag en installatie
- Deuken, krassen ect. kunnen worden veroorzaakt door vorkheftrucks, kettingen enz.
Ontwerpfouten:

- Er is onvoldoende bescherming door guides en ankers
- Er wordt niet binnen de opgegeven waarden van de fabrikant gebleven
- Bellow wordt toegepast bij zeer gevaarlijke stoffen
- Bellow is niet bestand tegen procescondities of het medium
Installatiefouten

Fouten tijdens de installatie:

- Binnenpijp staat niet in de stromingsrichting
- Het scharnier staat in de verkeerde stand
- Er is niet volgens tekening geïnstalleerd (verkeerde plaats)
- Transport bescherming wordt voortijdig verwijderd (Hierdoor niet in correcte uitgangspositie)
- Er is schade ontstaan door het lassen of slijpen in de omgeving
Falen tijdens Bedrijf of Watertest

Falen van de Bellow tijdens bedrijf of watertest:

- Overbelasting
- Trillingen
- In- en uitwendige corrosie
- Te grote bewegingen
- Erosie
- Vervuiling
Geen Axiale Bescherming
Flixborough Incident June 1974 (1)

“They did not know that they did not know!”
Flixborough Incident June 1974 (2)
Simulaties van het bezwijk-mechanisme van de Bellows

Fig 3 Mode of failure of 20 inch assembly

NOTE: The difference between A and B is that the energy of B is great enough to cause a buckle and hence a subsequent jack-knife.
Flixborough Incident June 1974 (4)
Slechte Uitlijning van Bellows
Bellows in Cryogenic Piping (1)
Bellows in Cryogenic Piping (2)

TYPICAL LOW TEMP EXPANSION JOINT
Bellows in Cryogenic Piping (3)

Crack in de isolatie
Bellows in Cryogenic Piping (4)

Anker in een Vapour Return Pipe
Verandering van Procescondities (1)

Defecte Bellows door gewijzigde procescondities
Verandering van Procescondities (2)

Lekkende Bellows in DN 450 MD stoomleiding
Corrosie door zout in Bellows

Bodycote Materials Testing BV
Foutief Onderhoud van een Stoomsysteem
Tankzettingen

Tankzetting compenseren d.m.v. Bellows
Hartelijk dank voor uw aandacht

Vragen?