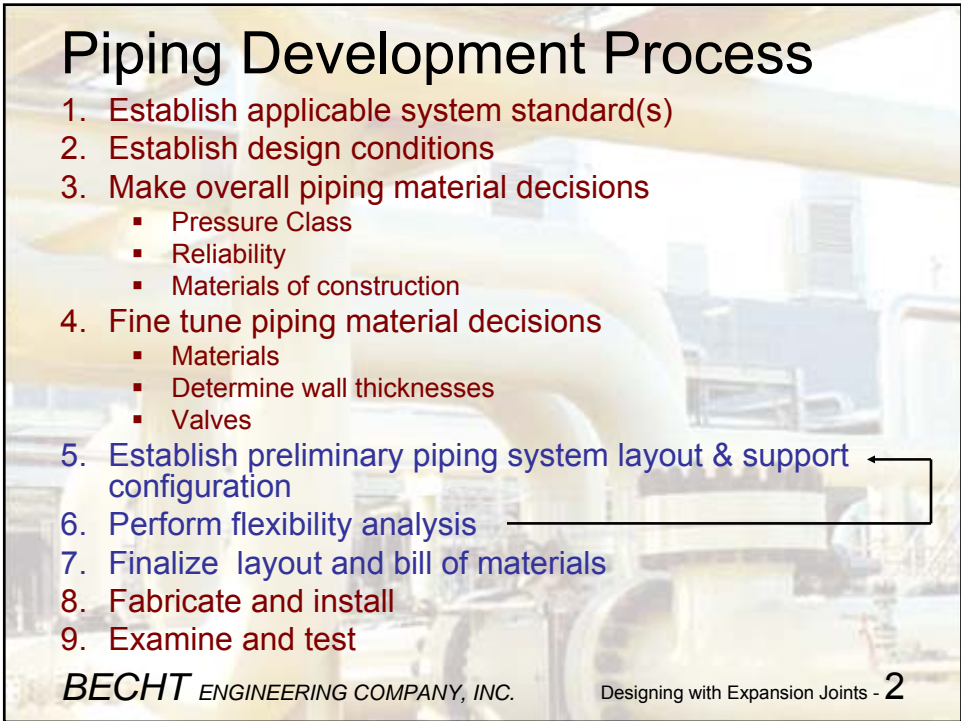




ASME B31.3 Process Piping

Charles Becht IV, PhD, PE
Don Frikken, PE
Instructors

BECHT ENGINEERING COMPANY, INC. Designing with Expansion Joints - 1



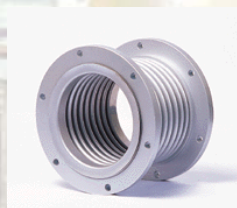
Piping Development Process

1. Establish applicable system standard(s)
2. Establish design conditions
3. Make overall piping material decisions
 - Pressure Class
 - Reliability
 - Materials of construction
4. Fine tune piping material decisions
 - Materials
 - Determine wall thicknesses
 - Valves
5. Establish preliminary piping system layout & support configuration
6. Perform flexibility analysis
7. Finalize layout and bill of materials
8. Fabricate and install
9. Examine and test

BECHT ENGINEERING COMPANY, INC. Designing with Expansion Joints - 2

11. Designing with Expansion Joints

- Types of Expansion Joints
- Pressure Thrust
- Installation of Expansion Joints
- Metal Bellows Expansion Joints



(Hanjo)



(General Rubber)



(Hyspan)

BECHT ENGINEERING COMPANY, INC.

Designing with Expansion Joints - 3

The Material in This Section is
Addressed by B31.3 in:

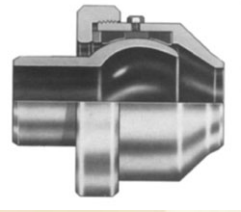
Chapter II - Design

Appendix X - Metallic Bellows Expansion
Joints

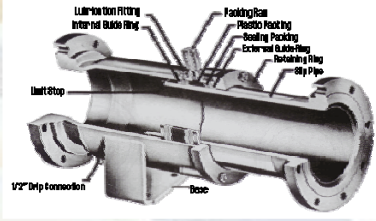
BECHT ENGINEERING COMPANY, INC.

Designing with Expansion Joints - 4

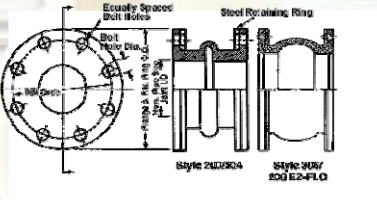
Types of Expansion Joints



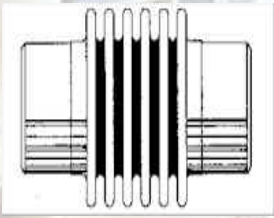
Ball



Slip



Rubber Bellows



Metal Bellows

BECHT ENGINEERING COMPANY, INC. Designing with Expansion Joints - 5

Pressure Thrust

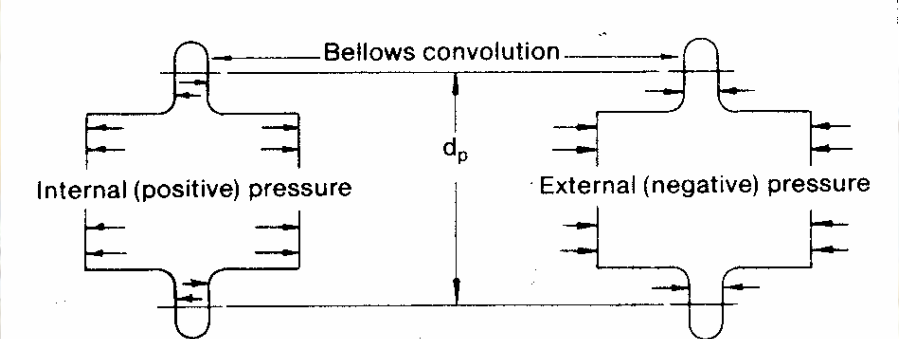


Fig. B-5 Pressure Thrust

Expansion Joint Manufacturer's Association (EJMA)

BECHT ENGINEERING COMPANY, INC. Designing with Expansion Joints - 6

Pressure Thrust

(EJMA)

Which types of expansion joints have this problem?

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Pressure Thrust

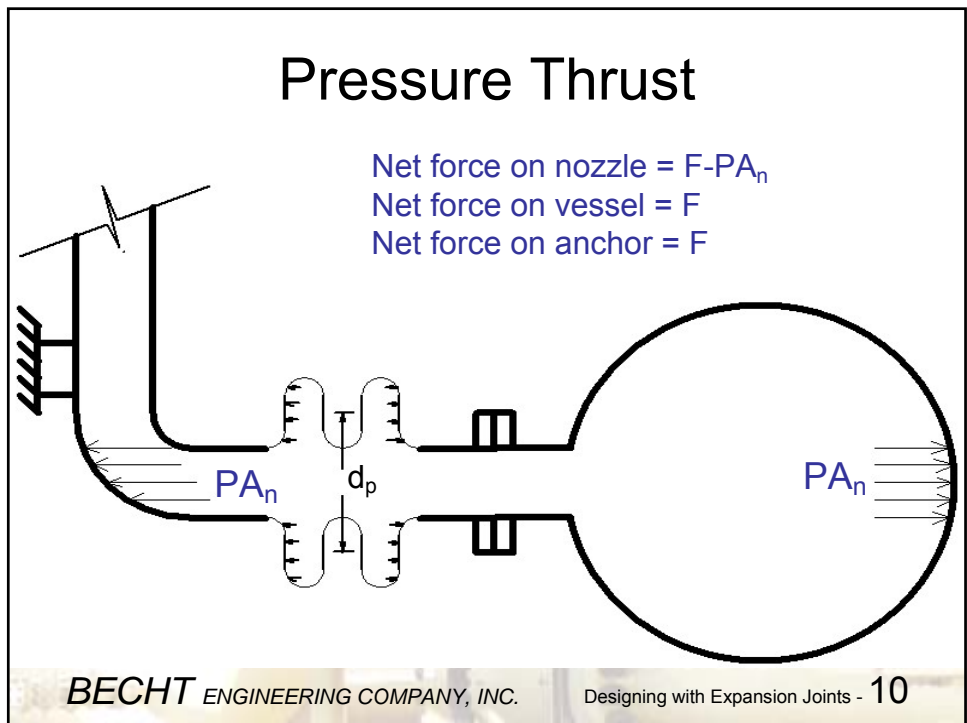
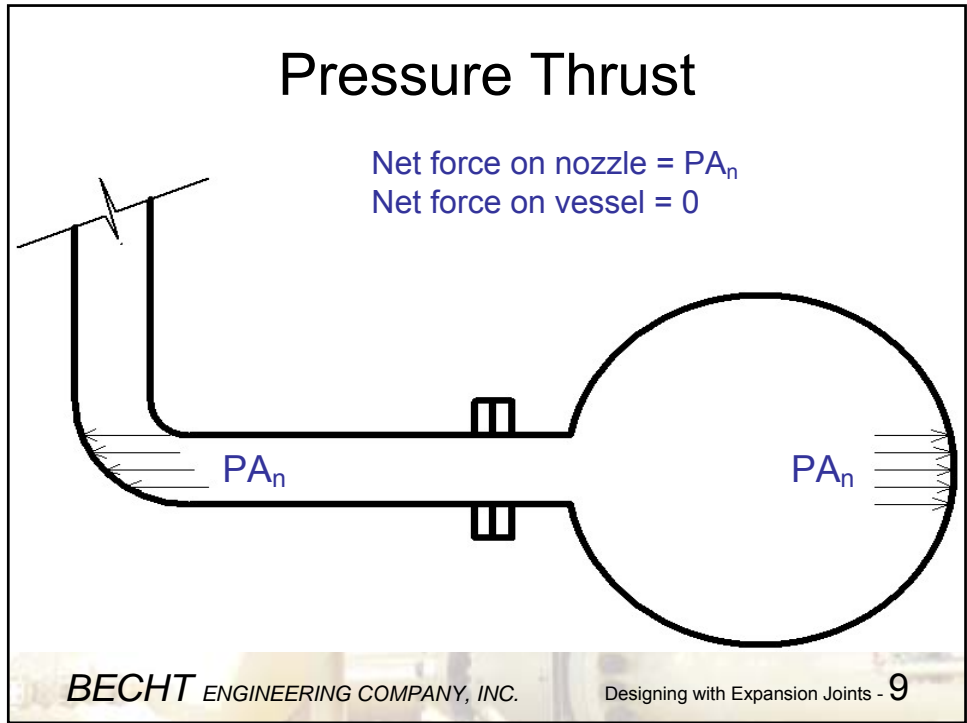
For a bellows type expansion joint, the pressure thrust force is the effective thrust area recommended by the manufacturer times the pressure. In the absence of this information:

$$F = P * \frac{\pi * d_p^2}{4}$$

Where

- F = pressure thrust force
- P = pressure
- d_p = mean diameter of bellows

BECHT ENGINEERING COMPANY, INC. Designing with Expansion Joints - 8



Pressure Thrust Workshop

What is the apparent change in the weight of a vessel caused by increasing the pressure by 100 psi (700 kPa)?

See the supplement, page 52.

The diagram shows a horizontal cylindrical vessel supported by two 'Weigh Cell (typ)' units. A 'Rigid Support' is attached to the top of the vessel. The vessel is also supported from below by a central support structure.

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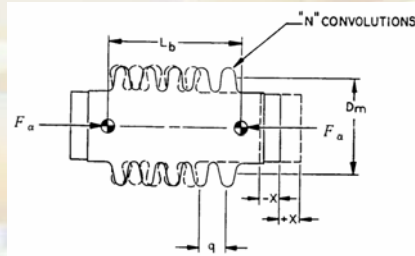
Installation of Expansion Joints

The diagram illustrates a piping system with an expansion joint. It shows a horizontal pipe with an expansion joint in the middle. The pipe is supported by anchors labeled 'MA' at both ends. The expansion joint is labeled 'G1', 'G2', 'G', and 'G'. The pipe is shown at an angle θ to the horizontal. The expansion joint is shown in a vertical position.

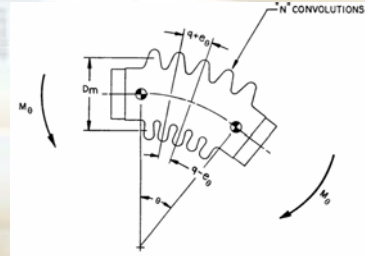
Anchors must be designed for full pressure thrust based on maximum operating pressure. (EJMA)

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Bellows Movement

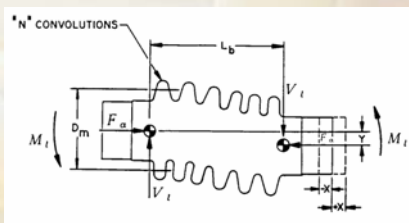


Axial (EJMA)



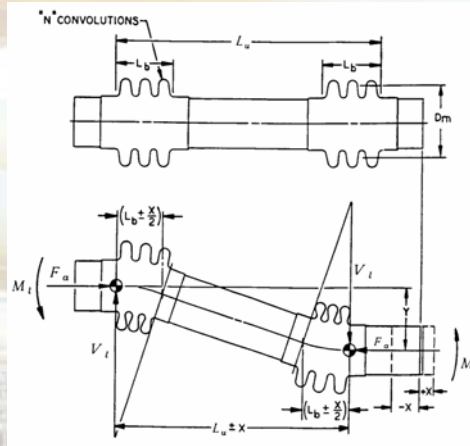
Rotation (EJMA)

Bellows Movement



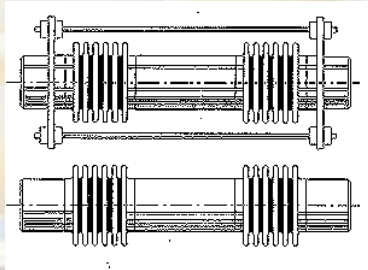
**Lateral (EJMA)
Inefficient for bellows**

Bellows are not intended to take torsional displacement.



**Efficient use of bellows for
Lateral movement (EJMA)**

Universal Expansion Joint



Piping Technology & Products
(PTP)

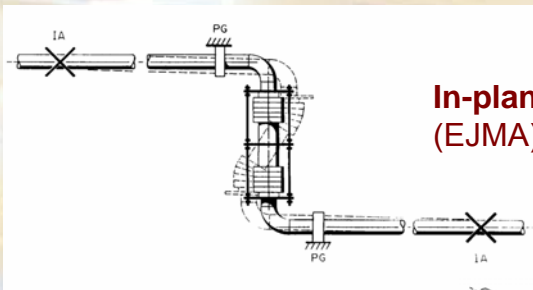


(PTP)

BECHT ENGINEERING COMPANY, INC.

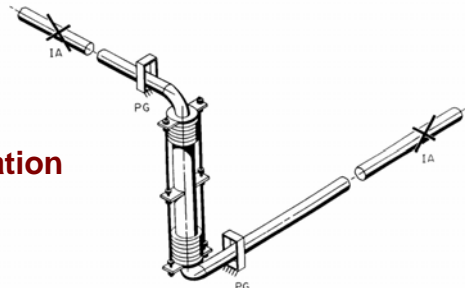
Designing with Expansion Joints - 15

Universal Expansion Joint



In-plane application
(EJMA)

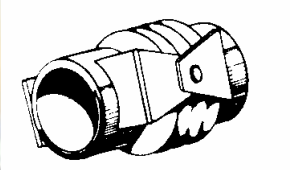
3-dimensional application
(EJMA)




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Designing with Expansion Joints - 10

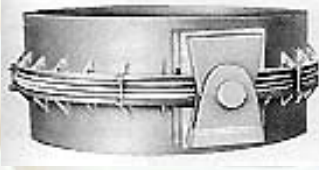
Hinged Expansion Joint



(EJMA)



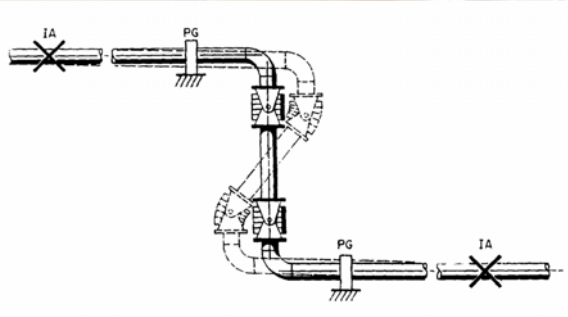
(Adesco)



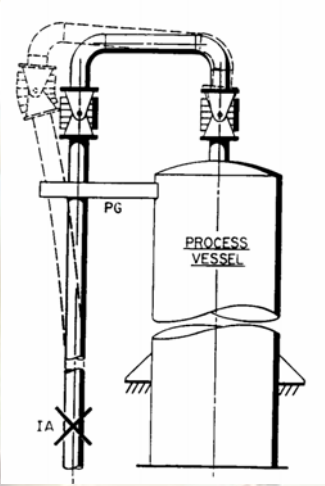
(Hae Jo Industrial)

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Hinged Expansion Joint



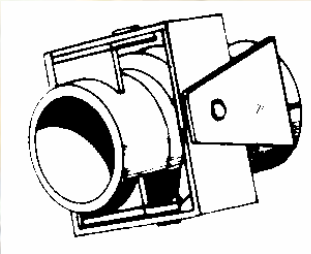
(EJMA)




(EJMA)

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Gimbal Expansion Joint



(EJMA)



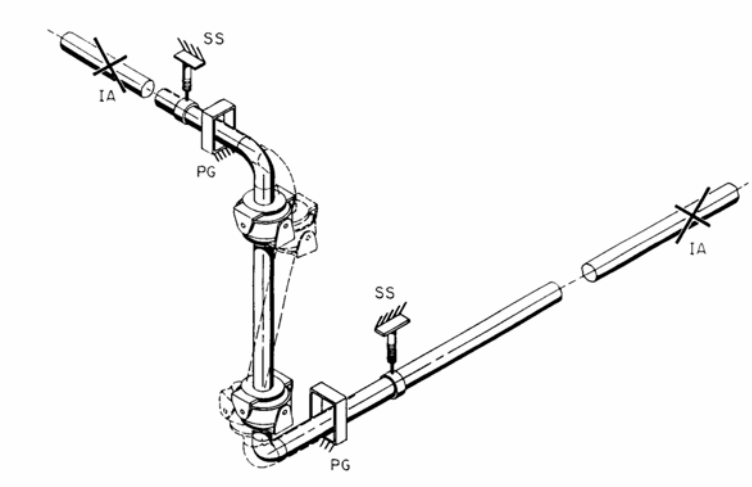
(Adesco)



(Hae Jo Industrial)

BECHT ENGINEERING COMPANY, INC. Designing with Expansion Joints - 19

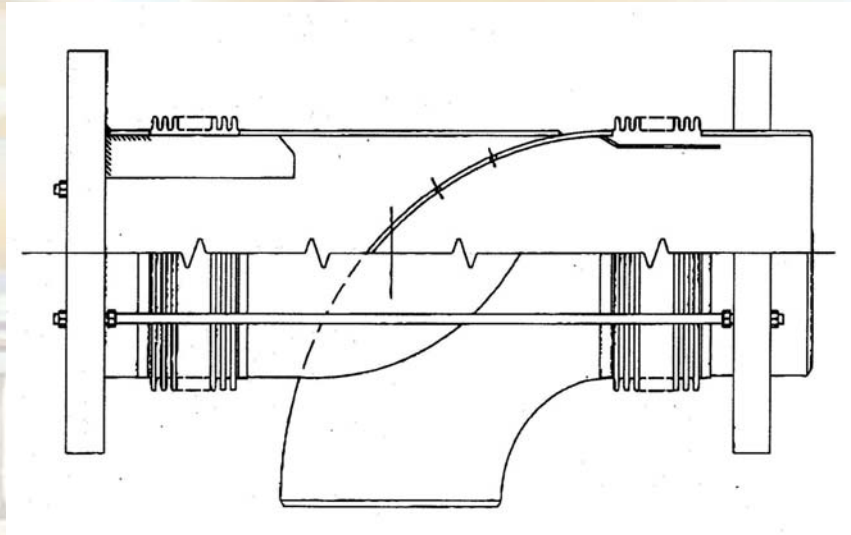
Gimbal Expansion Joint



(EJMA)

BECHT ENGINEERING COMPANY, INC. Designing with Expansion Joints - 20

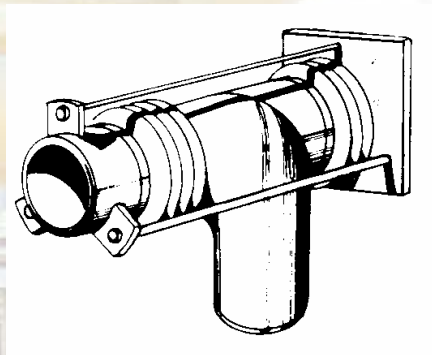
Pressure Balanced Expansion Joint



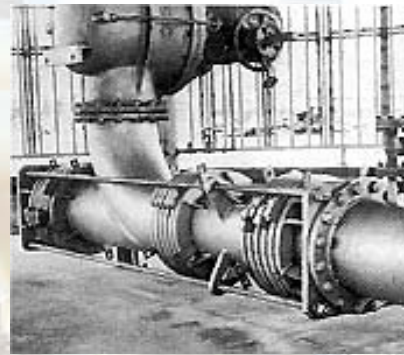
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Designing with Expansion Joints - 21

Pressure Balanced Expansion Joint



(EJMA)



(Hae Jo Industrial)

BECHT ENGINEERING COMPANY, INC.

Designing with Expansion Joints - 22

Pressure Balanced Expansion Joint

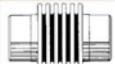
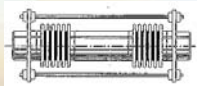


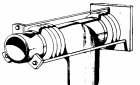
(EJMA)

(EJMA)

(EJMA)

BECHT ENGINEERING COMPANY, INC. Designing with Expansion Joints - 23

Bellows Expansion Joint Types

Type	Type	Axial	Lateral	Rotation	Pressure Thrust
Single		Yes	Small	Yes	Yes
Universal (tied)			Yes	Yes	
Hinged				Yes	
Gimbal				Yes	
Pressure Balanced		Yes	Small	Yes	

BECHT ENGINEERING COMPANY, INC. Designing with Expansion Joints - 24


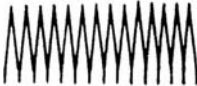

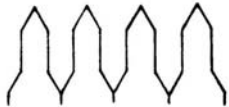
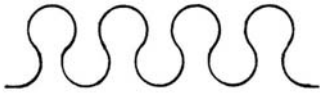

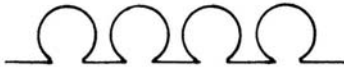

Metal Bellows Expansion Joints

- Bellows Shapes
- Failure Modes



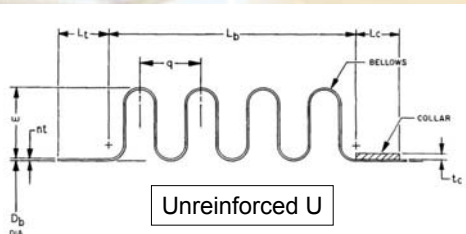
BECHT ENGINEERING COMPANY, INC. Designing with Expansion Joints - 25

Bellows Shapes (EJMA)

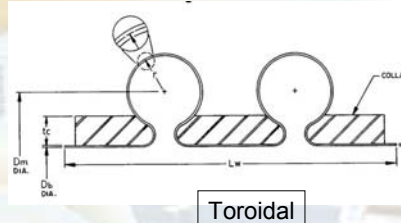
 Semi-toroidal	 Flat
 U-shaped	 Stepped
 S-shaped	 Single Sweep
 Toroidal	 Nested Ripple

BECHT ENGINEERING COMPANY, INC. Designing with Expansion Joints - 26

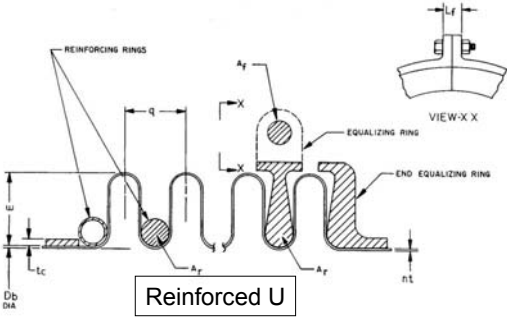
Bellows Shapes (EJMA)



Unreinforced U



Toroidal

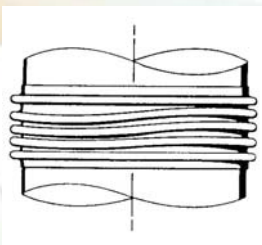


Reinforced U

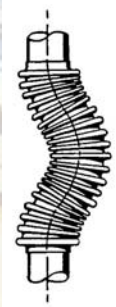
BECHT ENGINEERING COMPANY, INC. Designing with Expansion Joints - 27

Metal Bellows Failure Modes

- In-plane squirm
- Column squirm
- Fatigue
(Design Factor = 2.6 on cycles)
- Creep-fatigue
- Burst, collapse, over stretching
(Design Factor = 3.0 on burst)
- Corrosion




In-plane squirm



Column squirm

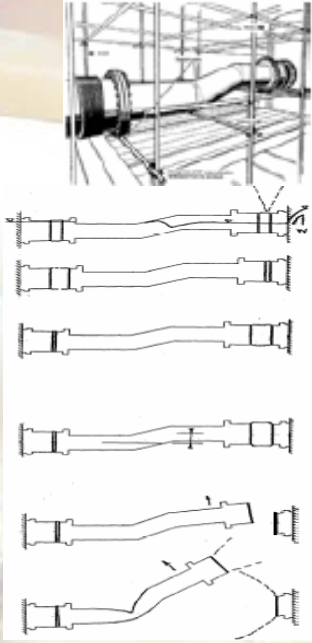
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Flixborough Disaster



FLIXBOROUGH 01 06 1974
UK

- 1974 cyclohexane vapor cloud explosion (UK)
- Killed 28, injured 89, damaged 1821 homes
- Caused by plant personnel's failure to recognize expansion joint pressure thrust problem



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Designing with Expansion Joints - 29

