IPSS	SPECIFICATION FOR METALLIC BELLOWS	IPSS:1-06-036-99
	Corresponding IS does not exist	

0. **FOREWORD**

0.1 This Inter Plant Standard prepared by the Standards Committee on Pipes, Fittings, Valves and Piping Layout, IPSS 1:6 with the active participation of the representatives of all the steel plants and associated organizations in the field was adopted in November 1999.

0.2 Metallic Bellows are nothing but expansion joint used commonly for pipeline for absorbing three basic movement of pipes i.e. axial movement (compression and extension), lateral deflection and angular rotation.

0.3 In the preparation of this standard, assistance has been taken from BIS 6129(Part 1):1981 'Code of Practice for the selection and application of bellow expansion joints for use in pressure systems' (British Standard).

1. **SCOPE**

1.1 This Inter Plant Standard covers the guidelines for selection, design data, inspection and test procedures and other relevant details of corrugated metallic bellows for steel plant piping applications.

Note: The design and application of bellows shall conform to the latest edition of Expansion Joints Manufacturers Association (EJMA).

2. **TERMINOLOGY**

2.1 For the purpose of this standard, the following definitions shall apply:

2.1.1 **Nominal Size (DN)** - A numerical designation of size which is common to all components in a piping system other than components designated by outside diameters or by thread size. It is a convenient round number for reference purposes and is loosely related to manufacturing dimensions.

2.1.2 **Movement** - The various dimensional changes which an expansion joint is required to absorb, such as those resulting from thermal changes in a piping system.

2.1.3 Axial compression - The dimensional shortening of an expansion joint along its longitudinal axis. Axial compression has been referred to as axial movement or compression.

2.1.4 Axial extension - The dimensional lengthening of an expansion joint along its longitudinal axis. Axial extension has been referred to as axial movement, elongation or extension.

2.1.5 Lateral deflection - The relative displacement of the two ends of an expansion joint perpendicular to its longitudinal axis. This has been referred to as lateral offset, lateral movement, parallel mis-alignment, direct shear or transverse movement.

2.1.6 Angular rotation - The relative angular displacement of the two ends of the expansion joint so as to displace the longitudinal axis of the expansion joint from its initial straight line position into a circular arc. This has been referred to as angular or rotational movement.

2.1.7 Cyclic life - The number of cycles of movement at the specified conditions which an expansion joint can withstand without failure.

2.1.8 Expansion joints - Devices containing one or more bellows used to absorb dimensional changes such as those caused by thermal expansion or a contraction of a pipeline, duct or vessel.

2.1.9 Bellows - The flexible element of an expansion joint consisting of one or more convolutions and the end cuffs, if any.

2.1.10 Convolution - The smallest flexible unit of a bellow. The total movement capacity of a bellow is proportional to the number of convolution.

2.1.11 Weld ends - The ends of an expansion joint equipped with pipe suitable beveled for welding to adjacent equipment or piping.

2.1.12 Flanged ends - The ends of an expansion joint equipped with flanges for the purpose of bolting the expansion joint to the mating flanges of adjacent equipment or piping.

2.1.13 Internal sleeve - A device which shields the convolutions from direct contact with the flow of fluid. This device can also be referred to as a liner.

2.1.14 Cover - A device used to provide limited protection of the exterior surface of the bellows of an expansion joint from foreign objects or mechanical damage. it is sometimes referred to as a shroud or external sleeve.

2.1.15 Tie rods - Devices, usually in the form of rods or bars, attached to the expansion joint assembly, whose primary function is to restrain the pressure thrust or pull due to internal pressure or vacuum.

2.1.16 Control rods - Devices, usually in the form of rods or bars, attached to the expansion joint assembly, whose function is to distribute the movement between the two bellows. These devices are not designed to restrain bellows pressure thrust.

2.1.17 Main anchor - An anchor which is designed to withstand the full bellows thrust due to pressure, flow, spring forces, etc.

2.1.18 Pipe alignment guide - A guide in the form of a sleeve or framework fastened to some rigid part of the installation which permits a pipe line involving expansion joint to move freely in only one direction. These are designed primarily for use in applications involving axial movement only, but may also be used in certain applications involving lateral deflection and angular rotation.

3. TYPES OF BELLOWS AND THEIR APPLICATION

3.1 Bellows which are commonly used and their applications are indicated below:

i) **Single type** - This type of bellows (see figure 1) offers lowest cost and is therefore considered first for any application.

Single bellow units are used for absorbing axial movement (a compression and extension) of pipes and some lateral deflection and angular rotation with suitably placed guides and anchors in the pipeline.

ii) **Universal type** - In this type of bellows (see figure 2), two single bellow units are joined by a pipe for absorbing any combination of three basic movements (axial movement, lateral deflection and angular deflection). They are best used as a tied expansion joint in a 90° piping offset with the tie-rod adjusted to prevent axial movement.

iii) **Universal tied type** - In this type of bellows (see figure 3), the tie rods are used for absorbing lateral movement and restrict axial movement.

This type of bellow is usually selected where main anchors cannot be provided. The tie-rods should be designed to absorb pressure thrust.

iv) **Hinge type** - In this type of bellows (see figure 4), the hinges are provided to allow angular rotation in one plane. They are usually used in sets of 2 or 3 to absorb lateral deflection in one or more directions. Each individual bellow in such a system is restricted to pure angular rotations by its hinges. However, each pair of bellows separated by a segment of piping will act in unison to absorb lateral deflection.

These are much more expensive than the other.

A typical system using single hinged bellows is given at figure 5.

v) **Pressure Balanced type** - In this type of bellows (see figure 6), the main purpose is to maintain balance when the pipeline is turning through 90^{o}, by providing an opposed bellow tied by tie-rods to the main bellows to absorb axial movement and/or lateral deflection but retains pressure thrust.

This is perhaps the most expensive bellow for a given diameter.

A typical system using a pressure balanced bellow is given at figure 7.

vi) **Gimbal type** - It allows regular rotation in any plane by the use of two pairs of hinges fixed to common floating gimbal ring. It retains the thrust of the bellows due to internal pressure and extraneous forces, where applicable.

A typical safe and unsafe practices in systems using gimbal are given at figure 8 & 9 respectively.

4. MATERIAL

4.1 Austinetic stainless steel as per IS:6911-1992 'Stainless steel plate, sheet and strip (first revision) (Amendment 1)' shall be used for the manufacture of the metallic bellow. The convolutions of bellow can be made from stainless steel to ASTM 240 Gr 304/316/316L/321, with details as given in Appendix A.

4.2 The austinetic stainless steel of 300 series shall be generally preferred for bellows fabrication. They possess excellent forming properties, fatigue strengths, high temperature strengths and immunity to most forms of corrosion. BS 3072-NA16 can be used where 300 series of stainless steel is inadequate. This is a high nickle alloy and has excellent resistance to chloride stress corrosion and to sulphuric acid. The chemical composition of this type is given in Appendix A.

4.3 Flanges, tie-rods and hinges shall be of carbon steel. Internal sleeve shall be of stainless steel/carbon steel depending upon the services.

4.4 Carbon steel is also being used for making steel bellow in older pipelines in the plants but carbon steel bellow have limited service life and high anchoload. However, efforts should be made to replace CS bellow with stainless steel bellow.

4.5 The space between the telescopic pipes and convolution shall be filled with mineral wool or equivalent packing materials for ceiling purpose.

5. DESIGN DATA

5.1 Following design data/information shall be furnished to expansion joint manufacturer by the purchaser:

a) Item No.
b) Pipe Size (DN, OD x Thk)
c) Quantity (Nos.)
d) Type: axial/angular, etc
e) Fluid handled
f) Flow rate
g) Design pressure (kg/cm^2g)
h) Test pressure (kg/cm^2g)
i) Temp (^oC)
   1. Design
   2. Maximum/Minimum
   3. Installation
j) Compensating capacity
   1. Axial [compression/extension (mm)]
   2. Lateral (mm)
   3. Angular (degree)
k) No. of plies (single/multiple)
l) Installation position (horizontal/vertical)
m) End type (weld end/flanged)
n) Materials
   1. Bellows
   2. Liner
   3. Cover
   4. Tie/limit/control rods
o) Flange material/drilling standard
p) Design cyle life and minimum life (cycles) for normal operation
q) Design code: EJMA
r) Dimensional limitations, if any
   1. Overall length (mm)
   2. Overall diameter (mm)
s) Spring rate limitations, if any
   1. Axial (kg/mm)
   2. Lateral (kg/mm)
   3. Angular (kgm/deg)

   Note: In case the information is not available with the purchaser, to be provided by the manufacturer along with sketches/drawings.
t) Cold pull (mm)
u) Accessories required
v) Heat treatment in case of carbon steel bellow
w) Inspection classification and name of inspecting authority

5.2 For refractory lined bellows, lining material and thickness and other application details may be furnished by the purchaser and shall be mutually agreed between purchaser and manufacturer.

6. INSPECTION AND TESTING

6.1 Inspection and testing shall cover visual inspection, dimensional check, non-destructive and destructive tests. Fabrication tolerances, test procedures and acceptance criteria for various tests shall conform to the requirements of EJMA.

6.2 Non-destructive Tests

6.2.1 Non-destructive tests shall generally include the following:

i) Pressure testing: All bellows shall be subjected to pressure testing. Pressure testing may be hydrostatic or pneumatic. The pneumatic testing shall normally be limited to test pressure (preferably upto 0.5 kg/Cm^{2}g). For convenience, hydraulic testing is preferred. The minimum test pressure shall be 1.5 times the design pressure or equal to the field test pressure for piping whichever is higher. The duration of the pressure testing should be 5 minutes. Any other test pressure shall be mutually agreed upon between purchaser and manufacturer.

The pneumatic testing is potentially a much more dangerous method of pressure testing than hydraulic testing irrespective of bellow sizes as any failure during testing is likely to be of a highly explosive nature.

The pneumatic testing shall normally be limited to low pressure (preferably upto 0.5 kg/Cm^{2}g)

ii) Halogen leak test: This test is normally done with low pressure for determining the presence of a leak and also in locating that leak in critical cases involving vacuum application. This is more sensitive than a pressure test but does not validate the structure integrity of the bellow.

iii) Liquid Penetrant test: This test is frequently in use in evaluating bellows welds before convolution formation and testing of welding between bellows and their end-fittings.

However, for critical applications, other tests like radiographic/magnetic particle/ultrasonic examination may be recommended.

6.3 Destructive test

6.3.1 Destructive tests are costly and time consuming and therefore shall be specified in critical applications only.

The most common destructive test is life cycle test for demonstrating the ability of a bellow to withstand a given number of cycles. This test is performed on a proto-type. Hence purchaser may accept a test certificate for type test or may indicate in that order, the number of bellows of each type to be subjected to destructive test.

For critical application squirm testing may also be done on a proto-type to determine stability of bellows convolution due to internal pressure.

7. CONFORMANCE TO STATUTORY REGULATIONS

7.1 The inspection of bellow for the pipelines governed by statutory regulations shall conform to the stipulation of those regulations.

8. VENDOR QUALIFICATION

8.1 The bellow manufacturer shall comply with the requirement of quality assurance as per EJMA. Each manufacturer shall be required to furnish, on request, a copy of his quality assurance manual.

9. RECOMMENDATION ON SUPPORTING OF BELLOWS

9.1 Supporting of bellows shall be done as per recommendations of EJMA.

10. PRECAUTIONS FOR STORAGE HANDLING AND INSTALLATION

10.1 Shipping devices which are used for maintaining the proper face-to-face dimensions of an expansion joint during shipment should always be specified. This may be of various forms, such as strips or angles tack welded to both the end-fittings of the expansion joints in order to prevent movement. Shipping devices are normally painted yellow and should be removed only after final installation but before pressure testing of this system.

10.2 The following shall be observed during installation.

a) Bellows shall be inspected for transit damages before installation.

b) All shipping devices should be removed only after the installation is completed but before the pressure testing of the system.

c) Welding operation shall not be carried out close to unprotected bellows.

d) Steel wool or wire brushes shall not be used on bellows.

e) Cleaning agents containing Chlorides shall not be used on stainless steel bellows.

f) The expansion joints should never be subjected to compression, extension, offset or rotation in order to make-up for piping mis-alignments, unless the joint is specifically designed for this purpose.

g) Bellows Expansion Joints, if provided with internal sleeve, should be installed with the proper orientation with respect to th direction of flow.

h) Shipping devices shall not be used to restrain the pressure thrust if the bellows are tested at site prior to installation.

10.3 Precaution during storage, installation and use to avoid damage due to corrosion as per BS 6129 (Pt 1):1991 shall be adopted.

APPENDIX-A

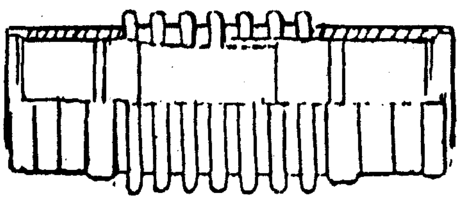
ASTM A 240

Type	304	316	316L	321
UNS Designation	S3040	S31600	S31603	S32100
Carbon	0.08	0.08	0.030	0.08
Manganese	2.00	2.00	2.00	2.00
Phosphorous	0.045	0.045	0.045	0.045
Sulphur	0.030	0.030	0.030	0.030
Silicon	0.75	0.75	0.75	0.75
Chromium	18.00 - 20.00	16.00 - 18.00	16.00 - 18.00	17.00 - 19.00
Nickel	8.00 - 10.50	10.00 - 14.00	10.00 - 14.00	9.00 - 10.00
Moly	--	2.00 - 3.00	2.00 - 3.00	--
Nitrogen	0.10	0.10	0.10	0.10
Copper	--	--	--	--
Other Elements	--	--	--	TI5 x (C+N) min 0.70 max

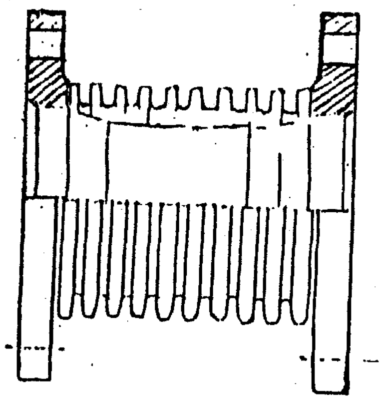
CHEMICAL COMPOSITION TO NA 16 NICKEL IRON CHROMIUM MOLYBDENUM COPPER ALLOY

Element	Min	Max
Carbon	-	0.05
Silicon	-	0.5
Manganese	-	1.0
Sulphur	-	0.03
Aluminium	-	0.20
Chromium	19.5	23.5
Copper	1.5	3.0
Iron	---- Remainder----	
Molybdenum	2.5	3.5
Nickel (including not more than 2% cobalt)	38.0	46.0
Titanium*	0.6	1.2

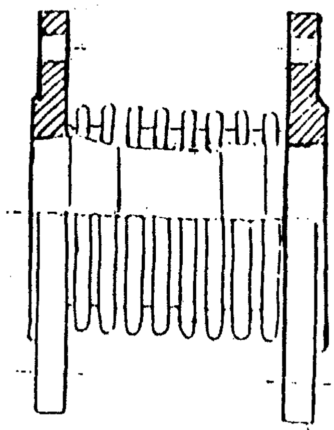
* The titanium content shall be atleast 20 times the carbon content.



With weld ends

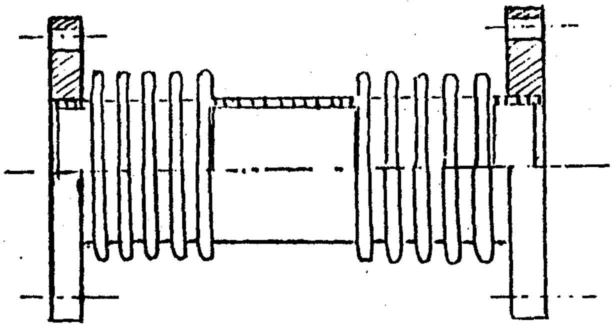


with flanged ends

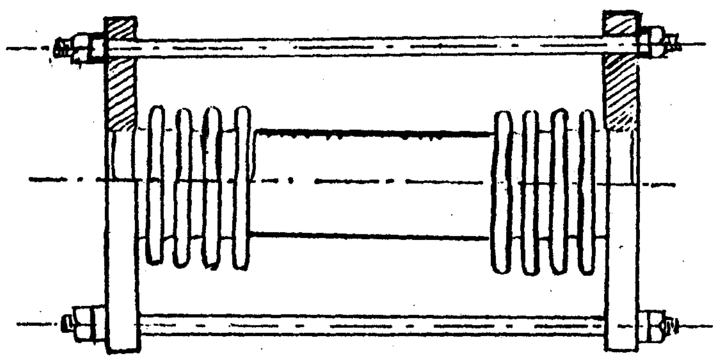


with floating ends

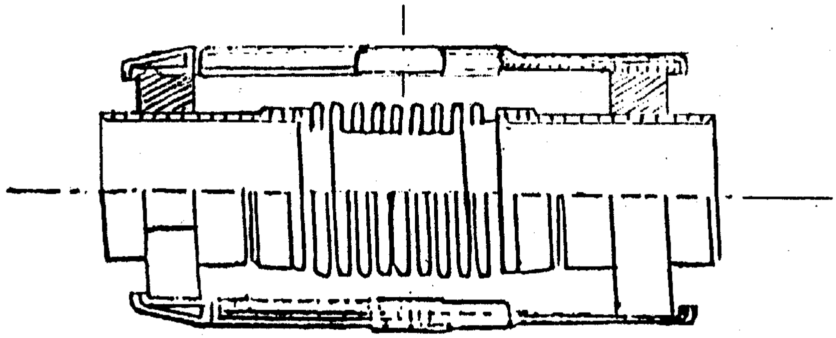
(Fig 1) AXIAL EXPANSION BELLOWS(SINGLE TYPE)



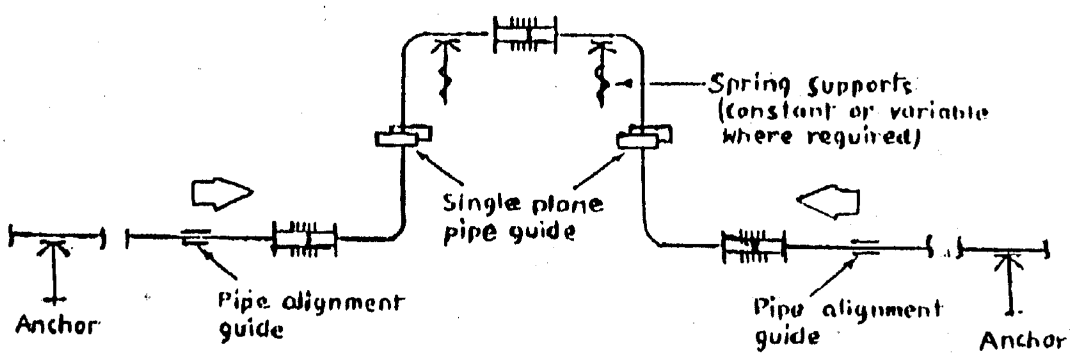
(Fig 2) UNIVERSAL EXPANSION BELLOW



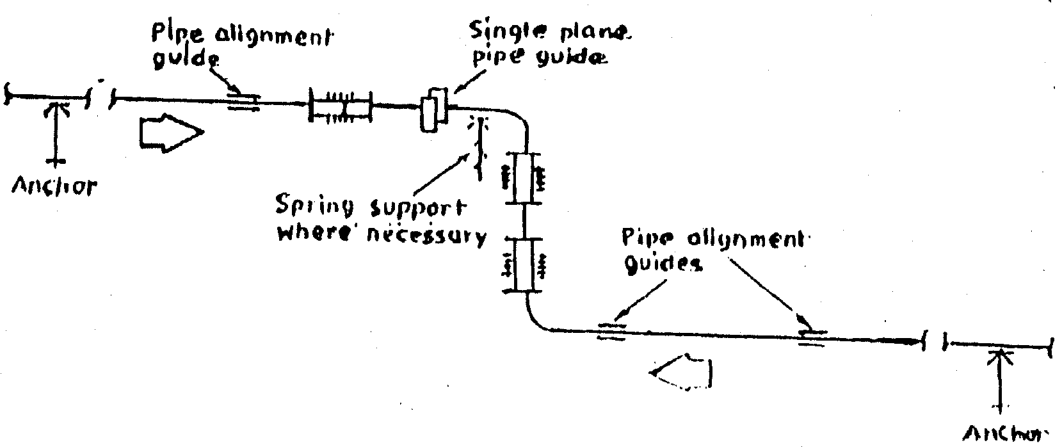
(Fig 3) BELLOWS WITH UNIVERSAL TIE ENDS



(Fig 4) HINGED EXPANSION BELLOW

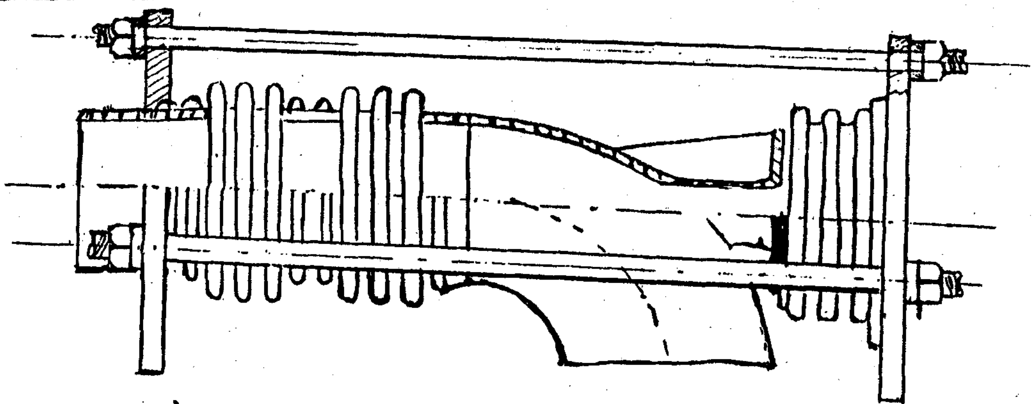


(a) U-Type Pipe Configuration

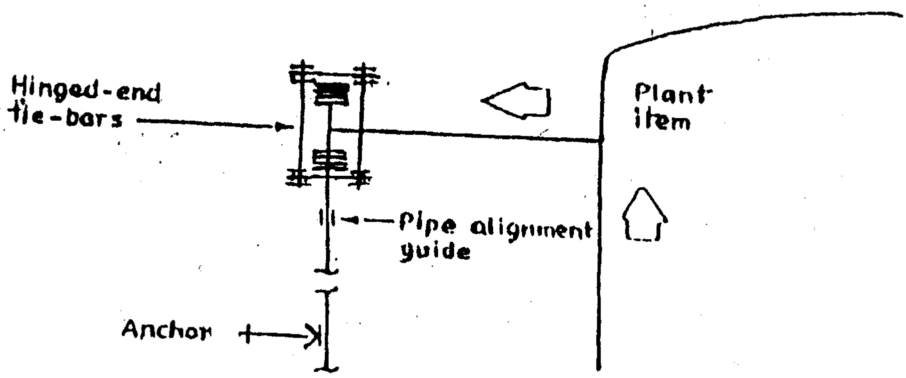


(b) Z-Type Pipe Configuration

(Fig 5) TYPICAL SYSTEMS USING SINGLE HINGED EXPANSION BELLOWS

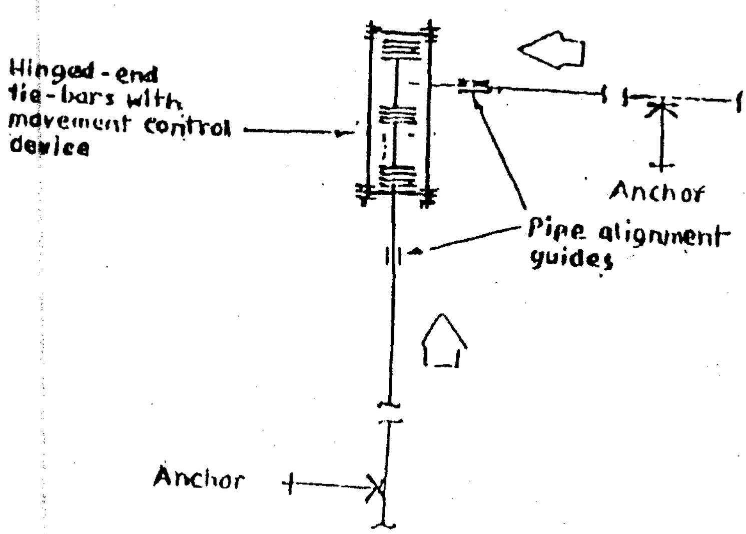


(Fig 6) PRESSURE BALANCED EXPANSION BELLOW



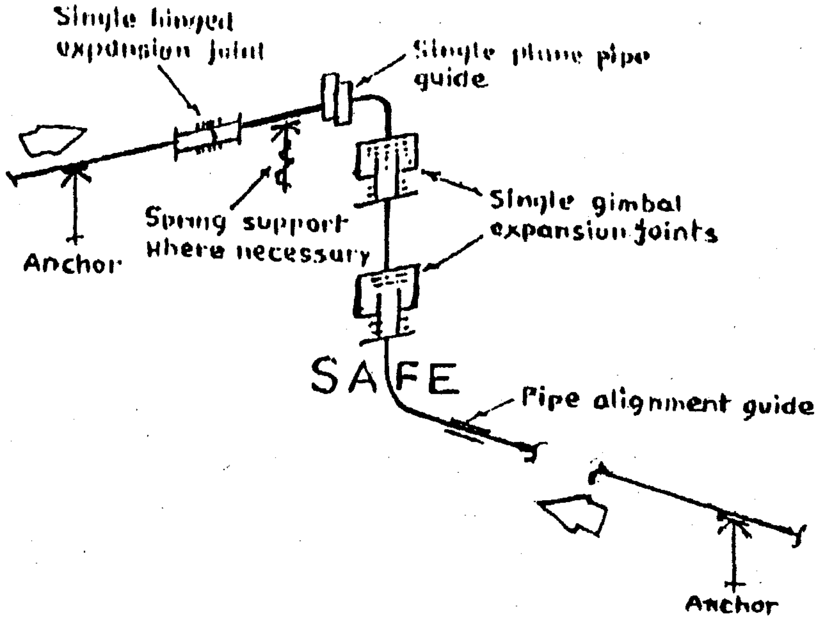
(a) A system designed for a small lateral deflection

2.

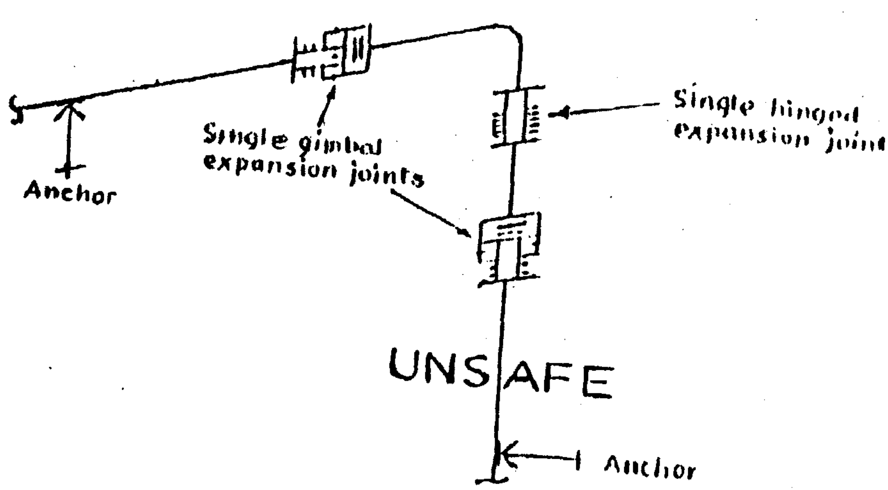


(b) A system designed for larger lateral deflection

(Fig 7) SYSTEMS USING A PRESSURE - BALANCED EXPANSION BELLOW



(Fig 8) SAFE PRACTICE IN SYSTEM USING ONE SINGLE HINGED EXPANSIO BELLOW AND TWO SINGLE GIMBAL EXPANSION BELLOWS



(Fig 9) UNSAFE PRACTICE IN SYSTEMS USING GIMBAL EXPANSION BELLOWS