

Code of practice for

The selection and application of bellows expansion joints for use in pressure systems —

Part 1: Metallic bellows expansion
joints

UDC 621.643.43

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- University of Manchester. Institute of Science and Technology
- Water-tube Boilermakers' Association*
- Welding Institute

The organizations marked with an asterisk in the above list, together with the following, were directly represented on the Technical Committee entrusted with the preparation of this British Standard:

- High Pressure Pipework Consultative Committee
- Ministry of Defence
- Individual expert

This British Standard, having been prepared under the direction of the Pressure Vessel Standards Committee, was published under the authority of the Executive Board and comes into effect on 31 July 1981

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The following BSI references relate to the work on this standard:
Committee reference PVE/13
Draft for comment 77/79382 DC

ISBN 0 580 12122 4

Amendments issued since publication

Amd. No.	Date of issue	Comments

Contents

	Page
Cooperating organizations	Inside front cover
Foreword	iii
1 Scope	1
2 References	1
3 Terms and definitions	1
3.1 Nominal size (DN)	1
3.2 Movement	1
3.3 Expansion joints	1
3.4 Effective area	2
3.5 Expansion joint components	2
3.6 Associated equipment	3
4 Materials for convolution manufacture and precautions to avoid corrosion in service	4
4.1 General considerations affecting the choice of material for the convolutions of a bellows expansion joint	4
4.2 Precautions during storage, installation and use to avoid damage due to corrosion	5
4.3 Typical materials used in the fabrication of bellows convolutions	6
5 Application and use of expansion joints	7
5.1 General	7
5.2 Thermal expansion of various pipe materials	7
5.3 Unrestrained expansion joints	7
5.4 Restrained expansion joints	9
5.5 Special service conditions	10
6 Definition of design conditions and working conditions and classification of inspection procedures	10
6.1 General	10
6.2 Design conditions	11
6.3 Working conditions	11
6.4 Classification of inspection procedures	11
7 Information to be provided by the purchaser and the manufacturer	12
7.1 Information to be provided by the purchaser	12
7.2 Information to be provided by the manufacturer	12
8 Pre-installation inspection and testing	13
8.1 General	13
8.2 Class I	13
8.3 Class II	16
8.4 Class III	17
9 Identification, protection, packing, transportation and installation	17
9.1 Identification	17
9.2 Protection	17
9.3 Packing and transportation	17
9.4 Installation	18
10 Testing of systems containing expansion joints	19
10.1 General	19
10.2 Cases where a standard pressure test, in accordance with 10.1.5, on a system including expansion joints is not reasonably practicable	20
11 Guide for maintenance of expansion joints after installation	20

	Page
11.1 General	20
11.2 Inspection after first full movement	20
11.3 Periodic inspection after an agreed interval of time	20
11.4 Accessibility	21
12 Modifications to pressure systems incorporating expansion joints	21
12.1 General	21
12.2 Examples of modifications hazardous to systems containing all types of expansion joints	21
12.3 Examples of modifications particularly hazardous to systems containing unrestrained axial expansion joints	21
12.4 Examples of modifications particularly hazardous to systems containing restrained expansion joints	21
13 Certification	21
Figure 1 — Typical system using unrestrained expansion joint	22
Figure 2 — Examples of unsafe practice in a system using unrestrained expansion joints	22
Figure 3 — Diagrammatic explanation of cold pull of unrestrained expansion joint	22
Figure 4 — Typical system using a tied double expansion joint with hinged-end tie-bars	23
Figure 5 — Typical system using a tied double expansion joint with spherical-ended tie-bars	23
Figure 6 — Typical system using two single gimbal expansion joints	24
Figure 7 — Typical system using one single hinged expansion joint and two single gimbal expansion joints	24
Figure 8 — Typical systems using single hinged expansion joints	25
Figure 9 — Examples of unsafe practice in systems using gimbal expansion joints	26
Figure 10 — Examples of cold pull in a piping system with restrained expansion joints	27
Figure 11 — Systems using a pressure-balanced expansion joint	28
Table 1 — Classification of inspection procedures	12
Publications referred to	Inside back cover

Foreword

This British Standard has been prepared under the direction of the Pressure Vessel Standards Committee.

Although there is a large amount of well established useful data on the use of bellows expansion joints this is contained either within manufacturing companies or publications originating outside the United Kingdom.

Industry, user organizations, inspecting authorities and other interested parties have therefore combined to prepare a new code of practice to give guidance on the application and use of expansion joints in pressure systems.

This is the first Part of the code and deals with metallic bellows expansion joints; Part 2 will deal with non-metallic bellows expansion joints.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 28, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

1 Scope

This British Standard gives information and recommendations on the selection, application and testing of metallic bellows expansion joints for use in pressure systems.

2 References

The titles of the standards publications referred to in this code are listed on the inside back cover.

3 Terms and definitions

For the purposes of this code the following terms and definitions apply.

3.1

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 only loosely related to manufacturing dimensions

3.2 movement

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

3.2.1

axial compression

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

3.2.2

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

NOTE Axial compression and extension are sometimes referred to as minus and plus respectively but this designation is non-preferred and is, in any case, to be used only in addition to and not instead of a clear statement describing axial movement in terms of compression or extension.

3.2.3

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 misalignment, direct shear, or transverse movement

3.2.4

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

3.2.5

rated movement

the maximum amount of movement (axial extension, axial compression, lateral deflection, angular rotation, or any combination thereof) which an expansion joint is capable of absorbing. This rating may be different for each size, type and make of expansion joint and is established by the manufacturer

3.2.6

cyclic life

the minimum number of cycles of movement at the specified conditions which an expansion joint is designed to withstand without failure

3.3 expansion joints

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

3.3.1

single expansion joint

the simplest form of expansion joint, of single bellows construction, designed to absorb all of the movement of the section in which it is installed. The most common example is that of a single bellows designed to absorb axial movements only. This is often referred to as an axial expansion joint

3.3.2

single gimbal expansion joint

an expansion joint containing one bellows and designed to permit angular rotation in any plane by the use of two pairs of hinges affixed to a common floating gimbal ring. The gimbal ring, hinges and pins are designed to restrain the thrust of the expansion joint due to internal pressure and extraneous forces, where applicable

3.3.3

single hinged expansion joint

an expansion joint containing one bellows and designed to permit angular rotation in one plane only by the use of a pair of pins through hinge plates attached to the expansion joint ends. The hinges and hinge pins are designed to restrain the thrust of the expansion joint due to internal pressure and extraneous forces, where applicable

3.3.4**pressure balanced expansion joint**

an expansion joint designed to absorb axial movement and/or lateral deflection while restraining the pressure thrust by means of tie rods interconnecting the flow bellows with an opposed bellows also subjected to line pressure. A pressure balanced expansion joint sometimes contains two bellows in the flow section separated by a common connector, to permit greater lateral movement

3.3.5**externally pressurized expansion joint**

an expansion joint designed so that the pressure acts on the outer surface of the bellows. This form of construction is often used where it is necessary periodically to completely drain the fluid within the system

3.3.6 double expansion joint

An expansion joint consisting of two bellows separated by a short connecting tube used to accommodate larger movements than are possible with single expansion joints.

3.3.6.1**untied double expansion joint**

a double expansion joint capable of absorbing combinations of axial, lateral and angular movement. For this reason this type of expansion joint is sometimes referred to as a universal expansion joint

3.3.6.2**tied double expansion joint**

a double expansion joint in which the pressure thrust is carried by external or internal ties across the bellows. These ties may be in the form of hinged or spherical ended bars attached to opposite ends of the unit or in the form of individual hinges or gimbal rings spanning each bellows. Because of these ties the units are only capable of absorbing lateral and/or angular movements. Depending on the construction, tied double units may be referred to as articulated, double hinged or double gimbal expansion joints

two tie bars are designed to allow limited angular rotation in one plane; three or more tie-bars prevent this rotation

3.3.7**internally guided expansion joint**

an expansion joint designed so that axial guidance is provided within the expansion joint by means of heavy internal sleeves which may incorporate bearing rings

3.4**effective area**

the cross-sectional area of the bellows over which the pressure is assumed to act, which is used for the calculation of axial thrust

3.5 Expansion joint components

The following are part of, or are used in connection with, expansion joints.

3.5.1**bellows**

the flexible element of an expansion joint, consisting of one or more convolutions and the end cuffs, if any

3.5.2**convolution**

the smallest flexible unit of a bellows. The total movement capacity of a bellows is proportional to the number of convolutions

3.5.3**cuffs**

the straight, unconvoluted portions at the ends of the bellows. They are sometimes referred to as tangents or tails

3.5.4**weld ends**

the ends of an expansion joint equipped with pipe suitably bevelled for welding to adjacent equipment or piping

3.5.5**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

3.5.6**internal sleeve**

a device which shields the convolutions from direct contact with the flow of fluid. This device has also been referred to as a liner, telescoping sleeve or baffle sleeve

3.5.7**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

3.5.8**root reinforcing rings**

devices fitting snugly in the roots of the convolutions to reinforce the bellows against internal pressure. Root reinforcing rings are fabricated from tubing or solid round bars of carbon steel, stainless steel, or other suitable alloys

3.5.9**reinforcing collars**

devices used to reinforce the cuffs of bellows

3.5.10**equalizing rings**

rings, usually T-shaped in cross section, used to distribute movement equally between the convolutions of the bellows. They are usually designed to act as reinforcing rings

3.5.11**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. Tie rods may be designed to provide the features of control rods

3.5.12**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 of an untied double expansion joint. These devices are not designed to restrain bellows pressure thrust

3.5.13**purge connections**

connections, usually installed at the sealed end of each internal sleeve of an expansion joint for the purpose of injecting a liquid or gas between the bellows and the internal sleeve to keep the area clear of erosive and corrosive media and/or solids that could pack the convolutions. Purging, where required, may be continuous, intermittent or used only on start-up or shutdown

3.5.14**shipping restraints**

temporary rigid or adjustable support devices also known as sizing bars installed on an expansion joint to maintain the overall length of the assembly for shipment. These devices may also be used to precompress, pre-extend or laterally offset the bellows, to facilitate correct installation

3.5.15**movement indicator**

a device used to indicate the axial or angular movement, relative to its free position, to which the expansion joint is being subjected. A movement indicator is particularly useful when checking that the correct cold pull has been applied to the system

3.5.16**lagging shroud**

a device used to prevent lagging inhibiting free movement of convolutions

3.6 Associated equipment

The following equipment is associated with pressure systems containing expansion joints.

3.6.1**main anchor**

an anchor which is designed to withstand the full bellows thrust due to pressure, flow, spring forces, etc. (see 5.3.1.1)

a main anchor base for connection to the anchor structure can be furnished as an integral part of an expansion joint, if desired

3.6.2**intermediate anchor**

an anchor which is designed to withstand the bellows thrust due to flow, spring forces, etc., but not the thrust due to pressure (see 5.3.1.2.)

an intermediate anchor base for connection to the anchor structure can be furnished as an integral part of an expansion joint, if desired

3.6.3**directional restraint**

a device which is designed to absorb loading in one direction while permitting motion in another. This device may be either a main or intermediate anchor, depending upon the application involved. When designed for the purpose, a directional restraint may also function as a pipe alignment guide. A directional restraint is known also as a sliding restraint

3.6.4**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 joints to move freely in only one direction. Pipe alignment guides 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

3.6.5**single plane pipe guide**

a pipe guide which permits lateral deflection and/or angular rotation of the pipeline in one plane only. This device is commonly used in applications involving lateral deflection or angular rotation resulting from "L"-or "Z"-shaped piping configurations

3.6.6 pipe support

a device designed to carry the weight of a pipe, its contents, insulation etc. A pipe support is not necessarily intended to act as a guide. Pipe supports are usually required at more frequent intervals than are alignment guides or other forms of restraint. Most pipe-work systems require both supports and guides

4 Materials for convolution manufacture and precautions to avoid corrosion in service

4.1 General considerations affecting the choice of material for the convolutions of a bellows expansion joint

4.1.1 Bellows wall thickness. The convolutions of metallic expansion joints generally have a wall thickness substantially less than that of the equipment in conjunction with which they are used. It is therefore essential to select material for their manufacture having adequate resistance to all the corrosive agents likely to be encountered in any particular application.

For a material to be satisfactory it should be especially resistant to pitting corrosion, intergranular corrosion and crevice corrosion, in addition to being adequately resistant to general corrosion under the intended working conditions. The possibility of stress corrosion in some environments should also be considered.

4.1.2 Corrosion allowance. Only in exceptional circumstances is it desirable to incorporate a corrosion allowance in the design of a bellows. Therefore, the use of material having a higher corrosion resistance than that used in the associated plant is generally necessary to ensure a satisfactory service life.

4.1.3 Environmental factors. Convolution material should not be selected only by reference to the corrosive agents present on the process side. The environmental conditions existing on the non-process side should always be carefully considered, and may dictate a choice of material superior to that needed for the process side. In the case of multi-ply bellows, the inner and outer plies may be made from different materials to provide optimum corrosion resistance to the internal and external environments.

Typical cases where the external environment may dictate the required corrosion resistance are exposure to industrial or marine atmospheres and submerged or buried pipelines.

4.1.4 Stress corrosion. The operating stresses in bellows convolutions are high, and under some operating conditions, and in the presence of certain specific corrosive agents, notably chlorides, caustic alkalis, hydrogen sulphide, and nitrates, the possibility of stress corrosion should be considered. Where such conditions are likely to be encountered, the use of convolution material resistant to this type of failure is essential, and suitable material should be selected in each case by agreement between the user and the bellows manufacturer.

4.1.5 High or low temperature service. The choice of material should take account of the elevated temperature and low temperature mechanical properties and corrosion resistance of the materials which are suitable for the manufacture of bellows convolutions. In some types of service high temperatures may alternate with lower temperatures with attendant risk of condensation and corrosion, and in these cases special materials may be required. The effect of condensation which may occur on start-up and shut-down should also be considered.

4.1.6 Avoidance of condensation. In some cases less expensive materials than would otherwise be required may be made to give satisfactory service by minor modifications of the operating conditions local to the bellows convolutions. For example, lagging to maintain the temperature above the acid dew point is of considerable value in boiler uptakes, and can virtually eliminate corrosion which would otherwise be severe. The condensation which may occur at start-up and shut-down should also be considered but these periods are usually of short duration and, provided condensate does not remain for long periods, this factor may often be ignored, as corrosion may not be serious. Condensation may also occur when plant is operated well below full rating, and this factor should not be ignored as serious corrosion may result in the absence of suitable preventive measures.

4.1.7 Specification of working conditions. In order that convolution material may be correctly chosen, it is essential that the user should supply the fullest details of the operating conditions and substances in contact with the bellows to the manufacturer at the time of enquiry.

When specifying the substances in contact with the bellows, details of any plant cleaning routines, precommissioning acid descaling of pipework, etc. should also be given, and in the case of steam and condensate lines the possibility of contamination with process media should not be overlooked. External environmental factors should also be specified. In critical applications the choice of material should be the subject of discussion and agreement between the manufacturer and the user.

4.2 Precautions during storage, installation and use to avoid damage due to corrosion

4.2.1 Pressure test water. Pressure test water may remain entrapped in bellows convolutions for a long period of time between installation and plant commissioning. The use of impure water may give rise to pitting corrosion of bellows materials in these circumstances, particularly if debris is present in the convolutions. Mains water should be regarded as being of the minimum acceptable purity for this purpose. In the case of austenitic stainless steel bellows a chloride content of 30 mg/l should not be exceeded. In critical applications, particularly where complete drainage after testing is not practicable, a chloride content of 1 mg/l maximum is recommended.

4.2.2 Storage, handling and cleaning on site.

Bellows should not be allowed to come into contact with acids or other chemicals, or with cements, plasters or insulating materials, many of which contain chlorides which may cause corrosion of bellows materials.

Trichlorethylene and other chlorinated solvents should not be used for cleaning austenitic stainless steel bellows.

4.2.3 Installation of lagging. It is inadvisable to allow lagging material to be in direct contact with bellows convolutions, because

- a) lagging materials usually contain chlorides in varying amounts and in the presence of moisture present a risk of pitting and stress corrosion to bellows materials, and
- b) even if the original lagging were chloride free, any liquid in the form of rain, plant leakages, etc. would soak the material and there would be risk of corrosion of the bellows by any impurities present.

Lagging should always be installed on lagging shrouds, placed with an adequate clearance from the convolutions to allow for movement, and arranged to be easily removable for inspection purposes.

Shrouds should be correctly replaced after inspection and not allowed to touch the convolutions because of risk of fretting damage under vibrational conditions.

4.2.4 Lagging to maintain bellows convolutions above the dew point. It is essential to maintain this lagging in sound condition at all times, and to ensure complete replacement after inspection, otherwise rapid corrosion may occur due to acid condensation.

4.2.5 Drip shields. Bellows may need to be protected from plant leakages and spillages. Where bellows are installed in culverts, consideration should be given to the need to shield them from drippage with suitable covers. Culverts should be adequately drained to avoid groundwater coming into contact with expansion joints.

4.2.6 Painting. Paints containing low melting point metals or their compounds, particularly those containing aluminium, lead or zinc, should not be allowed to come into contact with bellows convolutions as there is a danger of intergranular penetration in elevated temperature service, particularly with stainless steels and high nickel alloys.

4.2.7 Contact with zinc and other non-ferrous metals. At temperatures over 450 °C, either under working conditions or as a result of a plant fire, zinc can rapidly penetrate and embrittle austenitic stainless steels and high nickel alloys. The use of galvanized material or paints containing metallic zinc should be avoided in the vicinity of expansion joints. More information on this subject is available in Technical Data Note no. 53/1, "Zinc embrittlement of austenitic stainless steel" issued by the Health and Safety Executive. Other non-ferrous metals may cause damage similar to that caused by zinc.

4.2.8 Protection against internal or external corrosion. Non-metallic coatings may be used inside or outside metallic bellows to provide additional protection, e.g. PTFE and rubber. Spark testing may be needed to test the integrity of the lining (see CP 3003-1).

4.2.9 Gasket materials containing graphite. The use of gasket materials containing graphite, or gaskets faced with graphite in contact with stainless bellows flanges should be avoided as there may be risk of galvanic corrosion.

4.2.10 Self-adhesive labels. Self-adhesive labels are often made of PVC and, on heating, these liberate hydrochloric acid which can cause severe corrosion and stress corrosion of bellows materials, particularly stainless steels. Such labels should therefore not be applied to bellows.