



Standard Specification for Circular Metallic Bellows Type Expansion Joints for Piping Applications¹

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1. Scope

1.1 This specification establishes the minimum requirements for the mechanical design, manufacture, inspection, and testing of circular metallic bellows-type expansion joints used to absorb the dimensional changes resulting from piping thermal expansion or contraction, as well as the movement of terminal equipment and supporting structures.

1.2 Additional or better features, over and above the minimum requirements set by this specification, are not prohibited by this specification.

1.3 The layout of many piping systems provides inherent flexibility through natural changes in direction so that any displacements produce primarily bending or torsional strains, within acceptable limits. Where the system lacks this inherent flexibility the designer should then consider adding flexibility through the use of metallic bellows-type expansion joints.

1.4 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

2. Referenced Documents

2.1 ANSI Standards:²

ANSI B16.5 Pipe Flanges and Flanged Fittings
B16.25 Butt Welding Ends
ANSI B31.1 Power Piping Code

2.2 ASME Standards:³

Section VIII, Division 1 Pressure Vessels
Section IX Welding and Brazing Qualifications

¹ This specification is under the jurisdiction of ASTM Committee F25 on Ships and Marine Technology and is the direct responsibility of Subcommittee F25.11 on Machinery and Piping Systems.

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² Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

³ Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Two Park Ave., New York, NY 10016-5990, <http://www.asme.org>.

2.3 EJMA Standard:⁴

Standards of the Expansion Joint Manufacturer's Association

2.4 PFI Standard:⁵

ES-3 Fabrication Tolerances

3. Terminology Definitions

3.1 Expansion joint definitions shall be in accordance with those in the EJMA Standards.

3.2 *double expansion joint*—expansion joint consisting of two bellows joined by a common connector.

3.2.1 *Discussion*—The common connector is anchored to some rigid part of the installation by means of an anchor base. The anchor base may be attached to the common connector either at installation or at time of manufacture. Each bellows acts as a single expansion joint and absorbs the movement of the pipe section in which it is installed independently of the other bellows.

3.3 *gimbal expansion joint*—expansion joint designed to permit angular rotation in any plane by the use of two pairs of hinges affixed to a common floating gimbal ring.

3.3.1 *Discussion*—The gimbal ring, hinges, and pins are designed to restrain the thrust of the expansion joint as a result of internal pressure and extraneous forces, where applicable.

3.4 *hinged expansion joint*—expansion joint containing one bellow 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.

3.4.1 *Discussion*—The hinges and hinge pins are designed to restrain the thrust of the expansion joint as a result of internal pressure and extraneous forces. Hinged expansion joints should be used in sets of two or three to function properly.

3.5 *pressure balanced expansion joint*—expansion joint designed to absorb axial movement or lateral deflection, or both,

⁴ Available from Expansion Joint Manufacturer's Association, Inc (EJMA), 25 N. Broadway, Tarrytown, NY 10591, <http://www.ejma.org>. The standards of the Expansion Joint Manufacturer's Association are a collection of standards developed by this industry and published in one volume, herein called EJMA Standards.

⁵ Available from Pipe Fabrication Institute (PFI), 511 Avenue of the Americas, Suite 601, New York, NY 10011, <http://www.pfi-institute.org>.

while restraining the pressure thrust by means of tie devices interconnecting the flow bellows with an opposed bellows also subjected to line pressure.

3.5.1 *Discussion*—This type of expansion joint is intended for use where a change of direction occurs in a run of piping. The flow end of a pressure balanced expansion joint sometimes contains two bellows separated by a common connector, in which case it is called a universal pressure balanced expansion joint.

3.6 *single expansion joint*—simplest form of expansion joint, consisting of single bellows construction, designed to absorb all movement of the pipe section in which it is installed.

3.7 *swing expansion joint*—expansion joint designed to absorb lateral deflection or angular rotation, or both, in one plane.

3.7.1 *Discussion*—Pressure thrust and extraneous forces are restrained by the use of a pair of swing bars, each of which is pinned to the expansion joint ends.

3.8 *universal expansion joint*—expansion joint containing two bellows joined by a common connector for the purpose of absorbing any combination of axial movement, lateral deflection, and angular rotation.

3.8.1 *Discussion*—Universal expansion joints are usually furnished with control rods to distribute the movement between the two bellows of the expansion joint and stabilize the common connector.

4. Ordering Information

4.1 An expansion joint is a unique product and must be specifically designed for the intended service. It is the responsibility of the piping system designer to supply sufficient engineering data necessary for the complete design. The information compiled by the piping system designer must be complete and contain all pertinent data detailing the conditions under which the expansion joint is expected to operate.

4.2 Orders for each expansion joint shall include the following information:

4.2.1 Title, designation number, and latest revision of this specification.

4.2.2 *Size*—The nominal pipe diameter or specific ducting diameter.

4.2.3 *Type of Expansion Joint*—single, double, universal, guided, hinged, gimbals, swing, or pressure balanced.

4.2.4 *Flow Characteristics*:

4.2.4.1 *Flow Medium*—indicate whether the medium is gas or liquid.

4.2.4.2 Flow velocity, medium density, or viscosity, or combination thereof.

4.2.4.3 Flow direction.

4.2.5 *Pressure in psig (N/mm²)*—design, operating, and test pressures.

4.2.6 *Temperature in °F (°C)*—design, operating, and installation temperatures.

4.2.7 *Movement*—axial (extension, compression); lateral (single plane, multiplane); angular; torsional (to be avoided). Differentiate between start-up, operational, or field installation tolerance movements.

4.2.8 *Materials*—Material types (including that for the bellows) shall be specified by the purchaser (see 5.1 for material restrictions).

4.2.9 *Internal Liner*—Liner shall be specified when needed because of flow velocity or other flow conditions. Specific criteria for liners is shown in Section C-3 of the EJMA Standards (see 6.6).

4.2.10 *External Cover*—To protect personnel having close access to the bellows, when thermal insulation is to be added in the field, or when external mechanical damage is possible (see 6.5).

4.2.11 *End Fittings*—The type of end connections such as flanged, threaded, or others to match the mating piping or terminal equipment.

4.2.12 *Accessories*—Specify what accessories are required and the conditions under which they operate. Consider items such as insulation lugs, tie, limit, or control rods, pantographic linkages, trunions, gimbals, drains, purge connections, anchor bases, and interply monitoring devices.

4.2.13 *Dimensional Limitations*—If space limitations exist, specify the maximum overall length, maximum outside diameter, minimum inside diameter, and installation tolerances.

4.2.14 *Operating Forces*—Specify calculated bellows spring forces and pressure thrust forces if they are required for subsequent anchor design or other piping systems analysis. If there are maximum allowable values, these must also be specified.

4.2.15 *Installation Position*—horizontal, vertical (flow up or down). Specify if liner drainage holes are required.

4.2.16 *Cycle Life Requirements*—Specify an anticipated number of thermal cycles over the intended life of the expansion joint.

4.2.17 *Testing Requirements*—Specify testing requirements in addition to the hydrostatic test required by 9.4 (for example, vacuum testing, testing at operating temperature).

4.2.18 *Inspection Requirements*—Specify inspection requirements in addition to the inspection required by Section 9 (that is, radiographic, fluorescent penetrant, or mass spectrometer).

4.2.19 *Piping Code Requirements*—Specify any piping or design code that must be used as the basis for design in addition to those specified in 5.2.

4.2.20 *Special Requirements*—Specify the magnitude of special system conditions such as vibration, shock, or hydraulic surge.

4.2.21 *Shipping Requirements*—Specify whether special packing is required including protection for extended outside storage, export handling, or special lifting considerations for heavy or large assemblies.

4.2.22 *Piping Drawing*—In addition to specifying the above information it would be beneficial to provide a drawing of the proposed piping system.

4.2.23 *Supplementary Requirements*—Specify any additional requirements not identified herein.

4.3 Fig. 1 and Fig. 2 should be used as a guide in ordering expansion joints to this specification.

COMPANY:			DATE / /		
			SHEET OF		
PROJECT:			INQUIRY NO.		
			JOB NO.		
ITEM NO./EJ TAG NO.					
1	QUANTITY		EJMA PAGE REFERENCE		
2	NOMINAL SIZE/I.D./O.D. (IN.)				
3	EXPANSION JOINT TYPE		1		
4a	FLUID INFORMATION	MEDIUM GAS/LIQUID	5, 6, 147 77		
4b		VELOCITY (FT./SEC)			
4c		FLOW DIRECTION			
5	DESIGN PRESSURE, PSIG		6, 19,		
6	TEST PRESSURE, PSIG		83, 135		
7a	TEMPERATURE	DESIGN (°F)	6, 13		
7b		MAXIMUM/MINIMUM (°F)			
7c		INSTALLATION (°F)			
8a	MAXIMUM INSTALLATION MOVEMENT	AXIAL COMPRESSION (IN.)	6, 7, 8, 141		
8b		AXIAL EXTENSION (IN.)			
8c		LATERAL (IN.)			
8d		ANGULAR (DEG.)			
9a	MAXIMUM DESIGN MOVEMENTS	AXIAL COMPRESSION (IN.)	6, 7, 13, 47		
9b		AXIAL EXTENSION (IN.)			
9c		LATERAL (IN.)			
9d		ANGULAR (DEG.)			
9e		NO. OF CYCLES			
10a	OPERATING FLUCTUATIONS	AXIAL COMPRESSION (IN.)	84		
10b		AXIAL EXTENSION (IN.)			
10c		LATERAL (IN.)			
10d		ANGULAR (DEG.)			
10e		NO. OF CYCLES			
11a	MATERIALS OF CONSTRUCTION	BELLOWS	5, 6, 45 77, 78		
11b		LINERS			
11c		COVER	3, 7, 72		
11d		PIPE SPECIFICATION			
11e		FLANGE SPECIFICATION			3, 43
12	RODS (TIE/LIMIT/CONTROL)		3, 4, 41		
13	PANTOGRAPHIC LINKAGE		4		
14	ANCHOR BASE (MAIN/INTERMEDIATE)		1, 2, 17		
15a	DIMENSIONAL LIMITATIONS	OVERALL LENGTH (IN.)			
15b		OUTSIDE DIAMETER (IN.)			
15c		INSIDE DIAMETER (IN.)			
16a	SPRING RATE LIMITATIONS	AXIAL (LBS./IN.)	54		
16b		LATERAL (LBS./IN.)			
16c		ANGULAR (IN.-LBS./DEG.)			
17	INSTALLATION POSITION HORIZ./VERT.		8, 141		
18a	QUALITY ASSURANCE REQUIREMENTS	BELLOWS WELD NDE	LONG. SEAM ATTACH.	133	
18b					
18c		PIPING NDE			
18d		DESIGN CODE REQ'D.			
18e		PARTIAL DATA REQ'D.			
18f					
18g					
19	VIBRATION AMPLITUDE/FREQUENCY				

FIG. 1 Standard Expansion Joint Specification Sheet

5. Materials and Manufacture

5.1 *Materials:*

5.1.1 Pressure-containing parts shall be manufactured from material specifications and grades listed in Section VIII, Division 1, of the ASME Code or ANSI B31.1. End connection material shall have in service properties similar to the bellows material. Flanges shall meet ANSI B16.5.

5.1.2 All other materials of construction shall be of the type specified by the user and shall conform to an ASTM or ASME material specification. Materials not identified by the ordering data shall be of the manufacturer's standard and of the same quality used for the intended purpose in commercial practice.

5.1.3 Materials used shall be free from defects that would adversely affect the performance of the expansion joint.

5.1.4 All material incorporated in the work covered by this specification shall be new. The use of rebuilt or used products is not allowed under this specification.

5.1.5 Materials for hinge or gimbal hardware, or other sliding parts, shall be chosen to minimize galling of the contacting parts.

5.2 *Manufacture:*

5.2.1 Expansion joints shall be designed and fabricated in accordance with requirements set forth in the ordering data and the EJMA Standards.

5.2.2 Nonstandard flanges shall be designed and fabricated in accordance with Appendix 2 of Section VIII, Division 1, of the ASME Code. Flanges machined from plate shall not be used at pressures exceeding 150 psi (1034 kPa) and temperatures exceeding 450°F (232°C). Hubbed flanges machined from plate or bar stock shall meet the requirements of Appendix 2, Paragraph 2-2(d) of Section VIII, Division 1, of the ASME Code.

5.2.3 All welding shall be accomplished in accordance with ANSI B31.1

5.2.4 Welding personnel and welding procedures shall be qualified in accordance with the applicable sections of Section IX, of the ASME Code.

5.2.5 All fabrication details not covered by the referenced codes and standards shall be taken from the appropriate ANSI standard. If no standard applies, accepted industry practice shall govern.

5.2.6 The bellows shall be of tested and proven convolution geometry.

6. Other Requirements

6.1 The details of design, material supply, fabrication, and testing of the complete product are the responsibility of the manufacturer unless specific details are requested by the purchaser.

6.2 The specified normal operating movements (axial, lateral, and angular) shall be available concurrently. The specified lateral and angular movements shall be available on either side of the expansion joint centerline.

6.3 Internal sleeves, external covers, and all attached hardware shall be constructed so as not to interfere with adjacent parts when the joint is in the fully deflected position.

6.4 Universal expansion joints shall be designed and fabricated to be self-supporting and not require any external structure for the support of the center pipe spool piece and its contents.

6.5 Expansion joints to be installed in systems above 150°F (66°C) shall have an external cover. When external mechanical damage is possible, a cover shall be fabricated to protect the joint and personnel.

6.6 Internal sleeves shall be installed in expansion joints when the fluid velocity of the system, where the expansion joint is to be installed, is greater than the values listed in Section C-3.1 of the EJMA Standards and where the flow velocity exceeds 75 % of the velocity calculated using Section C-3.1.4 of the EJMA Standards.

7. Dimensions and Permissible Variations

7.1 Dimensional tolerances on completed expansion joint assemblies shall be in accordance with Section D-2.9 of the EJMA Standards and Standard ES-3 of the Pipe Fabricating Institute.

8. Workmanship, Finish, and Appearance

8.1 The quality of workmanship shall be such as to produce a product that is in accordance with the requirements of this specification and ensures the proper functioning of all parts of the unit.

8.2 The bellows shall be manufactured and carefully handled to prevent surface flaws or deep scratches from being generated. The surface condition of the completed joint assembly shall be free from injurious surface discontinuities and any contaminants that would affect the operation of the assembly.

8.3 On completion of fabrication, and before shipment, the manufacturer shall clean the inside and outside of the completed assembly of all loose scale, grease, dirt, sand, rust, weld spatter, cutting chips, and any other foreign matter by any suitable means. The inside of the assembly shall then be inspected for cleanliness. All openings where practicable shall be suitably closed to prevent the entrance of foreign matter after cleaning and during shipment. The use of chlorinated solvents is prohibited.

9. Inspection

9.1 The responsibility for quality control rests with the manufacturer. However, all phases of fabrication may be subject to review by a representative of the purchaser.

9.2 The inspector representing the purchaser shall have access at all times, while work on the contract of the purchaser is being performed, to all parts of the manufacturer's plant that concern the manufacture of the product ordered. The manufacturer shall afford the inspector all reasonable facilities to satisfy the inspector that the product is being furnished in accordance with this specification. Inspection shall be made at the place of manufacture before shipment, unless otherwise specified, and shall be scheduled not to interfere unnecessarily with the operations of the manufacturer. This requirement applies to all subcontractors.

9.2.1 Acceptance of a particular phase of manufacturer of an assembly by a purchaser's representative shall not be considered a waiver of any of the requirements of this specification and shall not relieve the manufacturer of the responsibility of furnishing a satisfactory product.

9.3 When the bellows is formed from a longitudinally butt-welded cylinder, the longitudinal weld(s) shall be 100 % liquid penetrant examined on the outside and inside surfaces (if accessible) before forming. Liquid penetrant examination on all accessible inside and outside weld surfaces shall be repeated after forming. All other welds essential to pressure containing or restraining shall be liquid penetrant examined. Ferromagnetic materials may be examined by magnetic particle inspection instead of liquid penetrant at the manufacturer's option. Liquid penetrant and magnetic particle inspection shall be in accordance with Section D-3.1.2 of the EJMA Standards.

9.4 All pressure retaining components shall be hydrostatically tested to 1.5 times their design pressure as outlined in Section D-3.1.6 of the EJMA Standards. Moment restraint, simulating piping rigidity, shall be used if necessary. The expansion joint shall be vented before hydrotest. Test pressure shall be held for 10 min.

9.4.1 Unless otherwise specified, potable water is acceptable for hydrotesting.

9.4.2 All piping and bellows shall be thoroughly drained after hydrotesting.

9.4.3 Pneumatic testing may be substituted for hydrostatic testing at the manufacturer's option. When substituted, pneumatic testing shall be accomplished in accordance with Section 137.5 of ANSI B31.1.

9.5 A dimensional inspection of the completed expansion joint assemblies shall be performed in accordance with Section D-2.9 of the EJMA Standards and Standard ES-3 of the Pipe Fabricating Institute.

9.6 A visual examination of the completed expansion joint shall be made.

10. Rejection and Rehearing

10.1 Expansion joint assemblies or parts thereof indicating fabrication not in accordance with the manufacturing drawings and procedures, or this specification, shall be subject to rejection and shall be resolved in accordance with the manufacturer's quality assurance program (see Section 14).

10.2 All repairs shall be in accordance with the specified code and other applicable specifications.

10.3 Expansion joint assemblies or parts thereof accepted by the purchaser's representative at the place of manufacture that subsequently reveal imperfections not previously detected or which by subsequent tests or analysis show nonconformance with this specification are subject to rejection.

11. Certification

11.1 When specified in the purchase order or contract, the manufacturer's certification shall be furnished to the purchaser. It shall state that each expansion joint has been manufactured, tested, and inspected in accordance with this specification and

the requirements have been complied with. When specified, a report of any test results shall be furnished.

11.2 When specified, certification of the conformance to the requirements of this specification may be made by a third party.

11.3 ASTM/ASME mill test reports are required for pressure retaining and containing components.

11.4 No records are required for pipe fittings or flanges provided they are made and marked in accordance with an acceptable standard (such as ANSI). Certificates of conformance are required when the markings are missing or are removed during fabrication.

12. Product Marking

12.1 Each expansion joint shall be provided with a permanently attached corrosion resistant nameplate indicating as a minimum the following information:

12.1.1 Manufacturer's name.

12.1.2 Manufacturer's model number.

12.1.3 *Design Conditions*—pressure, temperature, movements.

12.1.4 This specification number (indicating compliance thereto).

12.1.5 Purchaser's specified component item number, if ordered.

12.2 When an expansion joint is supplied with an internal liner, a permanent arrow indicating the direction of flow shall be plainly visible on the outside of the expansion joint.

12.3 Impression stamping directly on bellows material is not permitted.

13. Packaging and Shipping

13.1 The expansion joint shall be containerized or shipped on pallets with all materials strapped down and prepared for shipment in such a manner that the quality, cleanliness, and finish shall be maintained during shipment.

13.2 Yellow painted shipping bars shall be furnished to maintain proper shipping length and alignment, and designed not to interfere with the installation of the assembly. The shipping bars shall be removed after installation and before piping system test. Expansion joints with tie rods can be provided with tie rod spacers instead of shipping bars.

13.3 Installation instructions shall be supplied in a weatherproof envelope with each expansion joint assembly.

13.4 When the expansion joint is to be transported to the job site by ship, it should preferably be sent as below deck cargo.

13.5 All external surfaces shall be treated and painted in accordance with the manufacturer's standard practices, unless otherwise specified. Paint shall be suitable for service temperatures.

14. Quality Assurance

14.1 The manufacturer shall have a current certificate of authorization to manufacture ASME Section VIII, Division 1, Pressure Vessels to assure an adequate quality assurance program that is applicable to all phases of manufacturing, including materials supplied by subcontractors.

14.2 Nothing in this specification shall relieve the manufacturer of the responsibility for performing, in addition to the requirements of this specification, such analyses, tests, inspections, or other activities that the manufacturer considers necessary to ensure that the design, material, and workmanship are satisfactory for the service intended, or as may be required by common usage or good practice.

15. Keywords

15.1 expansion joint; metallic bellows-type expansion joints; piping systems; piping thermal contraction; piping thermal expansion

SUPPLEMENTARY REQUIREMENTS

The following supplementary requirements are for use when desired by the purchaser. Other requirements not identified in this specification may be included by agreement between the manufacturer and the purchaser.

S1. Documents for Approval or Records, or both

S1.1 Manufacturing drawings.

S1.2 Welding procedures and qualifications.

S1.3 Applicable nondestructive examination procedures.

S1.4 Heat treatment procedures or temperature charts, or both.

S1.5 Complete engineering design analysis calculations for the metallic bellows or hardware, or both.

S1.6 ASME partial data forms.

S2. Qualification Testing

S2.1 When specified, the manufacturer shall furnish a first article test assembly to determine conformance with this specification. The test assembly shall consist of the bellows and appropriate end connections. Liners, covers, tie, limit or control rods, hinges, gimbal rings, and other similar devices need not be provided on the first article test unit, unless they are necessary for the performance of the specific test(s) verification.

S2.2 When specified, cyclic endurance testing (fatigue testing) shall be performed for the required number of complete cycles. The test shall be performed under pressure at ambient temperature and the assembly need be cycled in axial movement only.

S2.2.1 During the test, the pressure in the assembly shall be adjusted to simulate, as closely as possible, the maximum design pressure of the unit being qualified. The pressure may vary from this value during each cycle.

S2.2.2 A single test bellows can be used instead of a multiple bellows assembly being qualified.

S2.2.3 In determining the qualifying extension or compression, or both, the equivalent axial movement caused by lateral deflection and angular rotation shall be included. The equivalent axial movement shall be computed in accordance with the EJMA Standards and shall be algebraically added to the specified values of axial movement.

S2.3 The purchaser may require that the expansion joint be certified as passing shock requirements. The shock requirements shall be specified by the purchaser.

S2.3.1 The purchaser may require that the expansion joint be certified as passing vibration requirements. The vibration requirements shall be specified by the purchaser.

S2.3.2 When specified, other qualifying tests shall be performed on a first article test unit under the requirements of the purchaser's contract.

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