



STANDARD PRACTICE **SP-117**

# **BELLOWS SEALS FOR GLOBE AND GATE VALVES**

Developed and Approved  
by the  
Manufacturers Standardization Society  
of the  
Valve and Fittings Industry, Inc.  
127 Park Street, N.E.  
Vienna, Virginia 22180  
(703) 281-6613  
Fax (703) 281-6671

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Other standards documents referred to herein are identified by the date of issue that was applicable to this standard at the date of issue of this standard. See Annex B. This standard shall remain silent on the applicability of those other standards of prior or subsequent dates of issue even though provisions of concern may not have changed.

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**BELLOWS SEALS FOR GLOBE AND GATE VALVES****1. SCOPE<sup>(1)</sup>**

1.1 This standard covers requirements for design, materials, fabrication, installation, qualification, examination, testing and shipment of metal bellows and/or bellows assemblies to be installed in manual and automated on-off globe and gate valves.

1.2 This standard is applicable to metal bellows used in conjunction with steel globe and gate valves which otherwise satisfy the requirements of standards such as API 600 "Steel Gate Valves- Flanged and Butt welding Ends," API Standard 602 "Compact Steel Gate Valves, Flanged, Threaded, Welding and Extended-Body Ends," ASME/ANSI B16.34 "Valves Flanged, Threaded and Welding End," API 603 "Class 150, Corrosion-Resistant Flanged End Gate Valves," BS5352:1981 "Steel wedge gate, globe and check valves 50mm and smaller for the petroleum, petrochemical and allied industries." Such standards are referred to herein as the "Parent" valve specifications.

1.3 This standard does not apply to non-metallic bellows or bellows made of low melting point materials such as brass, phosphor-bronze, or similar materials.

1.4 Except where specifically noted in the text of this standard, the requirements here are not intended to supersede or replace those requirements of the parent valve standard. This standard specifies additional requirements for those valves utilizing bellows seals.

1.5 It is the responsibility of the bellows valve manufacturer to ensure compliance with this standard.

<sup>(1)</sup> This standard is not intended for valves developed for and predominantly used in instrument piping systems.

**2. MARKING**

2.1 Valves utilizing bellows seals shall have a corrosion-resistant metal identification plate securely attached, giving the following information:

- 1) Bellows seal per MSS SP-117
- 2) Bellows Material: (insert actual bellows material)

Note: If the parent valve elevated pressure/temperature rating is to be derated or service temperature limited due to bellows design limitations, any bellows rated limitations to the parent valve pressure/temperature rating shall be marked as required by the parent valve specification.

**3. DESIGN****3.1 General**

3.1.1 The purpose of the bellows seal is to provide a metal barrier between the stem at its point of entry through the pressure boundary and the process fluid within the valve, to eliminate stem leakage. The bellows seal is not intended to be a structural member of the valve nor is it considered to be the ultimate pressure containing mechanism of the valve. Thus, the bellows seal is to be designed in conjunction with and not as a substitute for the conventional pressure boundary components normally required. See Figure 1 for an example of a typical valve assembly with bellows seal.

3.1.2 Because a conventional pressure boundary mechanism is available to act as the ultimate pressure containing mechanism, latitude is permitted in the design of bellows seals so long as they satisfy the performance and all other requirements of this standard.

3.1.3 Except as specifically noted herein, the rules governing the design of all other valve components found in the parent valve specifications apply.

### 3.2 Pressure-Temperature Ratings

3.2.1 The Pressure-Temperature ratings of ASME/ANSI B.16.34 or other parent specification for the pressure class and body material of the valve apply as well to the bellows seal. The bellows shall withstand the parent valve class full 100° F rating. The valve manufacturer may choose to derate the bellows seal to some lower pressure scheme at elevated temperatures than the pressure/temperature rating of the parent valve. The manufacturer may also apply an elevated temperature limitation due to the bellows limitations. The valve manufacturer shall provide published rating to end user when a derated pressure-temperature scheme applies.

### 3.3 Materials

3.3.1 Bellows seal material shall be selected so that the maximum temperature is below the creep range.

3.3.2 Acceptable bellows materials are:

Stainless Steel, 321, 316 and 316L-  
ASTM A 240/ A 312  
Stainless Steel, 304 and 304L-ASTM A 240/ A 312  
Stainless Steel, 347-ASTM A 240/ A 312  
Alloy 600-ASTM B 168/ B 167  
Alloy 625-ASTM B 443  
Alloy 718-ASTM B 670  
Alloy 400-ASTM B 127/ B 165  
Alloy C22-ASTM B 575/ B 622  
Alloy C276-ASTM B 575/ B 622

Other materials may be used with the concurrence of the purchaser.

3.3.3 Acceptable Material for the bellows end fittings, including rings, caps or flanges if utilized are:

Stainless Steel, 321, 316 and 316L-ASTM A 276/  
ASTM A 479  
Stainless Steel, 304 and 304L-ASTM A 276/  
ASTM A 479  
Stainless Steel, 347-ASTM A 276/ ASTM A 479  
Alloy 600-ASTM B 564

Alloy 625-ASTM B 446  
Alloy 718-ASTM B 637  
Alloy 400-ASTM B 164/ 564  
Alloy C22-ASTM B 574  
Alloy C276-ASTM B 574

Other materials may be used with the concurrence of the purchaser.

3.3.4 The bellows, bellows end fittings and final attachment point such as the stem shall be weld compatible and have no negative effect on the bellows' corrosion resistance.

### 3.4 Bellows Fabrication

3.4.1 The bellows may be constructed by forming individual convolutions from butt welded tube or drawn tube or by welding a series of formed disks together at both the outside diameter and the inside diameter of the individual disks. Forming may be accomplished either mechanically or hydraulically or any other suitable manufacturing method.

3.4.2 Precautions must be taken in the fabrication of multi-ply bellows to prevent moisture or other contamination between the plies.

3.4.3 Bellows may be welded together in series to accommodate the stroke requirements of the valve. Mechanical connections between bellows are not permitted.

3.4.4 Appropriate design features must be included to prevent squirm (buckling) of the bellows and to prevent localized contact between the bellows convolutions, valve body and stem which could lead to accelerated wear and premature failure.

3.4.5 Material certification of conformance for the bellows and end fittings is required to be furnished by the bellows manufacturer for each shipment if requested by the customer. Material certification should also be required for the end fittings of the bellows when furnished by the manufacturer.

### 3.5 Stem/Disk or Moving Connection

3.5.1 The bellows, or a ring welded to the end of the bellows at the moving end, shall be attached to the disk/stem of moving component by welding. A mechanical connection between the stem/disk or moving component and the bellows is not permitted.

3.5.2 The bellows shall not be subjected to torsional loads associated with operating the valve.

### 3.6 Fixed Connection

3.6.1 The bellow's fixed end shall be welded to the body, the bonnet or to a flange clamped or welded between the body and the bonnet. A mechanical connection to the bellows is not permitted. If welded to the valve body, this weld must be cut in order to perform maintenance of the valve seat.

### 3.7 Bellows Compression-Extension

3.7.1 Appropriate means shall be included in the valve design by the valve manufacturer to prevent compression or extension of the bellows beyond that qualified by the cycle life test.

### 3.8 Bellows Cycle Life

3.8.1 A cycle is defined as fully open to fully closed to fully open. The bellows design shall be qualification tested in accordance with the following table unless otherwise agreed to by the valve manufacturer and end user:

<u>Valve Size</u>	<u>Minimum Cycle Life</u>	
Up to and including class 800 valves	<u>Gate</u>	<u>Globe</u>
≤ 2"	2,000	5,000
2-1/2" - 4"	2,000	5,000
> 4"	1,000	2,000
Above class 800 valves		
≤ 2"	2,000	2,000
2-1/2" - 4"	1,000	2,000
> 4"	1,000	1,000

3.8.2 The suitability of the bellows assembly design shall be demonstrated by means of prototype tests upon representative samples per 4.1.

### 3.9 Bellows Welding

3.9.1 All welding of the bellows and bellows attachment welds must be performed by qualified operators using qualified procedures. All welding qualifications shall be per ASME section IX.

3.9.2 Bellows welds and bellows attachment welds if not attached directly to the valve body or bonnet are excluded from the heat treat requirements of the parent specifications.

## 4. INSPECTION AND TEST

### 4.1 Bellows Design and Qualification Testing

4.1.1 The bellows assembly shall be cycle life tested either by cycling in an assembled valve without packing, or in a test rig which replicates the actual installation including the clearance, stroke, loading, pressure and wear couples of the parent valve.

4.1.2 Any variation that constitutes a change in basic design parameters that affect cycle life of the bellows will require requalification by cycle testing (e.g. change in bellows supplier, material specification, number of plies, wall thickness or diameter).

A change in overall length or number of convolutions may not require requalification provided that the percentage of bellows movement in both compression and extension is the same or less than that of originally qualified bellows where:

$$\% \text{ Movement in compression} = \frac{(\text{Live length} - \text{Compressed length}) \times 100}{(\text{Live length})}$$

$$\% \text{ Movement in extension} = \frac{(\text{Extended length} - \text{Live length}) \times 100}{(\text{Live Length})}$$

4.1.3 After welding bellows to fittings and prior to qualification testing, each bellows assembly

shall be Helium leak tested and exhibit no detectable leakage using an instrument with sensitivity of  $10^{-6}$  cc/sec He.

4.1.4 Prior to cycle testing each bellows assembly shall be hydrostatic pressure tested at 1.5 times the 100° F valve design pressure. Each bellows assembly shall be fixed at the length where the valve is in the open position as required at normal valve shell test. The pressure shall be applied on the same side as the valve is designed to operate in service. Water used for testing of stainless steel bellows assemblies shall contain less than 100 ppm chlorides.

4.1.5 The frequency of cycling shall take into consideration excessive heat which may be generated by abnormally fast cycling. In no case shall the frequency of cycling exceed one cycle per second.

4.1.6 Cycling shall be carried out at ambient temperature and at the 100° F rated pressure of the bellows. The pressure shall be applied in a manner to simulate normal valve shell tests.

4.1.7 A minimum of three bellows of each basic design and material selected at random from those produced using the standard production manufacturing processes shall be cycled to achieve the appropriate minimum cycle life requirement of section 3.8.

4.1.8 After cycling the bellows per 3.8.1 each bellows shall be leak tested and exhibit no detectable leakage. Leak testing can be air under water at a minimum of 80 psig or by an instrument with sensitivity of  $10^{-6}$  cc/sec He.

4.1.9 Cycle life testing data shall be documented and available.

#### 4.2 Production Testing

4.2.1 Every bellows assembly shall be leak tested by a suitable method equivalent to Helium leak testing with an instrument with sensitivity of  $10^{-6}$  cc/sec.

### 5. SHIPMENT

#### 5.1 Protection

5.1.1 Each bellows assembly must be cleaned and packaged to prevent internal moisture or contamination.

5.1.2 Each bellows assembly shall be individually packaged to prevent damage in handling or in transit.

5.1.3 Each bellows assembly, if practical shall be marked to insure proper identification of the material. If it is impractical to mark each assembly, each package must be so marked.

### 6. ORDERING INFORMATION

6.1 If the Valve Manufacturer needs a bellows seal that deviates from this standard practice, it is the valve manufacturer's responsibility to clearly define such deviation and to furnish information to permit the bellows manufacturer to complete the order.

6.2 If no exceptions are to be taken to this standard, the purchase order need only make reference to MSS SP-117 and specify the following items:

- A. Valve size
- B. Pressure class or pressure temperature rating
- C. Materials and traceability
- D. Required travel or stroke
- E. Valve type - Globe or Gate
- F. Packaging Requirements
- G. Bellows Fabrication Method
- H. Inspection by valve manufacturer

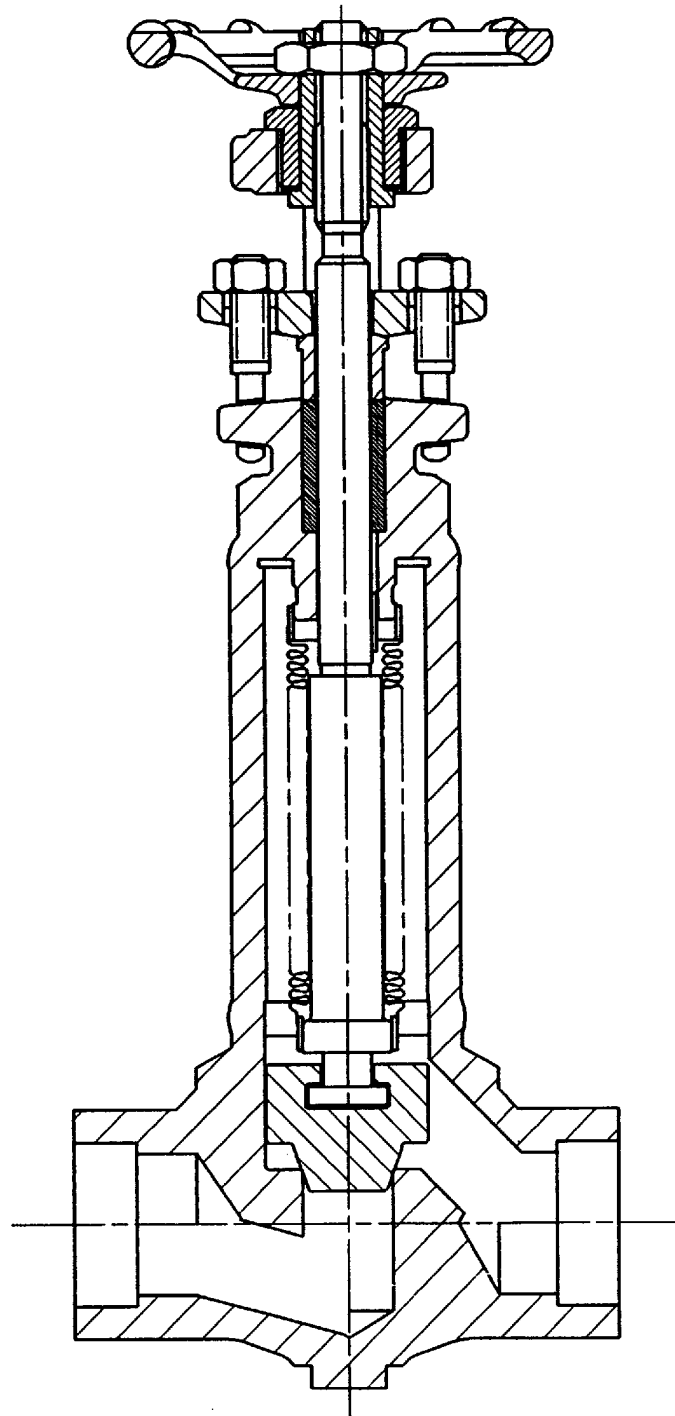


FIGURE 1 — TYPICAL BELLOWS STEM SEAL ARRANGEMENT

Note: This figure is for illustrative purposes only and is not intended to imply design requirements.



## ANNEX A DEFINITIONS

This annex is an integral part of this Standard Practice which is placed after the main text for convenience. Other definitions may be found in MSS SP-96.

<u>Assemblies:</u>	A combination of two or more components, one of which is the bellows and the other a fitting and/or a stem.
<u>Bellows, hydraulically formed:</u>	Bellows made by applying hydraulic pressure internally to a tube, generally forming all convolutions simultaneously and collapsed between a series of dies.
<u>Bellows, mechanically formed:</u>	Bellows corrugated individually and consecutively on a tube by rotating tools and/or rubber dies.
<u>Bellows, welded:</u>	A bellows made by joining alternately the outer and inner edges of a series of flexible disks by welding.
<u>Convolution:</u>	A single corrugation formed on the tube. One or more convolutions for a bellows.
<u>Cycle life:</u>	The estimated life of a bellows in terms of the number of movements it is capable of providing at a specific pressure differential, temperature and axial stroke.
<u>Live length:</u>	The pitch times the number of active convolutions. Also the active length.
<u>Overall length:</u>	The total length of the bellows, including end fittings.
<u>Stroke:</u>	Compression from free length plus extension from free length.
<u>Squirm:</u>	Severe buckling or similar distortion of a bellows, produced by too much pressure inside a relatively long bellows.
<u>Wall thickness:</u>	The wall thickness of the original tube from which the bellows is formed. It is the total wall thickness for multi-ply bellows.

## ANNEX B REFERENCED STANDARDS

This annex is an integral part of this Standard Practice which is placed after the main text for convenience.

### ANSI/ASME Standards

B16.34      1988      Valves - Flanged, Threaded, and Welding End

### API Standards

API 600      1991      Steel Gate Valves - Flanged and Butt-Welding Ends  
API 602      1993      Compact Steel Gate Valves - Flanged, Threaded, Welding, and Extended-Body Ends  
API 603      1991      Class 150, Cast, Corrosion Resistant Flange End Gate Valves

### ASME Boiler and Pressure Vessel Code

Section IX   1995      Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators

### ASTM Standards

A 240      1995      Standard Specification for Stainless and Heat Resisting Steel Plate, Sheet and Strip for Pressure Vessels  
A 276      1994      Standard Specification for Stainless and Heat-Resisting Steel Bars and Shapes  
A 312      1994      Standard Specification for Seamless and Welded Austenitic Stainless Steel Pipes  
A 479      1994      Standard Specification for Stainless and Heat-Resisting Steel Bars and Shapes for Use in Boilers and Other Pressure Vessels  
B 127      1993      Standard Specification for Nickel-Copper Alloy (UNS N04400) Plate, Sheet, and Strip  
B 164      1993      Standard Specification for Nickel-Copper Alloy Rod, Bar, and Wire  
B 165      1993      Standard Specification of Nickel-Copper Alloy (UNS N04400) Seamless Pipe and Tube  
B 167      1994      Standard Specification for Nickel-Chromium-Iron Alloys (UNS N06600, N06601, N06690, N06025, and N06045) Seamless Pipe and Tube  
B 168      1995      Standard Specification for Nickel-Chromium-Iron Alloys (UNS N06600, N06601, N06690, N06025, and N06045) and Nickel-Chromium-Cobalt-Molybdenum Alloy (UNS N06617) Plate, Sheet, and Strip  
B 443      1993      Standard Specification for Nickel-Chromium-Molybdenum-Columbium Alloy (UNS N06625) Plate, Sheet, and Strip  
B 446      1993      Standard Specification for Nickel-Chromium-Molybdenum-Columbium Alloy (UNS N06625) Rod and Bar  
B 564      1994      Standard Specification for Nickel Alloy Forgings  
B 574      1994      Standard Specification for Low-Carbon Nickel-Molybdenum-Chromium, Low-Carbon Nickel-Chromium-Molybdenum, and Low-Carbon Nickel-Chromium-Molybdenum-Tungsten Alloy Rod

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B 575	1994	Standard Specification for Low-Carbon Nickel-Molybdenum-Chromium, Low-Carbon Nickel-Chromium-Molybdenum, and Low-Carbon Nickel-Chromium-Molybdenum-Tungsten Alloy, Plate, Sheet, and Strip
B 622	1994	Standard Specification for Seamless Nickel and Nickel-Cobalt Alloy Pipe and Tube
B 637	1993	Standard Specification for Precipitation-Hardening Nickel Alloy Bars, Forgings, and Forging Stock for High-Temperature Service
B 670	1994	Standard Specification for Precipitation-Hardening Nickel Alloy (UNS N07718) Plate, Sheet, and Strip for High-Temperature Service

British Standards

BS 5352	1981	Steel wedge gate, globe and check valves 50mm and smaller for the petroleum, petrochemical and allied industries
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MSS Standard Practices

SP-96	1991	Guidelines on Terminology for Valves and Fittings
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Publications of the following organizations appear on the above list:

BSI	British Standards Institute 389 Chiswick High Road London, England W4 4AL
ANSI	American National Standards Institute, Inc. 11 West 42nd Street New York, NY 10036
ASME	The American Society of Mechanical Engineers 345 East 47th Street New York, NY 10017
ASTM	American Society for Testing and Materials 100 Barr Harbor Drive West Conshohocken, PA 19428
MSS	Manufacturers Standardization Society of the Valve and Fittings Industry 127 Park Street, N.E. Vienna, VA 22180