2472 Eastman Ave. Dept. 29, Ventura, Ca. 93003
Tel: 805 644-1474 Fax: 805 656-7272 E-mail: info@mini-flex.com Web: www.mini-flex.com
Manufacturer of Metal Bellows since 1961

Metal Bellows Design Guide

Please read carefully to avoid misinterpretation

Part Number (**Column 1**)**:** This number is used to order a Bellows made to stock dimensions listed in our catalog "Metal Bellows- test data of stock". Standard tolerances are noted in the "Metal Bellows Design Guide".
The addition of *"M"* to the last numeral (SS-125-46-80M) indicates the stock Bellows is to be *modified*. Please consult factory when modifications are required.
Part Number code example: SS-125-46-80, **SS** = (Material) Stainless Steel, **-125** = Tube diameter (.125) used to form the Bellows, **-46** = Wall Thickness (.0046), **-80** = Spring Rate (80 lbs/in.).

Convolution Inside Diameter (**Column 2**)**:** The nominal inside diameter (inches) is based on the wall thickness and tooling used to form the convolutions. This is a fixed dimension that cannot be modified. The dimension will vary slightly when compression or extended. The inside diameter in the "as formed" condition is equal to the neck inside diameter (approximately).
Stock tolerances are normally held to +/-.005. Production runs average +-.002 (approximately) or better.

Convolution Outside Diameter (**Column 3**)**:** The nominal outside diameter (inches) tolerance is used to vary the Spring Rate. An increase in diameter will reduce the Spring Rate.
Stock tolerance is normally held to +/-.010. Custom tolerances of +-.005 or less can be achieved when the spring rate is not critical.

Wall Thickness (**Column 4**)**:** Thickness (inches) of the tubing from which a Bellows is formed.
This tolerance is specified at +- 10% and normally purchased at +- 5%. Actual thickness is usually better than +-3%.
The wall thickness can be modified under certain conditions. Consult Mini-Flex for details.

Neck Outside Diameter (**Column 5**)**:** The neck is located on both ends of the convolutions and is used to attach mating parts. The neck diameter (inches) is based on tooling but can be modified by expanding or contracting.
Stock tolerance is normally held to +/-.002. Production runs average +-.001. Custom tolerances of +-.001 or less are possible.
Tight tolerance control is made by applying uniform pressure on the outside diameter using a round collet and at the same time supporting the inside diameter with a standard plug gage. Care must be taken not to over stress the thin wall.
Consult Mini-Flex Corporation for details.

Neck Inside Diameter: Equals the neck outside diameter minus twice the wall thickness.
Production runs average +-.001. Custom tolerances of +-.0005 or less are possible.
Tight tolerance control is made by applying uniform pressure on the outside diameter using a round collet and at the same time supporting the inside diameter with a standard plug gage. Care must be taken not to over stress the thin wall.
Consult Mini-Flex Corporation for details.

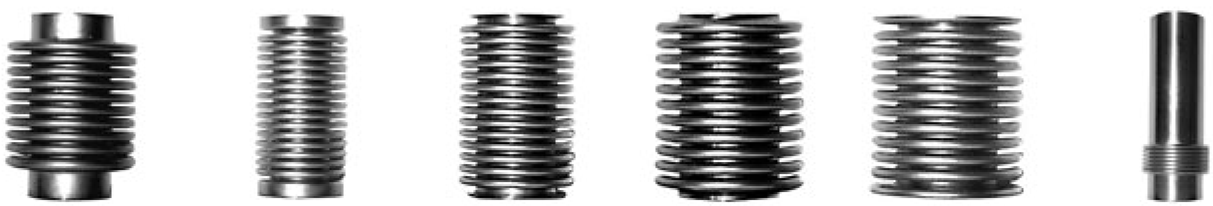
2472 Eastman Ave. Dept. 29, Ventura, Ca. 93003
Tel: 805 644-1474 Fax: 805 656-7272 E-mail: info@mini-flex.com Web: www.mini-flex.com
Manufacturer of Metal Bellows since 1961

Metal Bellows Design Guide

Please read carefully to avoid misinterpretation

Neck Length (**Column 6**)**:** Tube necks are measured (inches) from the outer face of the end convolution. Cup necks are measured from the inner surface. Neck length(S) can be modified upon request.
Stock tolerance is normally held to +/-.015. Custom tolerances of +-.005 or less can be achieved. Consult Mini-Flex for details.

Neck Types



Tube Neck | **Cup Neck** | **Flange Neck** | **Root Neck** | **Split Convolute** | **Custom Necks**

Tube Neck: The “A” neck is the standard type and most consistent in size.
Cup Neck: “C” type necks are utilized when access is a concern.
Flange Neck: “F” type necks can be made to one or both ends of any Bellows. The dimension is usually 75% of the convolution height. “F” necks can be made to the convolution outside diameter and larger upon request.
Root Neck: “R” necks can be made to one or both ends of any Bellows and is usually prepared to customize a stock bellows length.
Split Convolution Neck: “S” necks can be made to one or both ends of any Bellows and is usually prepared to customize a stock bellows length.
Custom Necks: Consult Mini-Flex for details.
Caution! Cutting a flange, root neck or split convolution from a Bellows will increase the Spring Rate and Squirm pressure, decrease the Maximum Deflection and Free Length.
Consult Mini-Flex for details.

Convolution Free Length (**Column 7**)**:** This is the free relaxed length (inches) of the convoluted section and is measured from the outer faces of the end convolutions. Bellows with Cup type necks are measured from the inside face at he base of the neck(s).
Bellows Overall Length equals the convolution Free Lengthplus both neck lengths. The approximate Pitch of the convolution equals convolution Free length divided by Number of convolutions.
Stock tolerance is normally held to +.050 -.010. Production runs average +-.005. Modified tolerances of +-.005 or less are possible.
The minimum compressed length is equal to the nominal free length minus the maximum deflection. See “Maximum Deflection in Compression” for more details.
The Free Length can be modified for certain applications. See “Number of Convolutions” and “Maximum Deflection in Compression” for more information.
Flexible hose applications : The cataloged Bellows can be supplied up to 150% longer.
Contact Mini-Flex for more information.

2472 Eastman Ave. Dept. 29, Ventura, Ca. 93003
Tel: 805 644-1474 Fax: 805 656-7272 E-mail: info@mini-flex.com Web: www.mini-flex.com
Manufacturer of Metal Bellows since 1961

Metal Bellows Design Guide

Please read carefully to avoid misinterpretation

Maximum Deflection in Compression (**Column 8**)**:** This is the maximum travel (inches) or movement from the nominal Free Length (in compression) without permanent deformation of the convolutions. It is inadvisable to use this total travel when long life is required. Hydro-Formed Bellows function best in compression.
The cataloged dimension is measured with the face of both end convolutions restrained from movement. The Bellows is then compressed until convolution contact creates a significant increase in force.
Additional stroke (equal to .375 convolution stroke per end approximately) is available when the convolution face(s) is free to move.
Compression stroke can increase significantly by stretching the Bellows to the "As-Formed" length which is about 75% longer than the "Free Length of Convolutions". Stroke can then be made to the minimum compressed length. Caution! Cycle life will decrease, spring rate will change and permanent set will occur.
The minimum compressed length is equal to the nominal free length minus the maximum deflection. Movement beyond the minimum compressed length will cause convolution deformation. The result is permanent set that will not allow the Bellows to return to the original relaxed length. This deformation may not affect applications utilizing a mechanical (or forced) means of movement.
Extension is allowable when permanent set, spring rate and or cycle life is not critical.
Stroke per convolution (Dc) is equal to the "Maximum Deflection in Compression" (D) divided by the Number of convolutions (N): Dc=D/N
Consult Mini-Flex engineering when applications are critical.

Spring Rate Lbs/in. (**Column 9**)**:** This is the dead weight in pounds required to compress a bellows one inch. Stock Bellows are usually rated when compressed 30% to 50% of the maximum deflection. Spring rate linearity varies from part to part and within the specified maximum compressed range (convolution free length minus maximum deflection). Contact Mini-Flex when linearity is a concern or a spring rate is required at a required stroke.
Force required to compress the bellows (within its specified range) equals the spring rate multiplied by the travel.
Spring rate per convolution equals the spring rate multiplied by number of convolutions.
Stock tolerance is normally held to +-20%. Custom tolerances of +- 10 % or less can be achieved.

Effective area sq. inches (**Column 10**)**:** This is the calculated area in square inches of the effective diameter, which lies approximately halfway between inside and outside diameter of convolutions.
The effective area tolerance is generally determined by the Convolution outside diameter variation only. See "Convolution Inside Diameter" for details.

<u>Formulas</u>

Mean effective area (A) equals the convolution outside diameter (O) plus inside diameter (I) divided by four. The result squared then multiplied by pi: A= 3.14159(O+I / 4)^2 or simply **.1963(O+I)^2**. Calculate the internal or external effective area by adding twice the wall to the inside or outside diameter as required.

2472 Eastman Ave. Dept. 29, Ventura, Ca. 93003
Tel: 805 644-1474 Fax: 805 656-7272 E-mail: info@mini-flex.com Web: www.mini-flex.com
Manufacturer of Metal Bellows since 1961

Metal Bellows Design Guide

Please read carefully to avoid misinterpretation

Volume (V) in cubic inches equals' Effective area multiplied by Length. Bellows volume capacity (less the neck inside diameter) is Volume multiplied by the convolution Free Length (L): **V=AL**. Volume displacement is equal to the stroke (D) times the effective area **V=AD.**
Pressure (P) in pounds per square inch required to compress the bellows any distance within its maximum deflection equals spring rate (R) multiplied by the deflection (D) and divided by the effective area (A): P= (RD/A).

Critical Squirming Pressure P.S.I.G. (**Column 11**)**:** Squirm is a phenomenon occurring to a bellows, when the convolutions are unrestrained from sideways movement, the necks are fixed, and the Bellows is subjected to internal pressure. When the rated pressure is reached, a slight bow, or sideways buckling occurs. When pressure is increased slightly, the bellows will lose stability and enter into the form of a "U" bend. Squirm will not occur if the bellows is guided by a rod stem or used in a fairly close fitting hole. Squirm is more predominant when the convolution free length exceeds the convolution outside diameter.
The listed squirm rating is considered a reference due to wall thickness variation created by tolerance. The actual squirm pressure is considered a maximum internal proof pressure and the greater the safety factor the longer the life. Exceeding the actual squirm pressure will cause sidewall yield that may cause an increase in spring rate and a decrease in maximum deflection. In some cases this deformation is minor and will not affect the Bellows function.
External pressure does not cause squirm regardless of length.
Consult Mini-Flex engineering when pressure applications are critical.

Burst Pressure P.S.I.G. (**Column 12**)**:** The minimum internal burst pressure without fracture when a Bellows is restrained from sideways squirming movement. At this pressure, severe permanent deformation of convolutions takes place, making unit useless. This pressure is used for design information only indicating the minimum tensile strength of the material.
Actual internal or external burst pressures are much higher. Consult Mini-Flex when pressure applications are questionable.

Number of Convolutions (**Column 13**)**:** Modifying the convolution quantity is possible by splitting at the major or minor diameter. See "Neck Types". This split convolution would then become the bellows neck. Consult Mini-Flex for details.
Increase in spring rate and a decrease in travel and length must be considered if this method is used.

Revision "C" Effective Date: 04/18/02 **Print Date: 7/23/02**