Electroformed Metal Bellows

Servometer

Applications in Many Industries

- Aerospace & Defense
- Semiconductor
- Medical
- Energy
- Instrumentation
- Research
- And more...

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SYSTEM CERTIFICATION ISO 9001 SGS

Introducing Electrodeposited Bellows

Electrodeposited bellows are flexible, spring-like, precision engineered components **custom designed** to fit into OEM parts or assemblies. Of the various types of bellows available today, only our patented manufacturing technology employs our premium alloy FlexNickel™. It offers superior performance characterization and makes Servometer® electrodeposited bellows exceptionally unique.

Our electroformed bellows are **extremely rugged, yet lightweight**. They are very effective, especially in mission critical applications like Aerospace and Defense, where requirements demand extreme tolerances and complex geometries.

Today, OEMs worldwide rely on Servometer bellows daily to deliver precise control in thousands of Industrial, Medical, Energy, Semiconductor and UHV applications as well. If you have a project or application idea and you think a bellows is the right part for the job, our engineering team will work with you providing professional design assistance to make it possible.

Servometer electrodeposited bellows are available in a wide range of sizes, lengths and materials including nickel, copper, gold and silver. They can be custom manufactured in various wall thicknesses with outer diameters ranging from 0.020 inch to 12.0 inches and convolution lengths as long as 9 inches. Off-the-shelf solutions are available for low cost testing too.

Outstanding Features and Benefits

- **Thinnest wall construction (as thin as .0002 inch) for optimum sensitivity**
- **25x more sensitive than hydroformed bellows**
- **Provide large deflections with minute forces - as small as 4 grams.**
- **Superb flexibility - ideal for hermetic sealing, pressure sensors and valve seals**
- **Compress up to 60% of their free length**
- **Infinite cycle life expectancy possible with 100,000 cycles standard**
- **Leak tight to eliminate risk of contamination**
- **Lightweight, low mass**
- **No tooling charges**

Our Manufacturing Process

Servometer's Five Step Process of Electrodeposition

Servometer electrodeposited bellows are manufactured using a unique, patented technology that has been optimized to produce precisely engineered bellows to user specifications. The five step process starts with a mandrel that is machined to the exact shape of the inside of the bellows. Next, a layer of metal is deposited to the specified thickness to meet performance requirements. The ends are then trimmed and finally the mandrel is dissolved away. A bellows design from order to delivery is possible within six weeks, however; standard bellows are available for delivery within a few days. Using the process of electrodeposition, Servometer will design a bellows solution to meet your application needs.

Step 1

Aluminum bar stock.

Step 2

Machine internal geometry to create a mandrel.

Step 3

Electrodeposit metal onto mandrel.

Step 4

Trim plated mandrel to expose unplated surface.

Step 5

Chemically dissolve mandrel leaving plating as final component.

About Bellows

Performance and Properties

We concentrate on product performance, whether you're ordering a single prototype or approving a full production run. Since all bellows are not created equal, understanding key performance characteristics and how they can affect your design is important to maximizing product quality and exceeding your expectations.

Tolerances

Inside Diameter

- ± .005 inch for bellows ID .250 inch or larger
- Tolerance varies with wall thickness and diameter for bellows ID less than .250 inch

Outside Diameter

- Tolerance varies with wall thickness and size of bellows
- Maximum OD is 12 inches

Other important parameters

- Length of end trims: ± .005 inch
- Spring rate tolerance: ± 30% standard (± 10% possible)
- Minimum ID/OD ratio: 0.6 or greater (.65 optimal)*

*Higher values are possible but these may compromise stroke, especially when requirements specify maximum effective area or a small space.

Metal Composition

We employ Servometer's signature FlexNickel™, nickel alloy, in our manufacturing process. We also offer copper, silver and gold as either a base metal or a surface finish. Our premium FlexNickel™ is available in three combinations of nickel alloy including Standard, Low Sulfur and Weldable.

Features

- Bright and high in yield strength
- Contain 0.04% maximum sulfur (Standard)
- Contain 0.02% maximum sulfur (Low Sulfur and Weldable)
- Corrosion resistant
- Amenable to either welding, soldering or brazing depending upon application type

Normally our leak tight bellows have a .0001 inch lamination of copper between equal thicknesses of nickel to enhance leak tight properties, especially in thin walled bellows.

Mechanical Properties

Yield strength	110,000 psi (min.)
Tensile strength	125,000 psi (min.)
Elongation	1.0% (min.)
Hardness	270 Vickers (min.)
Young's Modulus	23,350,000
Specific weight	.321 lb./in^3.

Surface Finish

Servometer bellows normally have a bright corrosion resistant surface, but other finishes such as gold plate (24 carats, per ASTM B 488), silver plate, copper and Parylene® coatings are available for special applications such as electrical, medical, satellite hardware and water immersion which require a higher level of corrosion resistance.

Leak Tightness

If this is one of your requirements, we can verify that our bellows are leak tight to 1x10^{-9} cc He/sec using a Helium Mass Spectrometer. That's equivalent to one cubic centimeter of gas leaking every 32 years.

Environmental Tolerances

Some environmental conditions such as temperature, corrosive elements and magnetic applications can impact the overall performance of Servometer bellows. Our engineers can help you with the ideal design to meet your requirements.

Temperature tolerances	- 423° F to + 350° F
Magnetic properties	Ferromagnetic (nickel alloy) Non-magnetic (copper)
Corrosion resistance	High tolerance except for acids and seawater; gold plate may be used in some instances to enhance resistance. Please ask for assistance in choosing the appropriate material for your application.

Waveguide with Interior Copper Plating

Building the Perfect Bellows

The construction of your bellows relies on several design factors such as pressure, stroke, spring rate and effective area.

Our engineers are available to offer you design assistance in determining all of these factors.

To help guide you in determining all of your requirements for your bellows design, our engineers have created an 11 point checklist for you to follow:

01 Type of flexing required of the bellows: Specify extension, compression, bending, parallel-ends off-set, and any combination of these. Provide a drawing or sketch showing related fittings and extremes of flexing where possible. This is very important to enable our engineers to work out a reliable design.

02 Specify the amount of compression, extension, or flexing in inches, in degrees, or by dimensions on a flex diagram (maximums).

03 Specify pressure inside and outside of the bellows, maximum instantaneous pressure, and whether higher pressure will be applied inside or outside the bellows.

04 Specify whether rigid stops will limit the extension or compression of the bellows to its rated stroke, or if the bellows will be required to withstand pressure un-restrained. Note that a restrained bellows can typically withstand higher pressures.

05 Specify the spring rate, in pounds per inch, or conversely the amount of force available to flex the bellows the desired amount.

06 Specify the required useful life of the bellows expressed as the number of flexing cycles and define the flexing cycle.

07 State temperature extremes; both high and low.

08 Describe the working environment of the bellows and any potential for corrosive environment.

09 Specify vibration or shock to be experienced by the bellows.

10 Specify the method to be used to join the bellows to end fittings, such as soldering, welding, or adhesive bonding.

11 Specify types and lengths of ends.

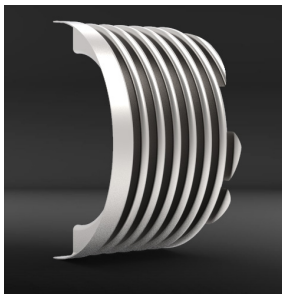
For an overview, we recommend visiting our website for the complete *Bellows Design Guide*. This helpful resource is **FREE** and provides convenient formulas for calculating important parameters like pressure and spring rate and helps you understand the relationship of stroke and cycle life. It provides simple explanations and definitions of bellows manufacturing terminology like “fins” and “grooves” plus much more!

Finishing the Perfect Bellows

Servometer is capable of finishing your bellows with either opened or closed ends in order to help simplify installation into a sub-assembly depending upon your application and usage requirements.

Choose from eight different end styles. Ends can be joined or attached using various methods including soft solder, silver braze, electron beam weld or adhesive. Servometer can recommend the best method for your particular application to ensure success.

End Styles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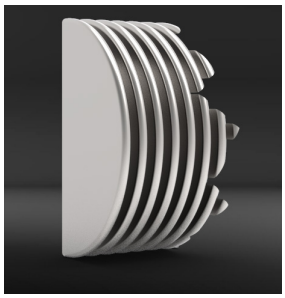
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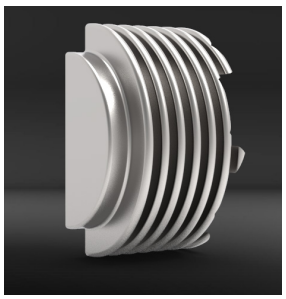
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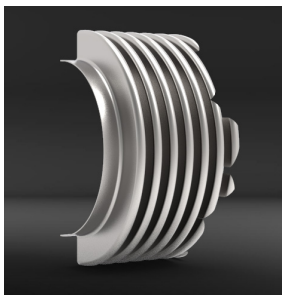
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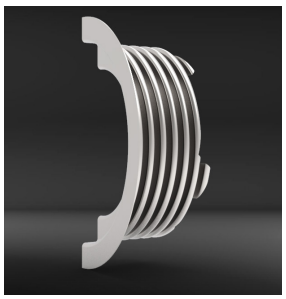
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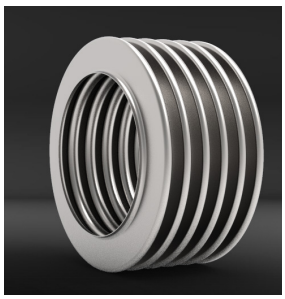
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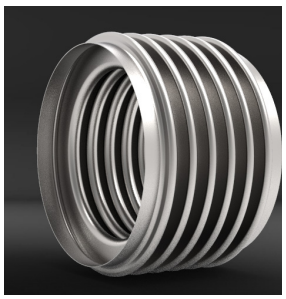
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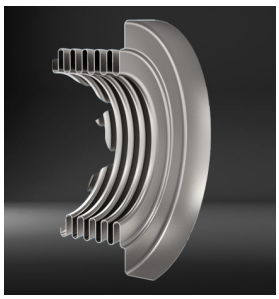
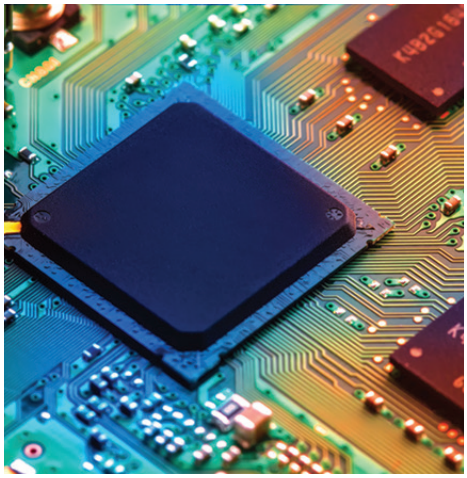
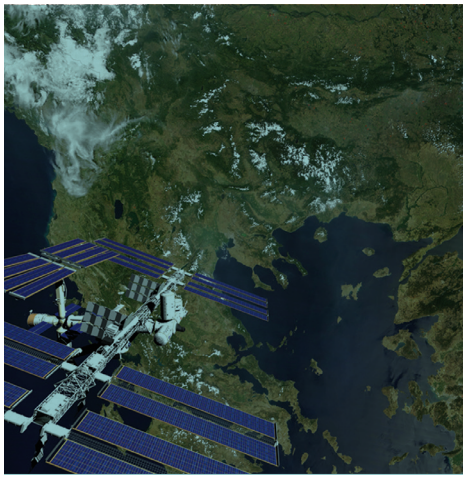

Type I

Industries and Applications

> “Using the Servometer bellows as an actuator in our clean room we were able to minimize fouling plus wear and tear in our assembly.”

> “We’ve been using Servometer bellows for years as a barometric pressure sensor to help measure volcanic eruptions, detect tornadoes and for the space shuttle re-entry.”





> “Your custom nickel bellows was the ideal replacement for the spring in our telescope assembly. It provided the perfect micro motion; ran with little or no fall out and came in at a very competitive price.”

Our products are recognized worldwide for the highest quality, highest performance and reliability.

We are the trusted supplier to top Fortune companies within these marketplaces:

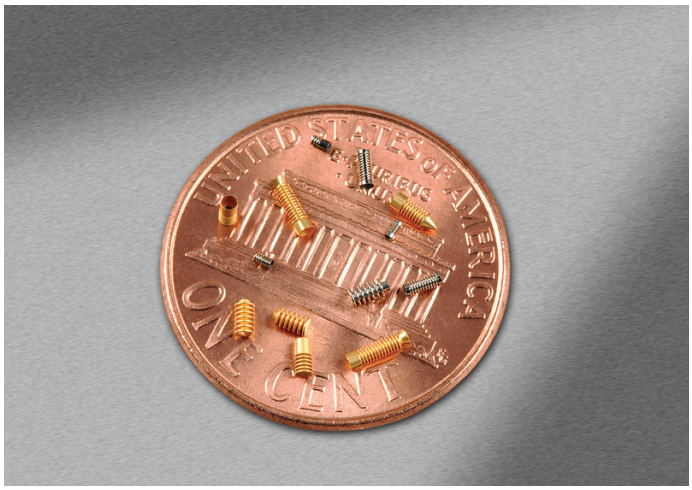
- **Aerospace**
- **Military & Defense**
- **Energy**
- **Instrumentation**
- **Research/Education/Laboratories**
- **Medical**
- **Industrial Automation**
- **Semiconductor/Ultra High Vacuum**
- **and more!**

Electrodeposited bellows are used in a vast array of components and applications as varied and as diverse as the people who have developed them. Whether it's a ground breaking product, or a replacement part, Servometer electrodeposited bellows are an ideal solution.

Application Types

- **Volume Compensators**
- **Pulsation Dampeners**
- **Actuators**
- **Mechanical Seals**
- **Electrical Spring Contacts**
- **Pressure Switches & Transducers**
- **Temperature Sensors & Transducers**
- **Valve Seals**
- **Expansion Joints**
- **Short/Full Range Aneroids**
- **Linear Multi pliers**
- **Flexible Shaft Couplings**
- **Thermal Expansion Tanks/Reservoirs**
- **and more!**

Pressure responsive bellows assembly



Miniature bellows

Lithography bellows

Athermalization assembly

Assembly Services

Electrodeposited Metal Bellows

For more than 60 years customers have relied on our proven experience to provide high quality assemblies to thousands of proprietary applications. From liquid filled sensors, to miniature sealed pressure switches, Servometer offers a complete range of assembly services regardless of size, shape, or quantity. Our team of professionals is ready to work with you to design and build your parts more reliably, more quickly and less expensively than you can do it yourself.

Electrodeposited Metal Bellows

Soldering

To avoid overheating the bellows, Servometer's assembly experts carefully use temperature sensors and controls while applying heat to the bellows assemblies. RoHS compliant solders are standard on all new designs. Solder joints are leak tight and can be tested to 1 x 10^{-9} cc He/sec.

Temperature Monitored Soldering

Electron Beam Welding

Electron beam welding enables state-of-the-art computer process control which delivers localized energy to the work piece; minimizing distortion of thin parts. It also produces exceptionally clean welds with no filler material for applications that cannot tolerate contamination or volatile outgassing. Servometer can e-beam weld parts from 0.03 inch to 8 inches in diameter.

Bellows with flanges

Torchless Brazing

Servometer assembly technicians use a proprietary induction brazing process to join sub-assembly components together, and then soft solder them to a bellows or an electroform.

Expert care ensures that nickel bellows are protected from overheating.

Adhesive Bonding

Servometer specializes in close-tolerance adhesive bonding with epoxy, anaerobic or cyanoacrylate adhesives. The adhesive application area and thickness are closely controlled for cleaner, robust bonded assemblies.

Machining

Three and five-axis computer numerically controlled (CNC) screw machines and multi-tool turning centers produce the most challenging shapes to tight tolerances. Our expert machinists produce bellows from 0.020 to 12 inches in diameter with tolerances to ± 0.0005 inch (± 0.013 mm). In addition to the multi-machining centers, our wire electrical discharge machine (EDM) creates complex geometry using wire as small as 0.003 inch in diameter.

Sub-Component Supply

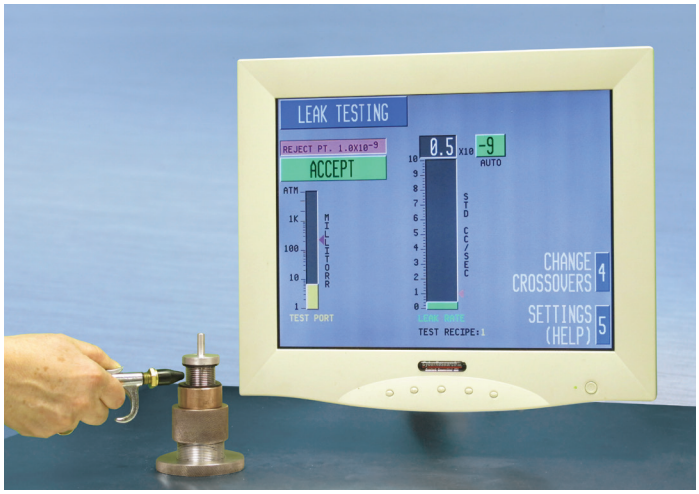
Servometer can be your single source provider for all your sub-component needs from manufacture to procurement.

Engraving

Laser applied part identification is offered for serialization, production lot control, bore size identification, part number and/or special marking. Engraving is typically applied to custom end pieces.

Helium Leak Test

Verified helium leak proof up to 1 x 10^{-9} cc He/sec, as required by design. Our equipment is NIST calibrated.



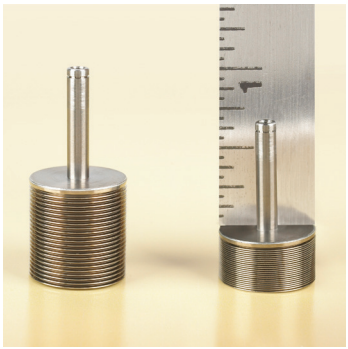
Helium leak testing

Specialty Designs

Special Types of Bellows

Some applications such as high pressure environments may require a specialized bellows. Servometer offers three unique types including High Compression, Multi-ply and Pre-compressed. Consulting with one of our design experts will help you make the right choice.

- **High Compression** – able to compress 60% of active free length
- **Multi-ply** – material wall thickness increases pressure rating, while the spring force increases linearly
- **Pre-Compressed** – special process adjusts free length for all stroke motion in extension



High compression bellows

Electroforms

If you are looking for the unusual, Servometer has a reputation for **making the impossible...possible**, using our unique, proprietary electrodeposition process to produce electroforms.

Electroforms are intricate custom parts with extremely close tolerances and fine surface finishes. They are a reliable solution for complex lightweight designs in Aerospace, Defense and Medical applications. For more than 50 years, Servometer has been the go-to provider for designing, manufacturing and delivering proprietary custom electroforms.

Features

- Extremely lightweight construction
- Structurally rigid
- Unusual shapes and sizes
- Able to withstand extreme temperatures from -423° to 1000° F for static applications
- Micro finished surfaces as fine as 4 R.M.S
- Varying wall thicknesses on a single part

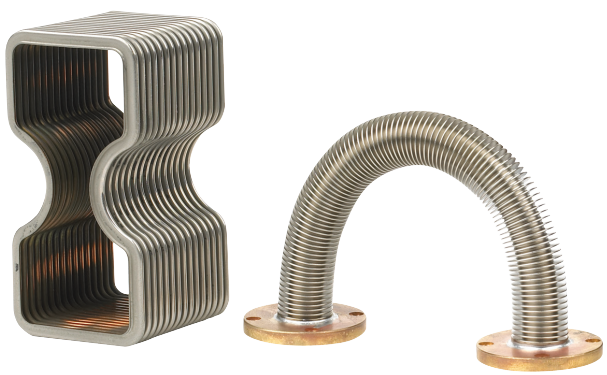
We can produce diameters as small as .020 inch (.5 mm) and dimensional tolerances to one ten-thousandth of an inch. Larger dimensions of 8 inches or greater are also possible depending upon your requirements.

Typical applications

- Camera desiccant container
- Diaphragm
- EMI connector shielding
- Reservoir (liquid, gas, lubricant, pressure)
- Lens holders
- Cold shields
- and more!

Our engineering team is **ready to provide FREE design assistance** with your electroform application. Pricing is determined by the complexity of the part, surface finish requirements, tolerances, and other variables. To learn more about Servometer electroforms call 973.785.4630 or visit our website www.MWcomponents.com

Engineering partners from concept through design.



Electroforms for Medical, Aerospace, and Defense applications.

Standard and Custom Solutions

More Flexible Bellows Solutions

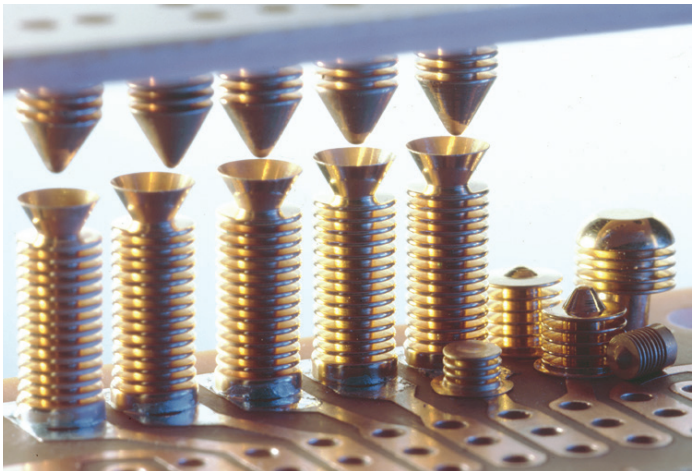
Couplings, Contacts, and Edge Welded Bellows

Flexible Shaft Couplings

Servometer electrodeposited bellows couplings deliver precise positioning under punishing environments for today's most demanding motion control applications. They offer zero-backlash, high flexibility, ultra-sensitivity and extreme accuracy for reliable 24/7 operation.

Bellows Electrical Contacts

Servometer bellows spring contacts are an ideal solution on precision circuit boards, relays and switches for enhanced conductivity and a lifetime of reliable interconnection. Our contacts are gold plated to ensure the utmost reliable signal paths. They can compensate for thermal expansion in critical assemblies.



Electrical Spring Contacts

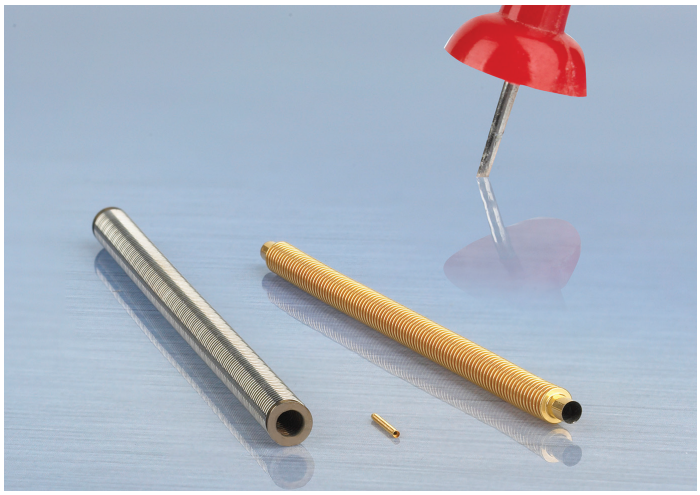
Edge Welded Metal Bellows

Edge Welded bellows can be made from a wide variety of metal alloys. They are ideal for higher temperature and pressure applications and are able to withstand corrosive environments as those found in Oil and Gas and Semiconductor industries. Manufactured and designed by Servometer's sister company MW Components – Ormond Beach (formerly BellowsTech, LLC). MW Components – Ormond Beach can quickly help you with a design or answer your application questions. Call 386-615-7530 today or visit mwcomponents.com for more information.

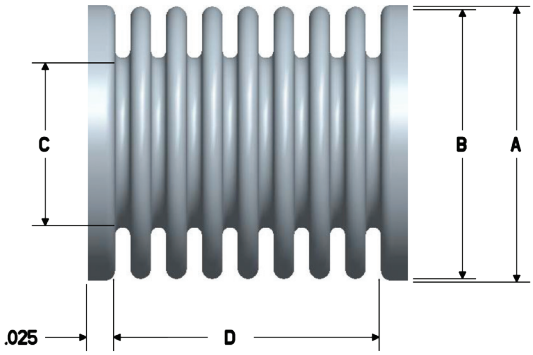
Standard and Custom Edge Welded Metal Bellows

Ordering Information

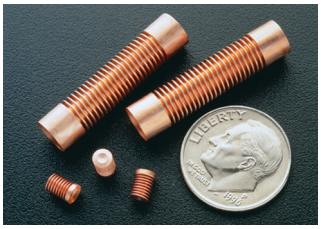
For convenient and low cost standard bellows solutions, Servometer offers 16 standard sizes from .250 inch OD to 1.00 inch OD in various lengths and wall thicknesses. These parts are available to order in small quantities. Select the sizes you need from the chart below then contact customer service today at 973.785.4630 for availability and pricing.



Designed to fit length, OD and finish specifications



Threaded bellows for Medical application



Copper Bellows

Standard Bellows *(In Stock and Available Off the Shelf)*

Part No.	Fin OD "A" (in.)	Skirt ID "B" (in.)	Inside Diameter "C" (in.)	Convolution Length "D" (in.)	Nominal Wall (in.)	Spring Rate (lb./in.)	Compression Stroke* (in.)	Number of Convolutions	Effective Area (in^2)	Working Pressure * (PSI)
FC-1	0.250	0.248	0.15	0.740	0.0015	5.90	0.149	24	0.0292	290
FC-2	0.250	0.248	0.15	0.370	0.0015	11.82	0.070	12	0.0292	
FC-3	0.250	0.248	0.15	0.245	0.0015	17.73	0.045	8	0.0292	
FC-4	0.250	0.248	0.15	0.185	0.0015	23.63	0.032	6	0.0292	
FC-5	0.375	0.372	0.25	0.740	0.0018	8.15	0.194	24	0.0723	265
FC-6	0.375	0.372	0.25	0.550	0.0018	10.87	0.142	18	0.0723	
FC-7	0.375	0.372	0.25	0.370	0.0018	16.31	0.092	12	0.0723	
FC-8	0.375	0.372	0.25	0.305	0.0018	19.57	0.075	10	0.0723	
FC-9	0.500	0.495	0.36	0.740	0.0025	21.62	0.172	24	0.1382	410
FC-10	0.500	0.495	0.36	0.490	0.0025	32.44	0.112	16	0.1382	
FC-11	0.500	0.495	0.36	0.370	0.0025	43.25	0.082	12	0.1382	
FC-12	0.750	0.744	0.57	0.980	0.0030	30.73	0.208	21	0.3280	355
FC-13	0.750	0.744	0.57	0.730	0.0030	40.33	0.156	16	0.3280	
FC-14	0.750	0.744	0.57	0.540	0.0030	53.78	0.114	12	0.3280	
FC-15	1.000	0.994	0.74	1.230	0.0035	24.66	0.320	18	0.5678	230
FC-16	1.000	0.994	0.74	0.730	0.0035	44.70	0.169	10	0.5678	

*See Bellow Design Guide for definitions and limitations

About Servometer

Servometer, an MW Industries company, has been a trusted supplier and contract manufacturer to the OEM industry for more than 60 years. As a privately owned company, we take pride in developing the highest level of quality products from design, through production, to delivery. Servometer employs a unique patented manufacturing technology that ensures precision products with exceptional performance characteristics. Our products are specified in hundreds of applications across multiple industries including Aerospace, Military, Defense, Medical, Oil and Gas, Semiconductor and Instrumentation.

Our company practices lean manufacturing techniques and standards and recognizes the importance of ITAR, RoHs and DFARS compliance. Servometer is ISO 9001 certified.

Engineering Partner

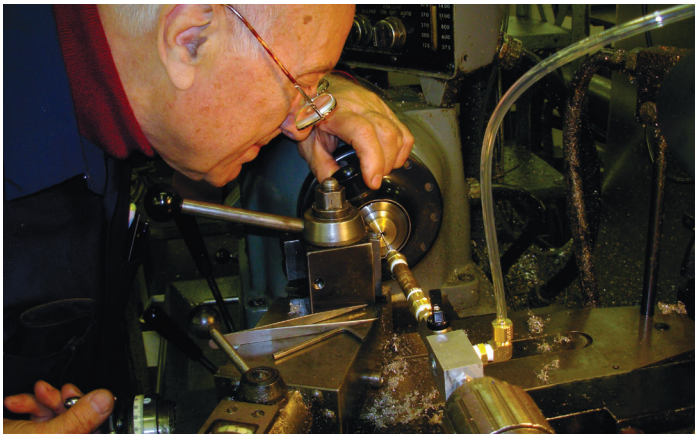
Rely on our team of engineers to operate as an extension of your organization. They will work with you to help select a standard part from our inventory or help modify a standard part to meet your needs. With thousands of designs at our fingertips we can borrow from the large volume of design ideas and match your requirements with a unique new bellows solution.

Whether you need one prototype quickly or one thousand pieces, we are able to adjust convolution lengths, material, plating thickness, spring rate and then test for function before production. Using this system of producing, trying and then modifying we are able to optimize the form and function of our bellows to fit your application needs.

Customer Service

Servometer is the approved supplier to leading OEM manufacturers around the world. Every product we manufacture is backed by our continuous customer support and a global sales presence in Europe, Asia and North America.

We offer both written and verbal quotes as requested and offer lower prices for higher usage orders on standard parts. We strive for on time or just in time delivery and will split shipments to suit your delivery requirements and help manage your inventory needs.



Committed to Product Quality

We are committed to maintaining the highest level of product standards from manufacturing through delivery. Our Quality Control department is “hands on”—inspecting and evaluating each and every part as required. The Quality Control engineers work closely with the Inspection Department personnel assuring that our raw materials and products pass our stringent performance and quality control tests. We operate by the principles of root cause and corrective action and in the true spirit of continuous improvement. We are committed to satisfying our customers’ expectations and requirements.

BellowsTech, an MW Industries Company

BellowsTech, an MW Industries company, is a premier manufacturer of high quality, dependable edge welded bellows and assemblies. Engineers in the aerospace, medical, semiconductor, UHV, and oil & gas industries rely on BellowsTech products for the highest cycle life, responsive design, wide material selection, and leak tight performance.

BellowsTech expert engineers partner with you to produce truly optimized designs for fast prototyping or full production runs. They can manufacture in all sizes, shapes, and material combinations to fit your unique applications.

With proprietary welding technology, in-house tooling and machining, and custom solutions, BellowsTech can supply a completed assembly with the best price to performance ratio in the industry. They excel at new designs with custom capabilities and short lead times and also offer repair and replacement services.

BellowsTech is ISO 9001 certified and dedicated to your overall satisfaction.

MW Components

About MW Components

MW Components is focused on accelerating the entire process of delivering custom, stock, and standard parts to virtually any volume and against demanding deadlines. We work to highly complex tolerances. We help simplify the management of any number of different components. And we take a no-compromise approach to quality. With MW Components, you can be sure you'll get the right part to the right specification when and where you need it.

MW Components. Whatever it takes.

MWComponents.com