the difference between

MW INDUSTRIES inc.
Bellows Solutions

THE DIFFERENCE BETWEEN:

Bellows Technologies

BELLOWS—flexible, spring-like, precision-engineered components—are used in pressure or volume compensation applications. They are also used as actuators, seals, feedthroughs, and more in industries including aerospace, semiconductor, medical, and industrial. The term "bellows" encompasses several unique technologies, each with its own performance characteristics, materials, and manufacturing techniques. Read on to learn the differences between electrodeposited, edge-welded, and hydroformed bellows.

Electrodeposited Bellows

Electrodeposited bellows are made by plating metal onto a substrate which is then removed to leave a thin-walled shell. The process starts by CNC machining a 6061 T6 aluminum billet to the inside dimensions of the final part. The bellows material—nickel, copper, or a nickel-copper alloy, along with optional gold or silver plating for environmental resistance and conductivity—is then electrodeposited onto the mandrel. The plated mandrel is trimmed to its final dimensions before the mandrel is removed by chemical leaching, creating the final pour. Secondary operations include performance testing and the addition of attachment provisions like flanges.

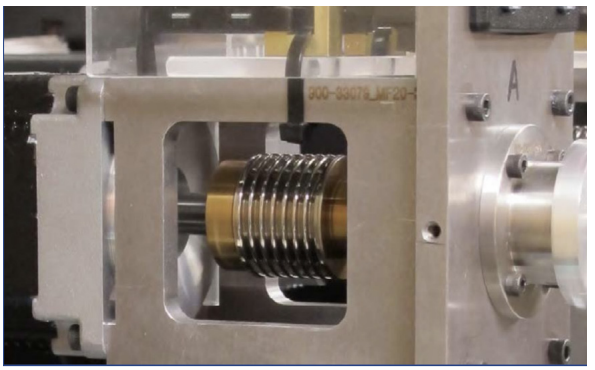
The resulting parts can have outer diameters (OD) of 0.020 in. to 9 in. and overall lengths up to 10 in. They have a typical compression stroke of around 35% of the convolution length, although it can reach upwards of 50% in some applications. The thin walls of electrodeposited bellows make them very flexible, vibration-resistant, and long-lasting. With the proper design, such bellows can have a theoretically infinite lifecycle, which is called out at one billion cycles.

Electrodeposited bellows have a standard leak rate of 1×10^{-6} cc of helium per sec at 1 atm, and rates as low as 1×10^{-9} cc of helium per sec at 1 atm are achievable for most bellows. These bellows can withstand maximum differential pressures up to 10,000 psi depending on bellows' diameter, stroke length, and desired cycle life.

These bellows are rated for temperatures up to 350°F, above which the nickel material may anneal or become brittle, resulting in a change of spring rate and performance ratings. In static applications, the electrodeposited bellows may be able to withstand temperatures up to 1,000°F. Although the lower end of these bellows' service temperature range is published as –423°F, engineers have successfully used them in as angled couplings in millikelvin research and to meter liquid helium at –452.2°F.

These characteristics have led to electrodeposited bellows' use in a variety of precision applications. Their vibration-resistant seamless construction makes them ideal for

Servometer's thin-walled electrodeposited bellows are available with diameters from 0.020" to 9" in diameter.



Servometer bellows can be used as an actuator within a pick-and-place system to allow movement of a semiconductor wafer from chamber to chamber and as a shaft seal on a shutter assembly.

temperature, pressure, and volumetric indication or actuation. One example is aneroid bellows, a type of assembly that has been fully evacuated and sealed with an internal vacuum. Aneroid bellows will then change length in response to changes in external atmospheric pressure. Such bellows are shorter at sea level than at varied elevations, a change used for fuel control, oxygen mask activation, and in-flight indicators.

Another use of bellows' pressure activation is as an accumulator that assures even fluid or gas flow with modulating pressures or that pumps gas or fluid to change the pressure in different systems. Such applications are found in the semiconductor industry, where different environments must be sealed from each other, and in the medical industry, where bellows may even be gold-plated for safe implantation within the body.

In other medical applications, electrodeposited bellows drive dosing pumps that require very high rotary transmission compliance, since the bellows' coupling does not store rotational information and input-to-output ratio is 1:1 with very low wind-up. These bellows can also form a flexible seal for small-diameter tubing for endoscopy and other instrumentation because they can transfer motion between environments while maintaining the pressure differential.

Another common application for electrodeposited bellows is within a pick-and-place system where vacuum drawn through the bellows is used to hold onto parts during transfer, and positive pressure delivered through the bellows aids in final positioning of the part.

BellowsTech manufactures custom edge-welded bellows for aerospace, military, and naval applications.

Edge-Welded Metal Bellows

Edge-welded bellows are noted for their long stroke length and variety of available materials. Engineers select from AM 350; 316, 321, and 347 stainless steel; titanium grade 2; Haynes 242; Hastelloy C276; Inconel 600, 625, and 718; and aluminum. Material selection depends on performance, corrosion resistance, and temperature requirements. Depending on the material, these bellows can withstand temperatures between –425°F and 1,500°F.

Manufacturing of these bellows starts with the forming and stamping of metal diaphragms. The inside diameters of the diaphragms are first welded together to create convolutions. Then the outer diameters of alternate diaphragms are welded together to form the bellows. Finally, fittings are welded on, and the parts are tested before the parts continue to their next assembly step.

Completed bellows are measured for dimensional tolerance. Edge-welded bellows' ODs range from 0.358 in. to 26 in. with lengths up to 96 in. per section. Standard bellows' material thicknesses range from 0.002 in. to 0.010 in.

Mass spectrometry leak-rate tests on edge-welded bellows generally return rates from 1×10^{-5} to 1×10^{-9} cc of helium per sec at 1 atm, equivalent to approximately 1 cc every 32 years. Smaller-diameter designs withstand up to 2,500 psi differential pressure, and oil-filled designs have reached 15,000 psi maximum pressure.

Edge-welded bellows have spring rates of 1 lbf/in. or less depending on their material. Engineers often choose them for their ability to stroke as long as their free length—typically 25% maximum in extension and 75% in compression—depending on material and heat treatment. Well-designed edge-welded bellows work for up to 3 million cycles and beyond.

Ameriflex products include hydroformed bellows, braided flex, lines, and machined parts.

Like electrodeposited bellows, edge-welded bellows are found in many industries where they act as accumulators, reservoirs, aneroids, mechanical seals, couplings, and actuators. A few examples are actuators to prevent cavitation and pressure spikes in the cooling systems for avionics; pressure-balanced bellows in series that properly pressurize welds in a gas lift device; shaft-seal bellows that actuate doors and gates in semiconductor equipment under vacuum; and pressure-isolation, pulse-suppression bellows in small dialysis machines.

Hydroformed Bellows

Engineers often choose hydroformed bellows because they can be made in large quantities while maintaining thin walls and tight tolerances. This makes them some of the most economical bellows on the market.

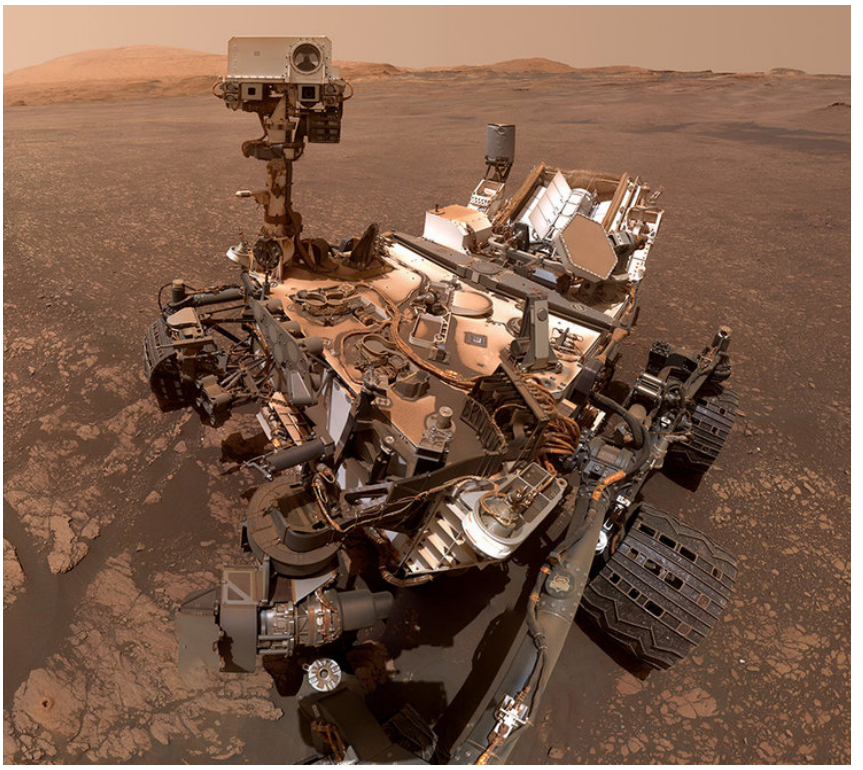
Like edge-welded bellows, hydroformed bellows can also be made from a variety of materials, including nickel alloys, copper, brass, phosphorus bronze, and titanium. Where basic corrosion protection is needed, 321 and 316L stainless steel grades are a good choice. For higher temperatures, engineers choose Inconel 600, 625, and 718 while Hastelloy C22 and C276 provide protection against extremely corrosive environments. Monel is another option, noted for its performance in seawater.

Hydroformed bellows start as metal tubes created from sheet metal of the desired thickness. Then the tube is clamped within a die with the desired convolution geometry, and high-pressure water is pumped in to force the tube to assume the shape of the die. Once the part is out of the die, the final convolution pitch is set by rolling or segmenting. Finally, the ends of the bellows are finished and welded to end connections.

This process produces material thicknesses between 0.002 in. and 0.10 in. with a tolerance of ±0.015 in. ODs can be as small as 0.25 in.; ODs as large as 43 in. have been created, with 50-in. ODs theoretically possible. Hydroformed bellows can be 3 in. to 200 ft long, depending on inner diameter (ID) design and material wall thickness.

A hydroformed bellows can operate to about 15% of its convoluted portion, also known as its live length, in compression and 10% in extension. Properly designed, a hydroformed bellows can achieve a lifecycle of 1 million to 30 million cycles.

These bellows are leak-checked to a standard of 1 x 10^{-9} cc of helium per sec at 1 atm. They can withstand maximum differential pressures up to



The Mars Rover Curiosity uses an Ameriflex fluid loop as part of its thermal control system.

3,500 psi, depending on diameter, wall thickness of the material, and application requirements such as stroke and cycle life.

The temperature capabilities of hydroformed bellows depend on the material from which they are made. For example, stainless steel bellows are rated for 900°F above which annealing, or embrittlement, could change their spring rate and performance. Inconel, however, can withstand temperatures between –420°F and 2,000°F.

These high temperature capabilities make hydroformed bellows a good choice for performance applications like IndyCar and NASCAR exhaust manifolds where slip-joint bellows withstand high heat and vibration. OEMs choose hydroformed bellows for applications within semiconductor processing equipment, including those that control pressure, vacuum, or motion. The tight tolerances and economical nature of hydroformed bellows make them particularly attractive in these applications.

Conclusion

Bellows are found in applications ranging from pressure and vacuum control to flexible sealing to feedthroughs to actuation, each with its own performance requirements. Engineers can choose from electrodeposited, edge-welded, and hydroformed bellows designs, each with its own range of materials, dimensions, temperature capabilities, and performance characteristics. In addition to the overview provided here, the websites and application engineers of bellows manufacturers like Ameriflex, BellowsTech, and Servometer can be a valuable resource for an engineer selecting a bellows design for his or her application.

MW INDUSTRIES FAMILY OF BELLOWS MANUFACTURING COMPANIES

ameriflex.net

AMERIFLEX, INC.®, Corona, CA, combines exceptional engineering, state-of-the-art manufacturing, extremely close dimensional tolerances, and over 30 years of industry experience to deliver top quality hydroformed metal bellows for any application. Since 1981, we have been a wholesale manufacturer of electronic component parts addressing the semiconductor, aerospace, lab and university, power generation, and many other industries. In addition to our metal bellows, we also manufacture expansion joints, convoluted tubing, bellows assemblies, and more, to match your exact specifications.

bellowstech.com

BELLOWSTECH®, Ormond Beach, FL, is a premier U.S. manufacturer of edge-welded metal bellows and assemblies, encompassing a wide array of alloys and dimensional configurations. BellowsTech has been serving the aerospace, medical device, cryogenic, semiconductor, solar, and oil and gas industries for 19 years. BellowsTech products are designed for high cycle life, low leak rates, and stroke 90% of their free length. Edge-welded bellows are offered in various materials, sizes, and configurations, which can be customized with various flanges and end caps to more easily accommodate the application requirements.

servometer.com

SERVOMETER®, Cedar Grove, NJ, is a preeminent manufacturer of quality-crafted metal bellows, bellows couplings, electrical contact springs and rigid electroforms using electrodepostion technology. Our electroformed bellows serve in hundreds of mechanical and electrical components and OEM products worldwide, from aerospace to semiconductor, and are trusted by engineers across the globe for their exceptional performance and reliability. Since 1957, our custom-engineered parts have made “the impossible – possible,” helping solve the most challenging motion control applications.

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