MW Components

design FAQs

How to Use Metal Bellows for Different Applications

Frequently Asked Questions

Q: What is a metal bellows?

A: Bellows are flexible seals. However, when made from metal the bellows will also exhibit a predictable spring rate due to the elastic property of the material of construction unlike leather, cloth, or plastic/rubber bellows. Hence, metal bellows are essentially "sealed springs." Specifically, precision engineered metal bellows convert pressure, mechanical, vacuum, and temperature changes into linear or rotational motion. They also operate in flexible electronic contact applications. Metal bellows are used in a diverse range of applications including industrial automation, aerospace products, medical devices, solar power, and oil-and-gas services.

Q: How are they manufactured?

A: There are several methods in which metal bellows can be manufactured. Electrodeposited or electroformed bellows are produced by plating metal onto a precision-machined bellows-shaped form or aluminum mandrel. The metal is most often nickel but can be a combination of nickel, copper, gold, and silver. The edges are trimmed and the mandrel is chemically dissolved. The electrodeposition process allows for precise controls of the bellows wall thickness. They can be as thin as 0.0002 inches with the smallest possible diameters up to 0.020 inches (5 mm). Electrodeposited bellows are compressible up to 45% of their free length, with a high cycle life of 100,000, highly flexible, and are leak-resistant.

Edge-welded bellows can be made from several different materials. These materials include stainless steel, Inconel, titanium, and many others.

They are produced by welding metal diaphragms that have been stamped from strip material, stacked together, and welded (inner diameter to inner diameter, then outer diameter to outer diameter) using plasma, laser, arc, or electron-beam welding. The edgewelded bellows can be manufactured in diameters from 3/8 inches up to 22 inches. The wall thickness can range from 0.002 to 0.012 inches. Some key attributes to edge-welded bellows are that the leakage is low, they have a compression of up to 90% of free length, a wide operating temperature range of -420°F to 1500°F, high pressure capability of up to 1,000 psi, a high cycle life, corrosion-resistance, and an all-metal construction. Other methods of manufacturing bellows involve mechanically formed and rolled and hydroformed bellows.

Q: What are typical applications of metal bellows?

A: Metal bellows are used in several mechanical and hydraulic applications. Mechanical actuation uses bellows by filling them with a known fluid that will compress or extend based on temperature changes. The fluid expansion will occur at a predictable response rate and the bellows can be used to provide precision positioning inside a machine assembly. Similar to thermal activation, a pressure change can be used to control compression or expansion of the bellows to perform a mechanical actuation. Common applications for pressure-based bellows are mechanical devices that see changes in altitude or pressure like aviation devices.

One of the interesting uses of bellows is for rotational indication. Due to their lightweight and rotational rigidity while remaining flexible along their primary axis, bellows that are joined at their ends to shafts that are misaligned or subject to linear, radial, or angular change can be used as a coupling or as a rotational indicator. The shape of the bellows allows for efficient transfer of rotational energy without issues of backlash as found in couplings. Encoders use these types of bellows since they depend on rotational accuracy.

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Q: What are typical applications of metal bellows? ***continued***

Metal bellows are also used in hydraulic applications such as positive displacement pumps, valve seals, and volume compensation and fluid power applications. Metal bellows prevent leakage without requiring O-rings. When used as a flexible member in pumps, they provide hermetical seals without frictional losses of power, providing higher pressure efficiency. Lastly, they can be used as traditional mechanical seals on an actuator to prevent contamination from scoring the shaft.

Q: What type of metals work best for specific environments?

A: For most metal bellows, nickel is the preferred material. Copper is preferable for low magnetic permeability and conductivity depending on the application. For semiconductor, vacuum, or research science environments (i.e. medical devices) stainless steel is typically preferred and if low magnetic permeability is required 316 stainless steel is the go to choice. Aerospace and medical environments use stainless steel typically but titanium may be preferred depending on the application such as low weight requirements, chemical resistance, or implantable devices. Most bellows are lightweight due to the thin wall thickness, however, connecting them to titanium hubs/ flanges is typically not preferred for a welded bellows unless the bellows is also constructed from titanium. Lastly, oil and gas applications typically require stainless steel or Inconel for enhanced resistance to chemicals such as hydrogen sulfide if required an enhanced chemical resistance to hydrogen sulfide, Inconel is preferred.

Q: What factors should engineers consider when working with metal bellows?

A: When designing or choosing metal bellows, engineers should keep the following characteristics in mind:

Spring rate: Do your metal bellows have the right flexibility?

Leak rate: Do they maintain the appropriate fluid amount after a certain number of cycles?

Effective area: Is the bellow sized appropriately for it to behave like a pressure based piston?

Internal and external pressure (static and dynamic): Does the bellows behave appropriately for the pressure differences?

Stroke requirements:

Compression/extension, bending, and offset need for actuation.

Chemical resistance: Is the material for the bellows appropriate for the environment if exposed to hazardous chemicals or environments?

Temperature: Is the operating temperature range appropriate for the metal bellows?

Cycle life: Metal will eventually fatigue and high cycle life may be achieved. Is the metal bellows chosen the correct one for the application life?

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