Spring-energized metal seals help protect equipment

Technology offers benefits over traditional sealing systems.

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Spring-energized metal seals provide numerous advantages in oil and gas applications, including but not limited to MWD and LWD tools, couplings, subsea compressors, enclosures/vessels, christmas trees, electronic submersible pumps and flowmeters. Extreme operating pressures and temperatures, together with more difficult resource recovery, zero tolerance for failure and environmental concerns, are placing unprecedented demands on this equipment.

Traditionally this industry has used solid machined seals that provide high compression loads but lack resilience. They also tend to have relatively high rates of leakage over time as flanges deteriorate. Recent advances in metal seal technology provide controlled compression, high resilience and reduced leakage.

Background

Industry once used elastomeric seals extensively but discovered they work only within a certain temperature range, becoming brittle in cold and tending to flow at warmer temperatures. At elevated temperatures and pressures, seals can undergo a phenomenon called explosive decompression, extruding out of a flange and resulting in catastrophic failure of the seal. The porosity of elastomeric seals makes them subject to increased leakage over time.

In addition, they are limited in terms of chemical compatibility and have a tendency to degrade with age.

FIGURE 1. Metal C-ring seals provide greater resilience and require less load than ring joint flange seals but are largely restricted to higher pressure applications. (Source: Technetics Group)

Metal seals, by contrast, offer greater chemical compatibility and longevity. They have no porosity problems and hold up better to aggressive media such as hydrogen sulfide. Metal seals have long been used by industry. Some companies even have their own sealing departments creating custom-machined metal and elastomeric seals to meet their specific requirements.

Among the machined metal seals these in-house departments produce are ring joint flange seals. These seals are inserted into trapezoidal-shaped grooves that allow them to tolerate bidirectional pressures. However, their lack of resiliency and plastic deformation results in extremely high seating loads.

Evolution of metal sealing

First used by the nuclear industry, metal O-rings were among the earliest types of resilient metal-to-metal seals. These were superseded by metal C-rings (Figure 1). Developed for the aerospace industry for weight reduction, these C-ring seals are more resilient than O-rings and require less load, allowing the use of smaller flanges and fewer bolts. Energized by higher pressures, C-rings are capable of achieving good sealing levels. Pressure-energized seals of this nature do not perform as well at lower pressures due to low seating loads and contact stress. In many cases, a silver coating can be used to improve sealing performance provided there is sufficient load to achieve plastic deformation.

Large-diameter spring-energized metal seals were originally developed for the French nuclear power industry. Unlike pressure-energized seals, they function by plastic deformation of a metallic jacket with greater ductility than the flange materials. This deformation occurs between the sealing face of a flange and an elastic core composed of a close-wound helical spring.

Spring-energized seals look similar to spring-energized C-rings but have a soft outer liner and open away from pressure (Figure 2). By contrast, spring-energized C-rings with plating have a hard outer layer and open toward the pressure.

The spring provides a specific resistance to compression, during which the pressure forces the jacket to yield, filling any machined finishes and imperfections on the face of a flange by making positive contact with it. Each coil of the helical spring acts independently, allowing the seal to conform to any surface irregularities on the flange.

Highly engineered with respect to pressure and leakage parameters, spring-energized seals are preferable not only to elastomeric seals but to plated metal C-rings as well. The soft liner/jacketing of these seals is typically three to five times thicker than such plating, providing more range to fill flange imperfections and rougher machined surfaces while eliminating the potential adhesion problems platings have at elevated temperatures.

Oil and gas applications

As noted, spring-energized metal seals are used extensively by the oil and gas industry. In North Sea operations they are used on the flanges of all equipment, where the seals provide longevity in the face of extreme temperatures and pressures. They also are used to protect subsea and downhole electronics that measure, log and transmit data while drilling. The seals can withstand typical operating temperatures from cryogenic to more than 538 C (1,000 F) and are subjected to pressures of up to 35,000 psi in a highly corrosive environment.

Another application for these seals is subsea valving systems, or christmas trees, where they prevent pressures of up to 15,000 psi from blowing out pipes and creating leaks. These also eliminate the potential for explosive decompression, which results in environmental issues and loss of production.

Valves are critical to subsea systems, yet some producers still use polytetrafluoroethylene and other elastomeric materials, which expand and contract drastically with changes in temperature and pose problems above 177 C (350 F). A better solution is to use spring-energized metal seals, which have the resilience to tolerate most operating temperature gradients.

Spring-energized seals are designed on a case-by-case basis. Like most metal seals, they have been used primarily in static applications, where movement due to thermal expansion, pressure cycling and flange deflection is not an issue. Due to the nature of recent oil and gas activity, traditional static applications are few and far between. It is not uncommon to see spring-energized seals in standard dynamic applications such as globe, ball and butterfly valves, where they serve as seat-sealing components. Designs of this type take time to develop.

Notwithstanding the difficulty of understanding flange dynamics and simulating actual operating conditions, semidynamic seals are continuously under development to accommodate greater flange movement. Helpful in this regard is a mnemonic acronym, STAMPS, that defines the basic criteria of seal design and selection, namely size, temperature, application, media, pressure and speed.

Spring-energized metal seals can be designed for a 30-year life while providing low leak rates with zero visible leakage over time. The seals can be manufactured using materials that meet the requirements of the U.S. National Association of Corrosion Engineers.

Another critical condition in oil and gas equipment is abrupt change in the axial direction of pressure, which can cause flanges, piping and seals to flex and shuttle. This can be an issue for some spring-energized seals, which must be specially designed to tolerate extreme bidirectional on/off pressures. It should be noted that bidirectional sealing capability is not a requirement for radial flange seal configurations.

Spring-energized metal seals are the sealing solution of choice for many oil and gas industry applications. The seals not only provide greater chemical compatibility and longevity than elastomeric seals but also the structural integrity that comes from metal-to-metal contact. In addition, they can offer more resilience and lower compressive loads than other types of metal seals.

Capable of handling extremes of temperature and pressure, the corrosion-resistant seals are particularly well suited for subsea applications, where they protect critical equipment and systems from harsh operating conditions. Their ability to absorb the flexing that accompanies temperature and pressure changes also protects piping systems in which the seals are installed.

Spring-energized metal seals meet both U.S. and other countries' industry standards, helping assure compliance with applicable safety and environmental regulations. New versions are being developed for semidynamic and bidirectional applications, further expanding the capabilities of metal seals. E&P

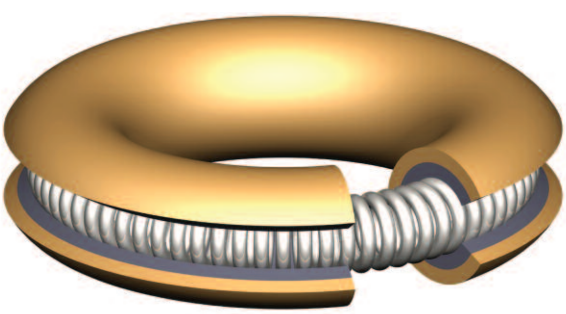

FIGURE 2. Spring-energized metal seals are the sealing solution of choice for many oil and gas applications. (Source: Technetics Group)