# The extreme edge of sealing—engineered seals for radical conditions

Seals for extreme environments, from jet engines to Antarctic winters, need materials and designs that can take the abuse. Radical temperatures, hostile elements, one-of-a-kind applications, and unique designs are all in a day's work for seal designers.

What do an Antarctic loading crane, a jet engine, and a solar array have in common? Sealing is a critical component that keeps these devices working.

To address these applications' requirements, designers continually advance sealing materials and designs. Sealing engineers need a deep appreciation of how critical even the smallest component—such as an O-ring—is to an application. Four industries driving emerging material and application trends for extreme applications are aerospace, fluid power, semiconductors, and renewable energy.

## The critical take-off

Aircraft depend on the security of their seals, so it is critical for aircraft engineers to use materials and designs that provide resilience in demanding elements.

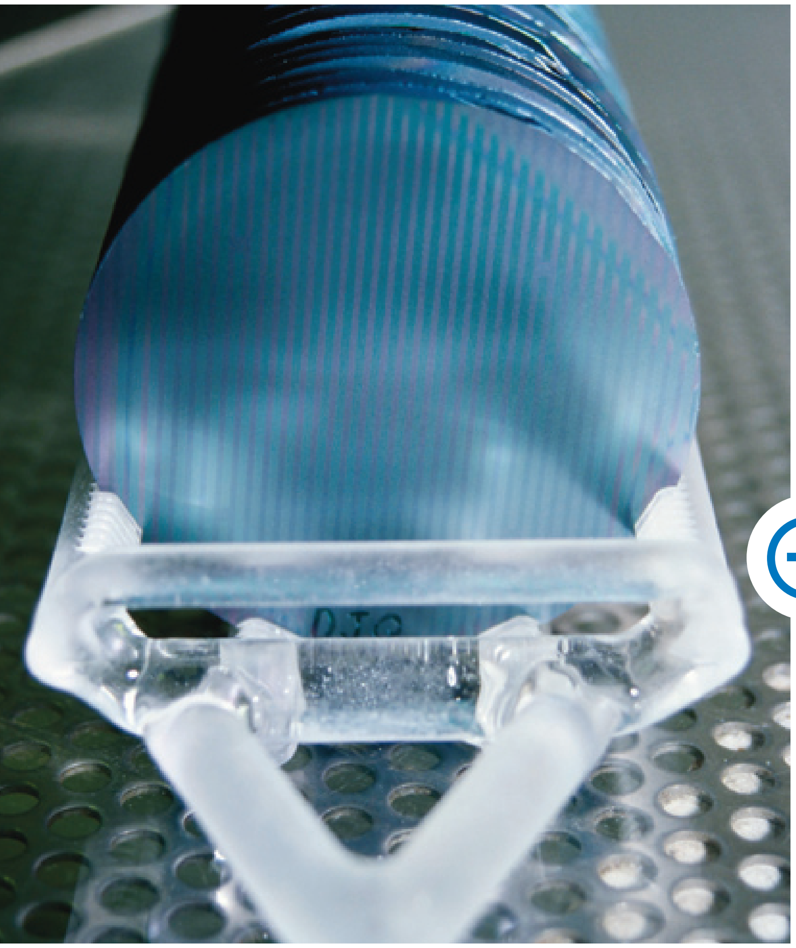
Extreme heat and cold and radical temperature fluctuations are just some of the hostile conditions of special concern in the aerospace market.

To combat these challenges, many sealing manufacturers develop custom components and systems to address a given application's unique design requirements.

For example, modern jet engines are expected to go more than 10,000 flight hours at extreme exhaust-gas temperatures before a major overhaul. Consequently, designers expect the surrounding components to also endure high temperatures for extended time frames.

Perfluoroelastomer (FFKM) compounds are among the few materials that meet the challenge. Their resilience makes them an excellent choice for demanding aerospace environments that not only need protection against extreme temperatures, but must also seal tightly and resist aggressive chemicals.

One such FFKM material is Simriz 498 from Simrit. The black compound's proprietary cross-linking system gives it long-term resiliency and resistance to compression set, aggressive chemicals (including nitric acid and amines), and temperatures above 300°C.



Semiconductor wafers are processed in sealed chambers where door seals must withstand aggressive chemicals and high temperatures.

## In brief

- Aerospace applications may call for seals that are fireproof, resist fluids, and work over a large temperature range
- Viscoelastic properties help elastomeric seals work in subfreezing temperatures
- Semiconductor and alternative energy applications require low-maintenance seals that resist chemicals and weather

Any questions or suggestions?
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A major regional jet manufacturer recently switched to Simriz 498 to reduce sealing-related warranty issues. A combination of aggressive fluids (such as jet turbine lubricants) and long-term exposure to high temperatures caused the original seals to fail before their 30,000-hour expected life. Lab testing duplicating the service conditions confirmed that Simriz 498 would meet or exceed the 30,000-hour requirement.

Away from fuel sources, designers turn to seals of ethylene-propylene-diene, class M rubber (EPDM) noted for its resistance to aviation hydraulic fluids. With good low-temperature capabilities and maximum compression set, Simrit's E454 and E458 (materials that meet NAS 1613 Revision 5 specifications) have also been used by major aircraft component manufacturers.

## When safety means fireproof

Given all the flammable fluids in aviation, many aerospace applications require fireproof materials and engineers may then turn to special silicones.

According to the FAA, a firewall material is fireproof if it can withstand 2,000°F for 15 minutes without any ignition away from the heat source. A North American very-light-jet (VLJ) manufacturer wanted a single material—as opposed to the industry standard silicone-ceramic fabric composite—that could provide fireproof seals for its aircraft engine firewalls. Simrit engineers developed a fireproof silicone that saved the company about $150,000 per year. Both the new material and the product are FAA- and EASA-approved for use as fireproof and fluid-susceptible materials in aircraft.

Additionally, the material also handles temperatures as low as –55°C, so it works at any altitude the VLJ flies.

## Resisting heat and cold

While some new innovations are generated from specific customer needs, seal engineers must also anticipate industry trends. One up-and-coming trend is the drive toward smaller hydraulic packages that see greater pressures and hotter temperatures, often due to new environmental standards. Such systems demand better seals, and one way hydraulics designers address future sealing challenges is to use a single seal that meets a range of geometric and operational requirements.

One such example comes from Simrit's modular rod-sealing system. By using standardized configurations to mount the sealing system and mix-and-match design and material combinations, Simrit engineers ensured seals could withstand temperatures of 100°, 110°, or 120°C, pressures up to 42 MPa, and resist fluid and chemical contact. Seal materials include Disogrin 9250 urethane, AU U641 urethane, A505 nitrile butadiene rubber, and NOK UH05 combined with G928 hydrogenated nitrile butadiene rubber. The modular design helps engineers meet current and future industry requirements while staying within price-performance requirements.

Cold temperature can cause sealing problems, too, especially at extreme temperatures like those at the South Pole.

A loading crane in the Antarctic was experiencing oil leaks in hydraulic cylinders for the boom and extension arm. Although the crane was only in use during the summer, its operating temperature is between –20°C and –40°C. It stands frozen under ice and snow for the remainder of the year.

Seals with a new low-temperature polyurethane stop oil leakage and boost the crane's productivity. The material, called 92 AU 21100, has viscoelastic behavior that lets it stay flexible over a wide range of temperatures. It has elastic behavior at temperatures as low as –50°C but resists extrusion at high pressures and temperatures up to 100°C. Operators have reported no leaks after seal installation in 2006.

## Semiconductor process sealing

Instead of meteorologic concerns, economics and quality are driving the semiconductor industry. For seal engineers, the challenge is maintaining the precision and consistency semiconductors require in the face of extreme fabrication environments that include