

Omniseal Solutions' Cryogenic Sealing Technology: Boosting Space Launch Vehicle Performance

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insights from industry

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In this interview, AZoMaterials speaks with Kha Le about advanced sealing solutions and high-performance materials that are enabling greater reliability and efficiency in space launch vehicles. Discover how precision-engineered components are driving innovation in the aerospace industry.

What are the main challenges of sealing solutions in space launch vehicles?

Sealing components in space launch vehicles face extreme challenges due to the harsh conditions encountered during launch, operation, and re-entry. These include ultra-high pressures, cryogenic temperatures, rapid thermal cycling, vibration, and mechanical shocks.

Additionally, handling aggressive chemicals, such as cryogenic and hypergolic propellants, adds complexity to sealing system requirements.

Conventional and basic seals often fail in these environments, as metals and polymers can become brittle or lose elasticity, leading to leakage and potential mission-critical failures. The following are the critical challenges space companies face and the advanced solutions they use to ensure successful missions.

1. Extreme Temperatures and Thermal Cycling

- **Cryogenic Challenges:** Materials tend to lose flexibility and become brittle at cryogenic temperatures, compromising sealing integrity.

- **Thermal Cycling:** Rapid shifts from cryogenic to high temperatures during launch and re-entry stress the seals, causing potential material fatigue and dimensional instability.

2. Pressure Fluctuations and Mechanical Stresses

- **High Pressures:** The sealing solution must withstand extreme pressures generated by propellant systems and flight dynamics.
- **Mechanical Loads:** Vibrations and shocks during liftoff and flight place additional mechanical stress on seals, demanding exceptional resilience.

3. Material Wear and Chemical Resistance

- Exposure to aggressive chemicals and prolonged use exacerbate wear, requiring seals with superior friction and wear control properties.

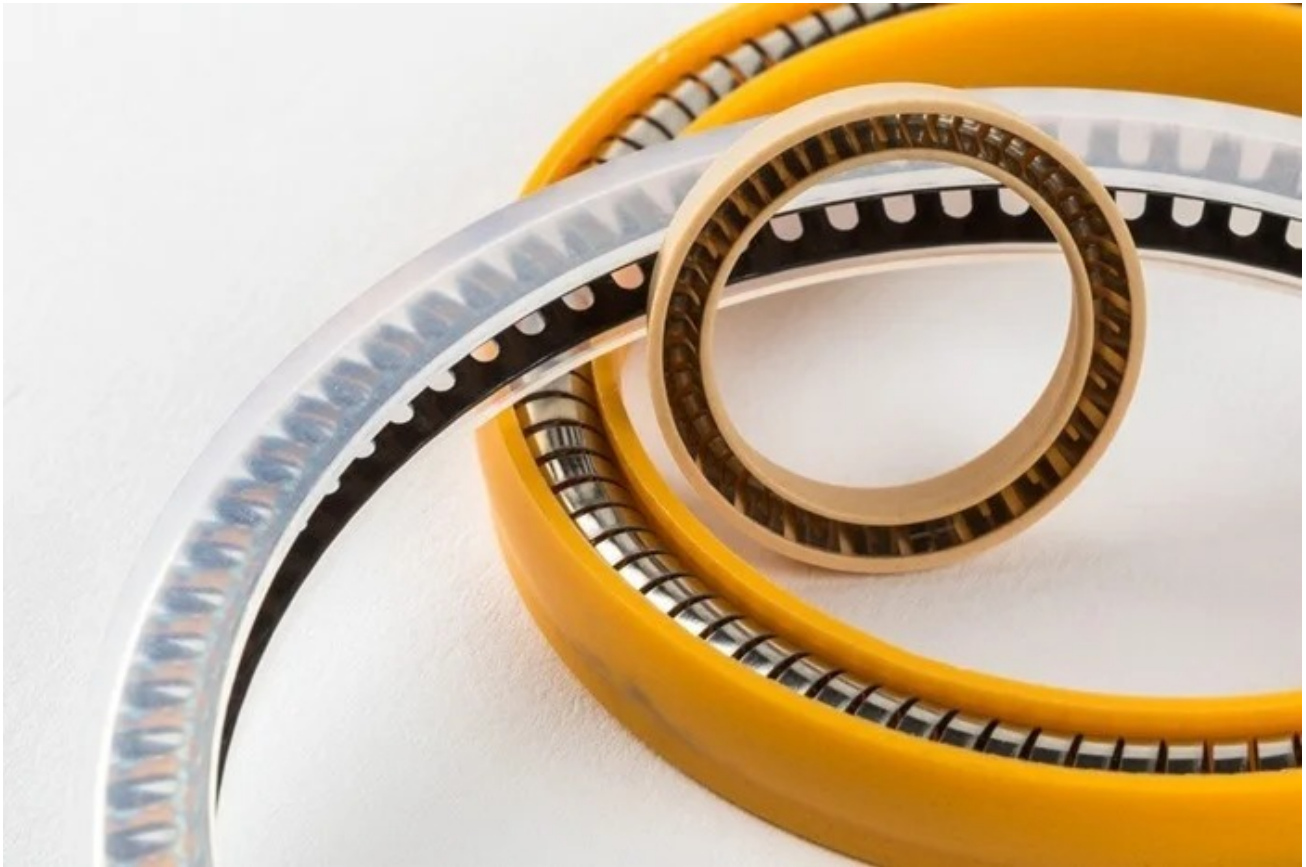
What solutions does Omniseal Solutions have in place to help tackle these challenges?

To solve these key challenges, Omniseal Solutions developed polymer, spring-energized seals, which are precision-engineered to ensure performance and reliability in extreme environments. These seals combine low-friction polymer materials (e.g., PTFE) with an internal metal spring that applies consistent radial or axial force against sealing surfaces, addressing issues like material wear, thermal expansion, and pressure variability. To ensure optimal sealing performance across a wide range of extreme conditions, advanced seal designs and spring-energized technologies are employed. Two key innovations include:

- **Unique Spring Designs:** These springs are designed for dynamic and static conditions, maintaining seal integrity even under extreme pressure and temperature fluctuations. Design options such as V-springs, canted coil springs, and helical coil springs are selected based on specific application requirements, i.e., high pressures, low temperatures, cryogenic, or vacuum.
- **Omniseal[®] RACO[®] Spring-Energized Seals:** Optimized for cryogenic static face seal applications, these U-shaped seals provide high sealing contact force and are resistant to shrinkage at cryogenic temperatures. This sealing solution consists of a high-performance polymer jacket energized by a corrosion-resistant, heavy-duty RACO[®] spring, which delivers exceptional spring force along the sealing lip.

By providing a robust, leak reduction barrier, Omniseal[®] spring-energized seals ensure the structural integrity of spacecraft and ground support equipment throughout their lifecycle. Their ability to handle the mechanical stresses, thermal extremes, and aggressive

chemicals encountered in space missions makes them indispensable for modern launch vehicles.



Omniseal[®] Spring-Energized Seals. Image Credit: Omniseal Solutions



Omniseal[®] RACO[®] Spring-Energized Seals. Image Credit: Omniseal Solutions

How has Omniseal Solutions innovated in cryogenic sealing technology?

Omniseal Solutions has a historical pedigree and legacy in advancing cryogenic sealing technology, rooted in the challenges of the US space race.

During this pivotal era in the 1950s and 1960s, Omniseal® spring-energized seals emerged as critical components to prevent leakage and catastrophic failure in launch vehicles, which were causing millions of dollars in loss to key space companies such as Aerojet General, North American Rocketdyne, and Lockheed. These seals were custom-designed to withstand cryogenic temperatures and high-pressure conditions with exceptional resilience—technological feats that revolutionized sealing reliability in extreme environments.

A notable breakthrough was the Omniseal® RACO® spring-energized seals, developed by Roy Creath, a sealing pioneer from Southern California. Its unique U-shaped spring design enables robust sealing performance under the severe temperature and pressure fluctuations typical of space launch vehicles and satellite applications. The ingenuity behind this engineered design ensured that spacecraft systems remained operational and secure even under the harshest conditions.

Today, Omniseal Solutions continues to support its space customers through advancements in cryogenic and high-performance sealing technologies. Our dedicated teams of engineers and R&D experts are constantly innovating to address the evolving demands of the space industry: lighter materials, chemical exposure, wear resistance and more high-stress conditions. Combining materials science experience with advanced engineering principles, we can manufacture sealing solutions that uphold the structural integrity of critical aerospace systems in the most extreme environments.

If you're curious about how our sealing technology got its start, check out "[The Omniseal® Origin - Our Race To Space](#)." This video shares the story of how our engineers took on tough sealing and leakage challenges during the space race—coming up with solutions like helically wound springs, PTFE-jacketed seals, and the Omniseal® RACO® spring-energized seals designed for cryogenic environments. That same drive to solve complex problems still fuels our work today, helping our space partners push the limits of exploration.

What factors contribute to the reliability of Omniseal Solutions' sealing systems?

The reliability of Omniseal Solutions' sealing systems, such as the Omniseal® RACO® spring-energized seals, stems from their precision engineering and ability to perform under extreme conditions characteristic of high-demand aerospace applications. Key factors include:

1. Innovative Spring-Energized Design

- The U-shaped spring design, combined with a corrosion-resistant RACO[®] metal part spring, provides consistent, high axial force along the sealing lip.
- This design compensates for thermal expansion, contraction, and material wear, ensuring a low leakage seal even under severe thermal cycling and pressure variations.

2. Exceptional Material and Surface Engineering

- Constructed from low-friction, high-performance polymers (e.g., PTFE), these seals excel in cryogenic and high-vacuum environments where conventional materials and elastomer seals fail. The specific recipe of the jacket material is tailored to the application parameters and specifications.
- The seals are custom engineered to ensure mating-surface compatibility and with an optimized surface finish to enhance sealing effectiveness, particularly in applications requiring large diameters and exceptional smoothness.

3. Adaptability to Extreme Conditions

- Omniseal[®] RACO[®] spring-energized seals maintain functionality in cryogenic temperatures and high-vacuum environments, where risks of leakage and material brittleness are most acute.

Additionally, could you highlight other key performance advantages that these solutions offer in such high-demand applications?

Beyond reliability, Omniseal[®] RACO[®] spring-energized seals offer a range of technology advantages that enhance their suitability for aerospace and other critical applications:

1. Compact, Lightweight Design

- The polymer seals utilize a compact design based on the cantilever beam principle, eliminating the need for heavy flanges or excessive bolts. This contributes to reduced hardware weight and simplified assembly without compromising strength or durability.

2. Cost-Effectiveness

- By minimizing the complexity of surrounding hardware and extending operational life through wear resistance, these seals deliver significant cost

savings over the system's lifecycle.

3. Scalability for Diverse Applications

- Available in large sizes and tailored configurations, Omniseal® RACO® spring-energized seals meet the diverse demands of launch vehicles, satellites, and ground support equipment.

4. High Resilience and Robustness

- The U-shaped spring design offers resilience against pressure fluctuations, vibrations, and thermal cycling, ensuring consistent performance throughout challenging missions.

Sealing requirements for launch vehicles, satellites, and other space applications are becoming increasingly challenging as we venture further into space with lunar and Martian missions, encountering vacuum environments, abrasive contaminants, and operational extremes. By combining advanced material science, precision engineering, and innovative design, Omniseal Solutions can design and deliver sealing technologies that not only withstand extreme conditions but also optimize performance and cost-efficiency.

As a proven and trusted partner in aerospace and other demanding industries for over six decades, we are excited to venture further into the world and universe and solve the most extreme environments.

About Kha Le

Kha Le is a Business Sales Manager for the space industry at Omniseal Solutions, bringing 25 years of experience in sealing solutions, including 20 years with the Saint-Gobain Group — recognized as one of the world's 100 most innovative companies. With a decade-long background in engineering and design, he possesses deep technical expertise in space and cryogenic applications. His extensive knowledge of high-performance sealing and composite solutions enables him to support mission-critical systems, ensuring reliability in extreme environments. Through his work, Kha plays a key role in advancing sealing and material technologies for the space industry, reinforcing Omniseal Solutions' commitment to collaborative innovation and precision, custom engineering.





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Omniseal Solutions is an engineering leader with over 65 years of global history and longevity, relentlessly dedicated to the design and manufacture of precision sealing and wear control solutions that protect critical applications in space, aviation, hydrogen, nuclear, life science and industrial extreme environments.

We are passionately driven to push *Beyond the Boundaries of Possible*; going beyond is what our team is known for! Customers trust Omniseal Solutions to swiftly resolve seemingly insoluble engineering and technology challenges that are extremely difficult, rapidly changing, unpredictable or not the norm.

With 17 manufacturing sites in 10 countries, we are not only global but also local to provide rapid response to customers and the communities they serve. We focus on collaboration to make positive changes - sharing experience and ideas to build unique solutions - to go beyond together.

BEYOND

the boundaries of possible