Solved and Sealed

Custom Sealing Solutions for Every Application

Apple Rubber

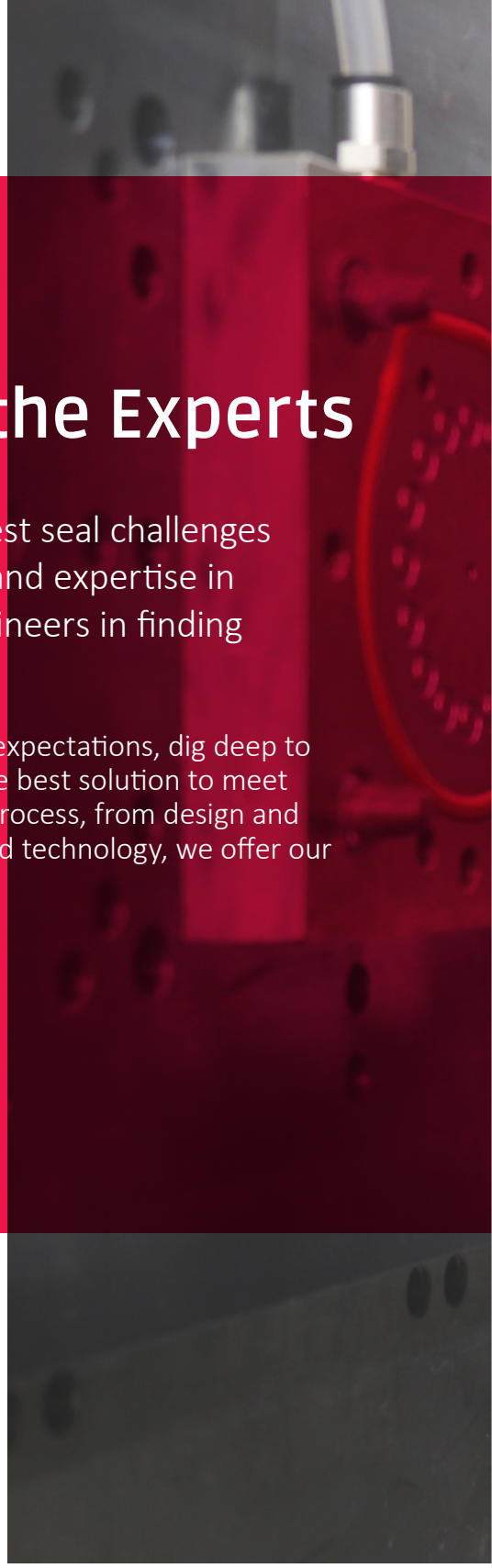
applerubber.com

Custom Seals Designed by the Experts

Apple Rubber engineers have solved some of the toughest seal challenges in a variety of industries. Our wide range of experience and expertise in custom engineered sealing solutions have aided our engineers in finding the right seal for every application.

Our engineers always put the customer first. We aim high to exceed expectations, dig deep to provide practical alternatives, and go beyond the seal itself to find the best solution to meet your needs. We will work with you at every stage of the production process, from design and prototyping through to production. Combining our skills and advanced technology, we offer our customers unparalleled solutions and expertise.

When you have a sealing challenge, Apple Rubber is ready to help.



How Are Your Seals Affecting Your Brew?

The Problem

Rubber o-rings, sanitary gaskets and tri-clamp gaskets are widely used in food, beverage and medical processing plants. In the brewing industry, certain rubber formulations can change the taste of different types of craft beer.

The Solution

Apple Rubber tested five common FDA compliant materials with five different craft brews to find out which o-rings were best for brewing. Our intended outcome was to:

- Identify which rubber compounds result in thelowest volume swell after immersion in different craft beers
- Verify if any ingredients that migrate out after immersion will affect the taste of the beer

---

Background of Rubber O-Rings

When using an o-ring in a brewing application, the specific rubber formulations can bleed out and change the fluid it is intended to seal. In typical industrial applications, the small extraction into a hydraulic fluid will not affect the overall process. For critical processes, such as food and beverage production, small extraction can have a large effect.

Most countries have come up with a list of chemicals that are allowed to be in contact with food or beverages. The USA uses FDA 21 CFR 177.2600, Germany uses KTW and EU uses EC1935. These are the list of materials a rubber compound can use to build a rubber formulation for a food sealing application.

The Process

Five of our common FDA compliant materials were tested into five different craft brews. FDA compliant means that these elastomers are formulated using FDA whitelist ingredients, also known as 21 CFR 177.2600, which is a guideline for creating rubber articles for repeated use. We picked materials from a variety of different elastomer types.

The test materials we used were:

- Nitrile (32BN7AP)
- EPDM (53EP7AP)
- Fluorocarbon (27VT7AP)
- HCR silicone (13SL7SX)
- LSR (14SL7ML)

The LSR is a platinum-cured material, nitrile is sulfur cured, and EPDM, fluorocarbon and HCR silicone are all peroxide cured. In addition to the standard curing time of 10 minutes at 350°F, the silicones received a post-cure of 4 hours at 400°F and the fluorocarbon received a post-cure of 4 hours at 480°F. Post curing is generally done to increase the material's physical properties and strengthen their resistance to taking a compression set, which is typically the most desired property of seal material.

For craft beer, we also tried to pick from different styles to get a broader understanding of how differences in these brews might affect the elastomers. To represent common light and dark styles, we chose:

- Ellicottville Brewing Companies Ellicottville IPA
- Southern Tier's Double Milk Stout
- Great Lakes Dortmunder Gold Lager

We also chose MackJac Hard Cider Black Currant Passion and Westbrook Brewing Co. Gose specifically because ciders and sours tend to have a higher acidity to them, which is very important when looking into seal materials.

Testing Seal Compatability

To test seal compatibility with the different brews, we submerged test pieces at 37°F and 194°F for 168 hours and measured the volume swell of the material. In the rubber sealing, volume swell is used as a general indicator of how resistant a material is to a given fluid. Another potential outcome is a negative swell. In this case, the fluid actually extracts something out of the rubber, which is undesirable for two reasons:

- The extracted chemicals end up in the brew that was being created which may affect the taste
- Due to that same extraction, the seal would shrink in size

This could potentially lead to a loss of compression on the seal and the creation of leaks as an o-ring or gasket retracts from the materials it was supposed to seal. It is possible to get both extraction and a positive swell overall in an incompatible material.

Taste Testing

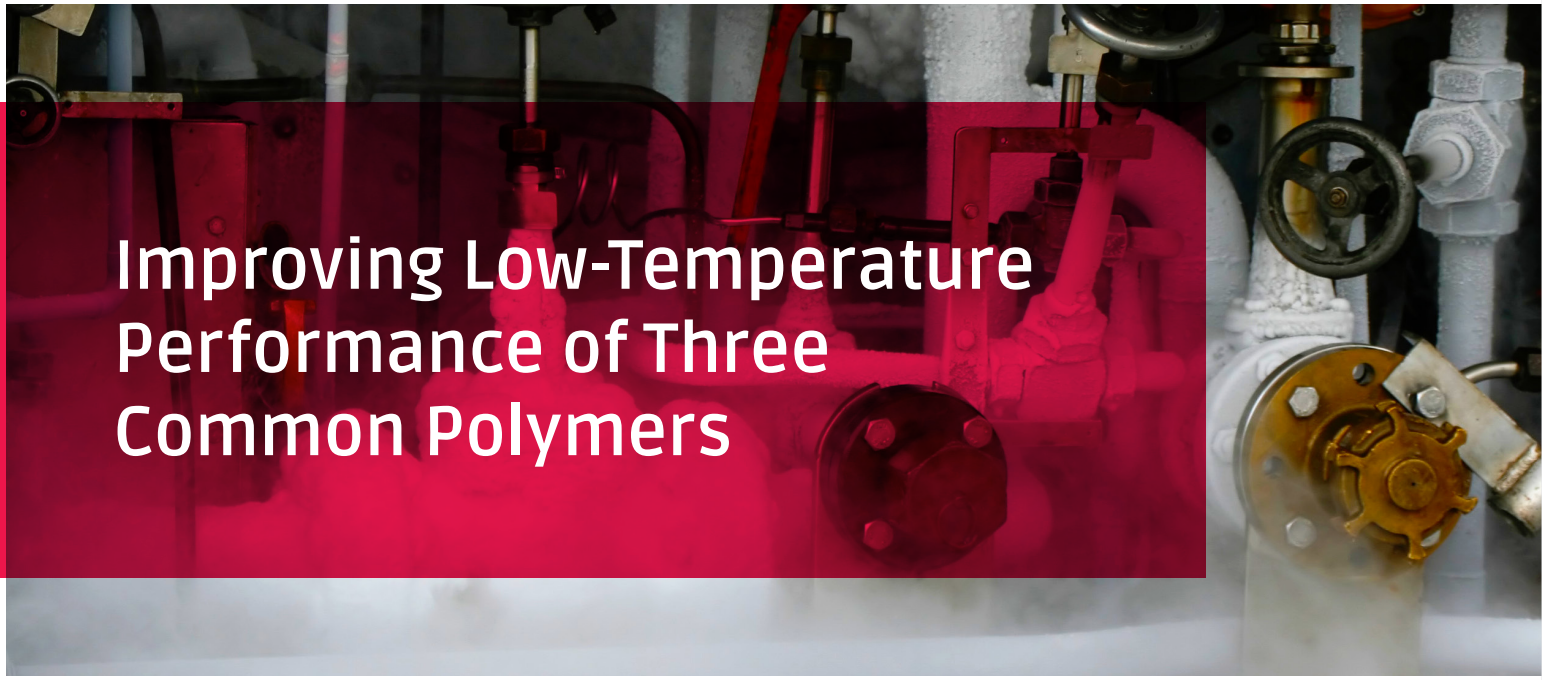
Thirty mason jars were numbered and used to test each material in all five beverages and in tap water, which would act as a neutral. After 168 Hours at 37°F, the test specimens were removed from the jars. The jars were then resealed so that our taste testers would be blind to the specific tests of each jar. Unexposed drinks were provided so that any taste differences from the original specimen could be derived.

The nitrile and EPDM changes to the taste were so strong that the changes could be smelled before anyone even tasted them.

As an extra test, we wanted to see if we could reduce or remove the effect of the rubber on the taste of beer. Given that the post-cured materials performed the best, we wanted to see if adding post-cure to the EPDM and nitrile could burn off any chemical that might be altering the taste of the beer. To achieve this, we took the 32BN7AP and the 53EP7AP and post-cured them for 4 hours at 300°F before retesting them for 168 hours at 37°F. The results were very promising, as there was no smell and almost no detectable change in the taste of the tap water.

The Key Takeaways

Looking at the overall volume swell data, the silicone materials were virtually unaffected by any of the brews. In our opinion, the only materials that performed poorly were the 32BN7AP material in high acidity sour beer and the 27VT7AP, which had a negative swell in the stout. The post-cured materials also performed the best when it came to the taste testing in the various brews and water. If you want a quality seal that isn't going to affect the flavor of your beer, silicone appears to be the best choice for your craft.



Improving Low-Temperature Performance of Three Common Polymers

The Problem

New applications are pushing the limits of low-temperature performance in standard rubber compounds. In most cases, formulation changes must be made to meet these new criteria.

For most rubber compounds as the temperature drops, the material begins to reach its glass transition temperature and the hardness of the rubber increases. We also see higher modulus or increased resistance to deformation. This can cause leakage for seal applications as the material is not deforming into the seal gland properly, which is a real problem for low-pressure applications.

The Solution

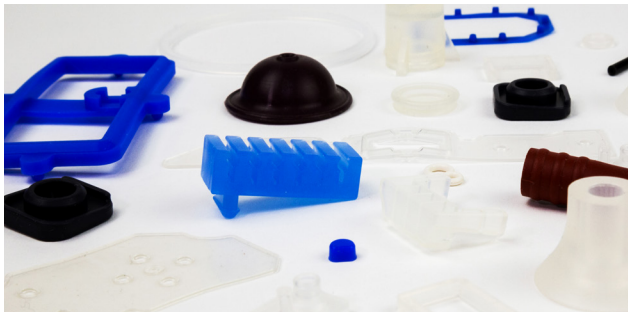
We took a closer look at three common polymers, Nitrile Rubber (NBR), Silicone (SL) and Fluorocarbon (FKM) to find ways to improve their performance at low temperatures.

Nitrile Rubber (NBR)

In an air braking system application for a rail car, a customer's industry requirements unexpectedly lowered from -30°C to -50°C. Since petroleum-based lubricants were present in this application, NBR o-rings were used, however the current compound contained a 33% acrylonitrile content (ACN).

For NBR compounds, the higher the ACN, the lower the volume swell in oil but the higher the glass transition temperature. Therefore, to meet lower temperature performance our compounders needed to change the ACN.

To improve low temperature performance, we used a base polymer of 23% ACN. ACN can range from 19% to 50%. To compensate for higher volume swell, we changed out the plasticizer that resists extraction. This allowed our customer's air valve to operate at a lower temperature while maintaining the same lubrication, and the polymer price was not affected.



Silicone (SL)

A well-known aerospace customer of Apple Rubber was using a standard dimethyl silicone that was rated to -65°C. During performance testing, they noticed that the flex strength was still too high at -65°C, and other durometers provided the same results. This was going to require the customer to replace the current motor with a higher force capability.

Our recommendation was to use a phenyl-based silicone. These silicones are rated down to -104°C. Typically, the polymer can be interchanged in compression molded formulation, but it would double the cost of the rubber. With Liquid Silicone Rubber (LSR), new tooling needed to be created, meaning that a new mold design and tool path was required. This is because phenyl-based LSR does not actually exist on it's own. Applying the phenyl-based silicone resulted in a lower torsional stiffness at -65°C and allowed the device to operate at lower forces.

Fluorocarbon (FKM)

A customer that produces sensors for oil field pipelines came to us for help. Since they primarily supplied to southern pipelines, low temperature performance was not a big concern for their sensor applications. When our customer wanted to increase their market share, they decided they needed to improve lower temperature performance of their sensor.

Their sensor application required a bisphenol cured standard FKM o-ring. These compounds are typically rated to -15°C for static applications. Moving to a low-temperature performance FKM base would change the polymer and cure system of the formulation. This change would then rate the compound to -40°C temperature performance. The new FKM compound would be cured with peroxide and have a slightly higher compression set. While the price of the new rubber compound would triple, the small size o-ring used for this application would not require a lot of material.

Additional Material Alterations

In some cases, a base polymer change will not meet requirements for an application and a completely different class of rubber may need to be used.

For example, if a customer is using silicone and needs to meet -65°C performance but now requires more oil and fuel resistance, they would need to change their material to a fluorosilicone to accommodate these requirements. We've also helped customers who have used EPDM rubber to seal a housing down to -40°C, but a new application requires a housing seal to resist oil. For advanced fuel resistance and ozone protection properties, we changed the housing seal material to HNBR.

Transitioning from Single Cavity Design to Multi-Cavity Tooling

The Problem

Starting a new part design, making sure it functions accurately and integrating it into production.

The Solution

Apple Rubber works with customers from the initial design phase – from single cavity or prototype stage to transition into a multi-cavity production tool – with full process validation.

Our customer came to us with a standard o-ring design. With engineers' assistance and our O-Ring Gland Calculator at applerubber.com, we assured the customer that their o-ring had the correct compression. We looked at both concentric and eccentric conditions to do a tolerance stack up. These ensure that, regardless of whether the design was shifted in the application, the correct compression will be maintained on the o-ring to assure sealing.

Through this process, one problem that we identified was the gland volume was less than the volume of the o-ring. This caused higher compression and potential leak paths. We recommended at least an 85% volume fill to avoid failure.

O-Ring Function Test

Our customer then received all of the mating components for functional testing. With our in-house tool making, we are able to make a single cavity tool with high-precision to match certain dimensions and tolerances. We noticed that other components were out of specification, so this caused our o-ring to fail in the applications. Using the O-Ring Gland Calculator again, we were able to assist our customer in changing the o-ring to meet their design with actual dimensions of the mating metal and plastic components.

O-Ring tooling is typically cheaper than changing plastic tooling. With the new o-ring, our customer was able to function test the new design, and

verify that it passed. Knowing our customer was using the o-ring for a disposable application, we knew automation assembly was going to be very important. Many assemblers use vibratory bowl feeds to try and feed silicone o-rings. This causes the silicone material to produce static electricity as it is vibrated, which means the o-rings will stick together. Therefore, for the prototype tooling, we added a blast bead surface to help rough the finished surface of the o-ring.

We also provided a coated o-ring to test. Testing this early in the design phase helps with a later phase of biocompatibility testing, because more changes will not have to be made then, which would slow the rest of the process.

Consideration for a Coated Part

For high volume automated installations, we strongly recommend coating o-rings. This will eliminate any variations in surface friction. Typically tolerance for hardnesson a rubber is part is +/-5 durometer points. This range can affect the surface friction especially when trying to run high volume installations. Any sticking can cause bowl feeders to miss feed, causing delays or shut downs. If you know this will eventually will turn into high volume, start with a coated part so the coating goes through regulatory approval. For silicone we typically use a cured silicone top coat or parylene coatings. Industrial application for nitrile or FKM, we can used a PTFE coating.

Integrating Into Production

With the higher durometer, the bead surface was all that was required to feed the automation equipment. Now that we reached the production stage, we designed a multi-cavity tool to fulfill the customer's current projections and 10-year projection. We completed the production tooling by providing a full process validation IQ OQ PQ. Installation qualification (IQ) was completed on the equipment that was being used to run the mold. Operational Qualification (OQ) was run varying the major processing factors. Runs were done at the high and low limits of all identified machine settings. Performance qualification (PQ) was completed by measuring all o-rings to look at CPK and PPK. Once qualified, we are able to provide millions of o-rings to our customers.

Rely on Apple Rubber for Custom Sealing Solutions

Apple Rubber has the resources to explore and develop new seal designs, materials and processes to deliver an effect solution. With a wide variety of capabilities and experience in a range of industries, you can count on our engineers to solve any challenge thrown their way.

Avoid Risks With Prototyping

Prototyping is an important step in the design process at Apple Rubber, especially for custom sizes and shapes. We use this process to get a closer look at design details and smooth out production to avoid any risks with scheduling, budget, quality and regulatory specifications. When you prototype with Apple Rubber, you can expect:

- A variety of rubber compounds on hand, including NBR, Silicone, FKM, and many more
- Custom color-match your materials
- Modify polymers to better handle environmental factors, like friction or chemical resistance
- Work directly with Apple Rubber engineers to take any prototype to high-volume tooling for production

Advanced In-House Technology

Apple Rubber offers a wide range of in-house capabilities to shorten lead times and reduce costs. We can provide transfer, compression, and liquid injection molding, as well as CNC machining and proprietary bonding all in our manufacturing facility. Our unmatched range of capabilities is constantly evolving, and we continue to implement new technology to meet the changing needs of our customers.

Home to the Largest Inventory of O-Rings

With access to one of the largest inventories of standard and non-standard size o-rings in the industry, our engineers have solutions right at their fingertips. From intricate MircrOrings® to the largest MacrOrings,® we can assure immediate delivery of most sizes in large or small quantities. If we don't have it in stock, we can make it. Our in-house tooling allows us to quickly develop custom solutions and expedite production.

Trusted Quality Assurance

Apple Rubber provides careful quality control throughout the production process to ensure that every seal meets strict requirements. Our Class 10000, ISO 7 certified cleanroom allows us to deliver in-house cleanroom processing, medical LSR molding, heightened quality assurance, and full lot traceability. We can also provide quality documentation from First Article to full IQ OQ PQ.

Advanced Manufacturing Capabilities

Apple Rubber has an unparalleled range of manufacturing capabilities and state-of-the-art technology to meet the changing demands of customers. You can expect to work with expert design engineers for custom solutions, as well as fully integrated manufacturing facilities. Our advanced in-house technology includes:

- Transfer molding
- Compression molding
- Liquid injection molding (LIM)
- CNC machining
- Proprietary bonding processes

We use a number of mold making machinery to produce customized, high-quality molds. Our engineers rely on sophisticated operations, advanced rubber processing machines and quality tooling to produce molded rubber products for countless industries, including medical, automotive and aerospace. No matter how specific your requirements may be, our in-house molding capabilities guarantee a high-quality part, easy customizations and short lead times.

When you work with Apple Rubber, you can count on 50 years of expertise, quality certifications, fast prototypes and the one of the largest seal inventories in the industry.

One Source for All Your Sealing Needs

Apple Rubber stocks AS568 and ISO 3601 standard sizes, most common metric sizes, plus a wide variety of non-standard o-ring sizes. Our materials meet mil-spec, medical and automotive specifications.

Apple Rubber offers expert custom molding for non-standard rubber products. With in-house tooling, we save more time and resources compared to offshore operations. We offer expertise at any level of production, from prototype to high volume tooling.

When you call Apple Rubber, you deal directly with the manufacturer. Our experienced staff provides complete and comprehensive service to help you get the correct product for your application.

Full Line of Quality Apple Rubber Products

Products:

O-Rings — standards, metrics, MicrOrings,® MacrOrings®

LSR (Liquid Silicone Rubber)

Composite seals (rubber bonded to plastic or metal)

Custom-molded seals and shapes

Medical seals

Thermobonded seals

FilterSeal™

Military specs

Standard and exotic materials

Services:

Design capabilities

Prototyping and production runs

Full quality-control laboratory

Class 10,000 (7) Cleanroom

ISO 9001 / AS 9100 Certifications

ITAR Registered

Apple Rubber™

310 Erie Street
Lancaster, New York 14086
P (716) 684-6560
F (716) 684-8302
info@applerubber.com

For more information or to order call 1-800-828-7745 or visit applerubber.com.

CERTIFIED ISO 9001 • AS 9100