SPECIAL REPORT — Silicone

Addition-curing HC silicone boosts heat resistance

By Norm Riley
Wacker Chemical Corp.

Heat-resistant elastomers are increasingly part of our daily lives. Wacker Chemical Corp. has responded to rising demand with a new addition-curing high consistency silicone rubber that pushes heat resistance to the limits of what is feasible.

Today, ovens are the center-of-attention among kitchen equipment. They have to offer more than just a baking and roasting function. Medium quality devices already provide numerous functions such as steam-cooking, simmering, broiling, roasting—you name it. The trend toward multi-functional devices continues. Ovens featuring integrated microwave, self-cleaning, and steam-cooking are in high demand.

Executive summary

Today's home appliances are trending toward multi-functional devices possessing capabilities far beyond those of previous generations, with new ovens having such features as convection heat, integrated microwave, self-cleaning and steam cooking. Consequently, all component materials must possess greater robustness when exposed to the extreme cooking environment.

Rubber elastomer seals in the multi-functional appliances must maintain performance after prolonged exposure at high temperatures. Wacker has introduced a new addition-curing, high-consistency silicone rubber with extraordinary thermal stability, Elastosil-brand R plus 4350/55, which maintains its mechanical and elastic properties after 170 hours of continuous exposure to temperatures up to 300°C.

Formulated for extrusion of silicone rubber sealing profile and hoses, Elastosil R plus 4350/55 generates no by-products affecting odor or taste during the crosslinking reaction. Additionally, the new silicone rubber meets the relevant requirements of the U.S. Food and Drug Administration and the German Federal Institute for Risk Assessment (BfR), making it considered safe for food contact applications.

The author

Norman Riley is technical marketing manager for Wacker Chemical Corp.'s Silicone Elastomer business in North America. He has been since 2015 and is a veteran of more than 30 years in the silicone elastomer industry.


Riley

He has experience in both marketing and technical management roles, with extensive experience in silicone elastomers, adhesives and polymers. Riley holds a bachelor's degree in chemistry from California Lutheran University.

He began his career as a formulating chemist for RTV-2 and liquid silicone rubber with Wacker in 1984. In 1990, he began a 25-year career with Applied Silicone and its successor companies in Ventura, Calif. His positions at Applied Silicone included research and development manager, technical service manager, quality manager, and technical marketing director for medical grade silicone elastomers and adhesives. He rejoined Wacker as a technical marketing manager in 2015 and relocated back to Michigan.

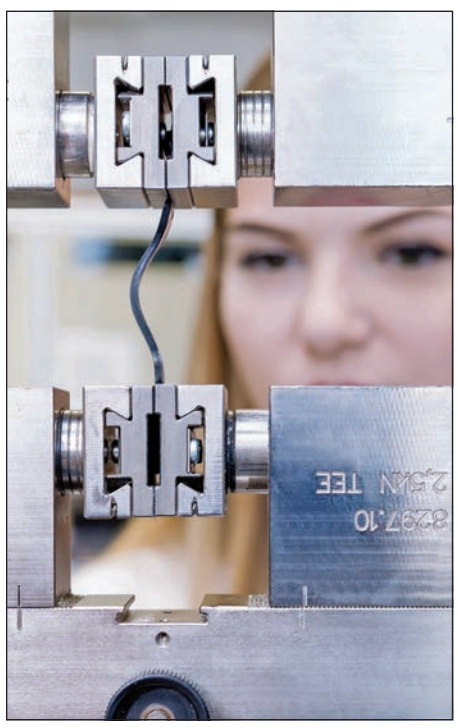
TECHNICAL NOTEBOOK
Edited by John Dick

As a consequence, the incorporated materials are being subjected to increasing demands and requirements. That is especially true for their heat resistance. For example, rubber-elastic parts must withstand temperatures up to 300°C more frequently and for increasingly longer periods. Organic rubber compounds are often not able to tolerate these severe conditions. Even silicone rubber is pushed to the limits of thermal stability unless it is specifically formulated to perform in conjunction with heat-stabilizer additives to survive the high-temperature environment. **(Fig. 1)**

For this reason, Wacker, the Munich, Germany-based chemical company, has developed a high consistency silicone rubber that, when combined with special heat stabilizers, can withstand high temperatures—even for longer periods. Hoses or profiles made with Elastosil R plus 4350/55, which is the name of the new product, retains their elastic properties, even after 170 hours at temperatures of up to 300°C. **(Fig. 2)**

Elastosil R plus 4350/55 cures by means of a platinum-catalyzed addition reaction and is designed to process primarily by extrusion. As crosslinking does not generate any by-products that could affect odor or taste, the industry is showing growing interest in these heat-resistant solid silicones, particularly in the case of food-sector applications—an area where Elastosil R plus 4350/55 rubber grades also are suitable for use.

Fig. 1: Sealing profiles and hoses made of Elastosil-brand R plus 4350/55 retain mechanical strength after aging 170 hours at 300°C.



These products meet the relevant requirements of the U.S. Food and Drug Administration and the German Federal Institute for Risk Assessment (BfR), and are safe for food contact use.

Wacker supplies the silicon compound Elastosil R plus 4350/55 as a silicone rubber base. This allows processors to prepare their own compound, optimizing it to suit the extrusion processes and the thermal stability and color requirements for the product by applying additives, especially heat stabilizers.

A challenge for seals

Oven-door seals are not only exposed to heat, but also other influences: they have to be resistant to hot splattered grease, for instance, as well as meat and fruit drippings, and the remains of food that has boiled over. While the doors and adjacent surfaces are protected from heat and grime thanks to complex designs, there still is no way to prevent the profile seal between the oven chamber and oven door from heating up during operation. The gasket can temporarily reach temperatures up to 400°C.

This is why oven manufacturers use tubular gaskets made of woven fiberglass that has been reinforced internally with wire mesh. The mesh supports the inside of the tube and gives the gasket the necessary resilience. Both materials can theoretically handle the temperatures that arise when the oven is in operation.

However, gaskets like these wear out quickly when used on a day-to-day basis. The repeated opening and closing of the oven door causes the wire mesh to lose its shape and therefore its ability to provide support. The fiberglass, in turn, absorbs the greasy fumes that arise during baking and roasting, and these condense when the oven cools. The resulting deposits go rancid and solidify over time, causing the mesh to harden and the gasket to become brittle. As fiberglass gaskets are hard to clean, they eventually become an eyesore.

Heat resistance

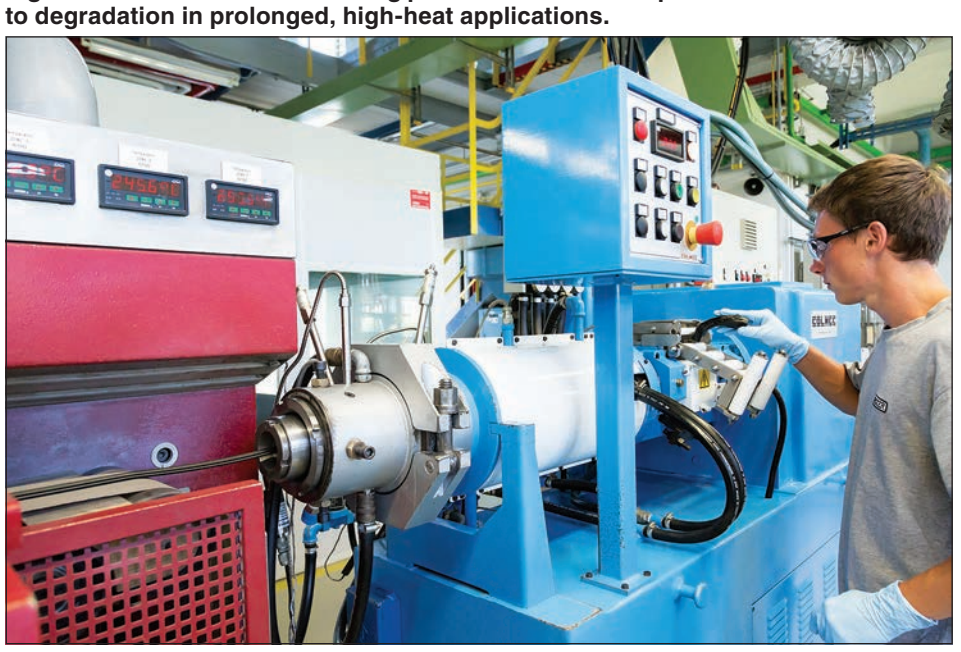
Door profile seals made of the new Elastosil R plus 4350/55 solid silicone rubber represent an alternative to fiberglass gaskets. They withstand high temperatures and remain elastic enough to provide a reliable seal for many years. They are quite impervious to certain amounts of fat and food residues, making them easy to clean.

The new product also offers another advantage: tests show that profile seals made of silicone do a better job of insulating against heat than those made of fiberglass. The benefit for oven owners is twofold, as the oven door heats up less and the oven itself loses less heat. That, in turn, reduces the energy required for baking, bringing electricity costs down in the process. **(Fig. 3)**

Consumers increasingly want ovens with an integrated steaming feature. These appliances combine the advantages of steam cooking—an especially gentle method for cooking vegetables, for instance—with the capabilities of traditional ovens. However, steam cooking also is challenging for silicone gaskets: the steam attacks the polymeric structure of the silicones, which causes the elastomer to lose elasticity and strength.

See **Silicone**, *page 15*

Fig. 2: Extruded hoses and sealing profiles of Elastosil R plus 4350/55 are resistant to degradation in prolonged, high-heat applications.



REGISTER NOW!

INTERNATIONAL SILICONE CONFERENCE

A Rubber & Plastics News event organized jointly with

2018 International Silicone Conference is Next Week!

April 10-11, 2018

Sheraton Suites Akron Cuyahoga Falls, OH

rubbernews.com/2018silicone

The International Silicone Conference will again bring together industry leaders to discuss cutting edge innovations in materials, processes and technology. Increase your knowledge of industry trends, learn the innovations that could accelerate your program and make valuable connections in this 1-1/2 day event.

Technical Program Agenda *(subject to change)*

Tuesday, April 10

9:00am - 9:30am
The Global Silicones Market -- Key Trends & Forecasts
Kent Furst, The Freedonia Group

9:30am - 10:00am
Regulatory Update
Alexandra Rinehart, Shin-Etsu Silicones

10:00am - 10:30am
The World-Records of Silicones - Innovations Powered by a Unique Elastomer
Oliver Franssen, Momentive Performance Materials

10:30am - 11:00am
Networking Break - *Compliments of CRI-SIL*

11:00am - 11:30am
Conductivity in Silicones While Retaining Elasticity and Color – New Solutions
Ekaterina Gorbunova, OCSiAl

11:30am - 12:00pm
The Adhesion of LSR and Different Polypropylene-Types after Storage Tests
Annette Rüppel, University of Kassel

12:00pm - 12:30pm
Si based Non-Leachable Novel Antimicrobial Material
Yash Khanna, KGH fiteBac Technology

12:30pm - 1:45pm
Lunch

1:45pm - 2:15pm
LAM 3D Printer Technology using Liquid Silicone Rubber
Rick Ziebell, R.D. Abbott Company

2:15pm - 2:45pm
The Best Gate Location and the Biggest Process Window Using Autonomous Optimization
Gabriel Geyne, SIGMASOFT Virtual Molding

2:45pm - 3:15pm
Moldable Optical Silicones – Material Introduction, Adoption and Innovation from a User's Perspective
Brian Zatzke, LumenFlow Corp.

3:15pm - 3:45pm
Networking Break - *Compliments of CRI-SIL*

3:45pm - 4:15pm
The Impact of High End Mold Making to Efficient Production
Markus Landl, Rico Group GmbH

4:15pm - 4:45pm
Innovations in Metering and Mixing Technology for LSR
Bernd Möller, 2 Komponenten Maschinenbau GmbH

4:45pm - 5:30pm
Keynote Address: Improving Competitiveness: Understanding the Generation Gap
Joe Walker, Freudenberg Sealing Technologies and Freudenberg-NOK Sealing Technologies

5:30pm - 6:30pm
Networking Reception
- *Compliments of Wacker Chemical Corp.*

Wednesday, April 11

8:30am - 9:00am
From Silicon to Silicone
Ray Hetherington, Hexpol Silicone Compounding

9:00am - 9:30am
How to Boost Silicone Rubber Compounds
Reimund Pieter, Hoffmann Mineral

9:30am - 10:00am
Reclaim Silicone for HCR Compounds
Erick Sharp, ACE Products & Consulting LLC

10:00am - 10:30am
Networking Break - *Compliments of CRI-SIL*

10:30am - 11:00am
The Magic of Dry Ice Cleaning in Rubber Molding (Theory, Process & Applications)
Steve Wilson, Cold Jet, LLC

11:00am - 11:30am
Molding a Stronger Future Through Exit Strategy Preparation
Zachary Corson, Douglas Group

11:30am - 12:15pm
Keynote Address: Silicone is in our DNA: 50 Years of Family Pioneering in Elastomer Molding
Rick Valeriote, Poly-Nova Technologies

Don't wait two years for the next Silicone Conference, register today!
Register Online: rubbernews.com/2018silicone

SPONSORS AND EXHIBITORS

SPECIAL REPORT — Silicone

Silicone

Continued from page 13

Wacker's new high consistency rubber offers advantages here as well. A series of tests were performed on gaskets made from Elastosil R plus 4350/55 in which the seals were exposed to steam heated to 250°C. After 28 days, elongation at break for the silicone gaskets was over 100 percent. The Shore A hardness of the samples increased by less than 15 percent.

Increased temperature stability

It follows that the new Elastosil R plus 4350/55 solid silicone grade is, in many cases, a technically superior alternative to the materials used to date for profile gaskets, hoses and cable sheathing.

The type and amount of heat stabilizers added to the silicone rubber dictate the maximum thermal stress the compound can withstand. To achieve maximum thermal stability, a suitable additive needs to be blended into the colorless, translucent base rubber compound.

Elastosil Aux Stabilizer H3, a heat stabilizer based on carbon black, can be added to Elastosil R plus 4350/55, allowing the latter to withstand temperatures of 300°C, for instance—significantly better than standard heat-stabilized silicones. Even after several days of thermal stress, the mechanical properties of the new grade are superior to those of other silicones.

In terms of heat resistance, the new product pushes addition-curing solid silicones beyond the current limits. This also has been demonstrated in tests performed at Wacker's applications lab, where samples of cured rubber made from Elastosil R plus 4350/55 were exposed to temperatures above 220°C for roughly 2,000 hours, with the temperature gradually increasing to 300°C.

The mechanical properties of the silicone were measured before and after heating, simulating the temperature stress that a door profile gasket is exposed to over a period of ten years. **(Fig. 4)**

The hardness of the new solid silicone initially rose from Shore A 55 to 75 in high-temperature conditioning tests. Standard heat-stabilized silicones, by contrast, hardened significantly more at considerably lower heat stress.

The elongation at break, which allows researchers to make inferences about the gasket's flexibility and durability, likewise, changed less in the new material, falling from an original value of 400 percent to 175 percent. The standard heat-stabilized silicone became brittle after high-temperature conditioning losing much of its elasticity.

Stable mechanical properties

Tests show that the new solid silicone rubber Elastosil R plus 4350/55 is more heat resistant than a standard high consistency rubber when used in conjunction with Elastosil Aux Stabilizer H3. **(Graphic 1)**

When exposed to temperatures of 300°C for 170 hours, hardness increases by 12 points as compared to 25 points for a standard HCR.

Elastosil R plus 4350/55 also possesses superior stability in elasticity. During the test cycle, the product retains 50 percent of its elongation at break. The standard HCR exhibited a substantial loss of elasticity.

Extended heat exposure testing for 650 hours (28 days) at 275°C show that the hardness of Elastosil R plus 4350/55 increases 8 points to 65 Shore A. In comparison, an addition- cure, heat-stabilized standard silicone rubber increases by 18 points under the same conditions. **(Graphic 2)**

Long periods of exposure at 275 °C will degrade the elasticity of a heat stabilized, standard silicone rubber. Elongation at break is down by 75 percent after 28 days or 650 hours. Elastosil R plus 4350/55 shows significantly better values in this respect. Its elasticity at break only declines by 55 percent. **(Graphic 3)**

Summary

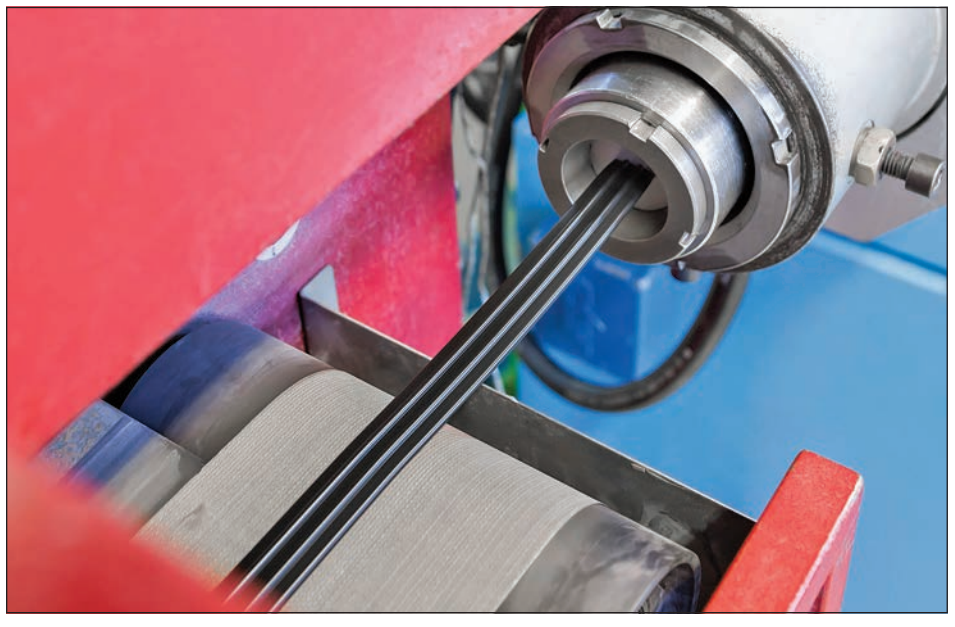
Consumers demand multi-functional appliances that place severe thermal stress on all components, including the seals and gaskets critical to proper performance.

Upon the addition of the Elastosil Aux Stabilizer H3 heat stabilizer, Elastosil R plus 4350/55 combines thermal stability at temperatures up to 300°C with the benefits of no by-products during cure.

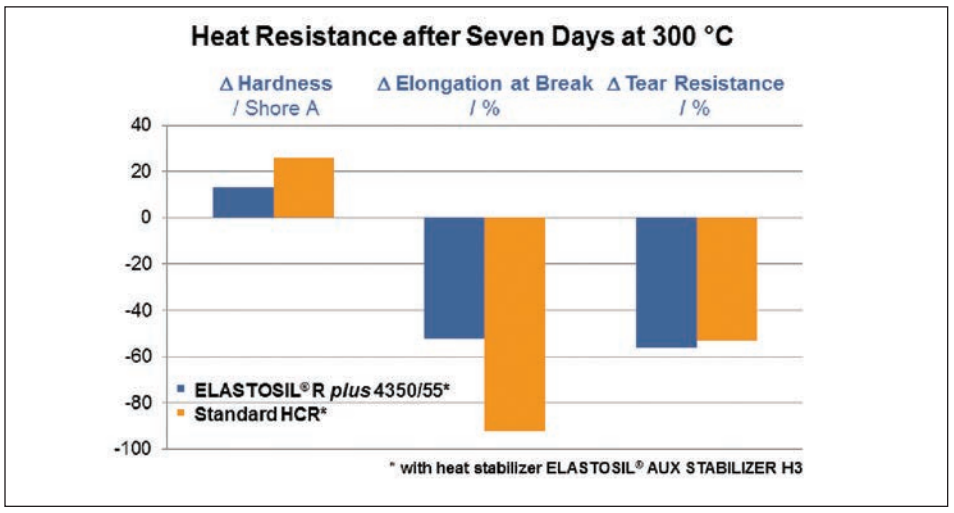
The cured silicone rubber retains mechanical integrity ensuring that assemblies incorporating seals or hoses extruded from Elastosil R plus 4350/55 will meet the performance required in high-temperature sealing applications.

Fig. 3: Elastosil R plus 4350/55 is specifically designed for high temperature applications in household appliances and the food industry. There are no by-products affecting odor or taste formed during crosslinking.

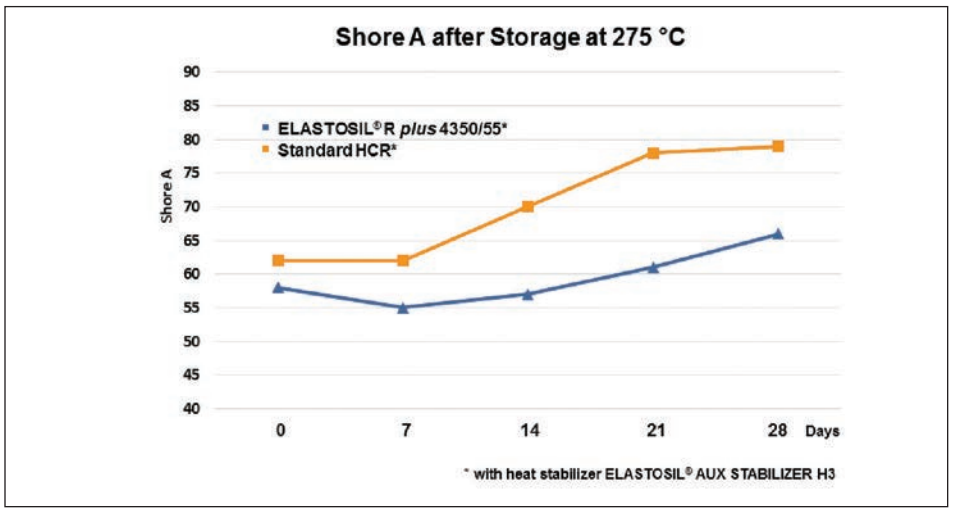
Fig. 4: Extrusion of a sealing profile made of the new Elastosil R plus 4350/55 solid silicone rubber.



Graphic 1: Heat resistance of Elastosil R plus 4350/55 as compared to a high consistency silicone rubber (HCR).



Graphic 2: Shore-A hardness change of Elastosil R plus 4350/55.



Graphic 3: Elongation at break—alterations of Elastosil R plus 4350/55 and a standard high consistency silicone rubber (HCR).