Redefining Boundaries to Achieve the "Impossible" with GE Sealants

imagination at work

Silicone Structural Glazing:

Redefining Boundaries to Achieve the "Impossible"

More than 70 years ago, GE ingenuity fueled the discovery of silicone. In the decades that followed, GE laboratories inspired innovations to silicone that created items such as gasket seals for WWII bombers and the protective shields for the boots and space suits worn by Neil Armstrong and his fellow astronauts. Building on the advancements from WWII and the U.S. Space Program, GE scientists continued to move forward, honing new applications for silicone that would serve as proving ground to silicone's indispensable use in modern day construction.

Today, the sealants team is at the forefront of the construction industry in the manufacturing and application of products used in silicone structural glazing (SSG), a cutting-edge construction method. GE scientists and lab engineers helped to pioneer SSG in the 1970s which, over time, transformed the world's skylines into towering skyscrapers and mirrored marvels. From the daring construction of the Chicago Art Institute in 1974, the world's first four-sided silicone structural glazing project without safety mechanisms, to the recent completion of the Shanghai World Financial Center, the world's tallest completed four-sided SSG façade, the sealants team of experts is behind many of the world's most awe-inspiring structures.

Outstanding mechanical properties, coupled with excellent flexibility across a wide temperature range and lasting durability, are fundamental to the high performance of GE sealants. This combination makes it possible to respond to today's ever-more-inventive, increasingly demanding architectural designs. Simply put, GE silicone structural glazing solutions help make the impossible possible.

CASE STUDY

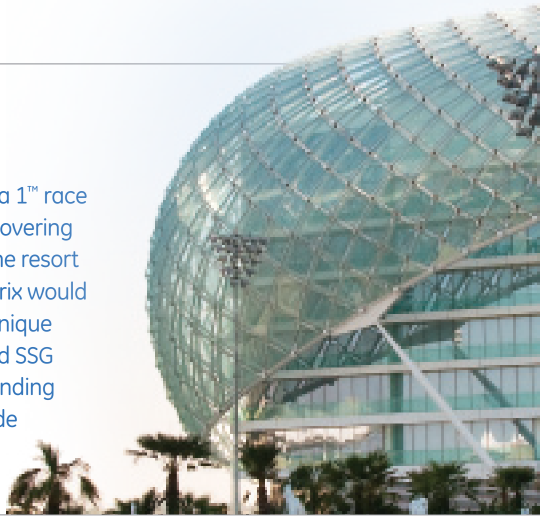
Achieving New Heights

In addition to being a part of the first four-sided SSG project without safety mechanisms, GE sealants were also selected for use in the world's tallest completed four-sided SSG facade, completed in 2008: the Shanghai World Financial Center. The complexity of the building design for this awe-inspiring 101-story, mixed-use skyscraper posed extraordinary design challenges. Earthquakes, typhoon-level winds, extreme weather conditions and ultraviolet exposure demanded an inventive structural design and an advanced SSG solution. Technical experts selected **GE SSG4400 UltraGlaze***, a high-strength, two-part sealant, to construct the tower's complex curtainwall system. With high mechanical strength and long-term durability, flexibility and stability, SSG4400 created a lasting bond between the glass and the Shanghai World Financial Center's aluminum frame. This combination delivered a high safety factor to the design and exceeded the required safety guidelines by five times.

CASE STUDY

Racing Past the Traditional

In the United Arab Emirates just outside of Abu Dhabi, in the middle of the desert, is a Formula 1™ race course and resort, the Yas Marina Circuit. The Yas Island Marina Hotel, shaped like a Cobra, hovering above the racetrack, is the focal point of the island. In winter 2008, the race was on—to get the resort ready for race spectators. In just one year, the Formula 1™ Etihad Airways Abu Dhabi Grand Prix would debut and the marquis hotel needed to be completed. Approximately 25,000m^2 of glass, all unique shapes and sizes in a unitized curtainwall, needed SSG. In assessing the design and four-sided SSG process, the sealants technical experts recommended **GE SSG4400 UltraGlaze*** for its outstanding strength and adhesion capabilities and accelerated cure time. The team completed the façade process in an impressive six months allowing the five-star hotel and resort to open on time.



SSG: From 3-Story Wonders to Mirrors in the Sky

Silicone structural glazing has forever changed skylines and has provided architects and fabricators with a powerful tool when approaching building design. Honing silicone for use in building construction because of its durability and permanent flexibility, into a precision engineered rubber, was central in the evolution of constructing buildings with free-standing glass. This feat by GE scientists forged the GE sealant legacy of 40 years of participation in many of today's most interesting facades.

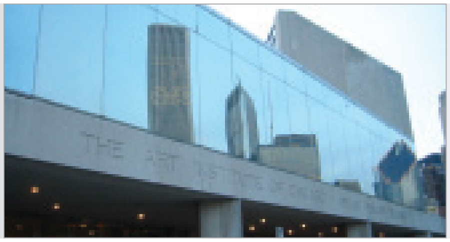
Playing a Critical Role in the Development of SSG

From the invention of silicone, to the emergence of the "Glass Mullion System," to the construction of one of the first four-sided SSG projects, GE sealants and the sealants team of experts has played a critical role in the development of silicone structural glazing.

In the 1950s and early 1960s, as the curtainwall industry emerged, architects began experimenting with larger expanses of glass and metal, taking the place of the previous 100 years of masonry wall construction. GE scientists, familiar with pioneering new applications and uses for the new "space age" silicone material, rose to the challenge. They used the lab to find a way to morph the existing paste-like putty silicone into a material that was sticky enough to bond materials together, yet strong and durable enough to be used in building construction. Enter GE silicone construction sealants.

Later in the 1960s, architectural designs continued to utilize larger glass spans to create wider and taller "vision" areas unimpeded by architectural metal framework. As such, the "Glass Mullion System," a method by which free-standing glass is bonded directly to adjacent glass or metal, emerged. GE scientists and engineers largely participated in the creation of this method—which was the predecessor to today's silicone structural glazing—in its dawning days. During this transformative period, GE scientists also developed new silicone products and essential information related to the interworking of glass, joint design, exact measurements for load-bearing weights, and overall bondage. In fact, they even predicted correctly that, in order to maintain the exterior beauty of these buildings, a high-performance silicone elastomeric rubber with the ability to remain durable and flexible while also carrying repeating loads, would become instrumental to the construction business.

In the 1970s, one of the products that GE experts had been working on, GE SCS1200 Construction was used in one of the early applications of SSG as part of an overlay to the building process in a structurally glazed project at the Saks Fifth Avenue Department Store in Pittsburgh, Pennsylvania (U.S.). The success of this project was proof that SSG was a viable construction technique with vast potential.



Chicago Art Institute in Chicago, Ill.

E. H. Hahn Building in El Segundo, Calif.

Warner Bros. Corporate Offices in Burbank, Calif.

Advancing SSG as a Reliable, Durable Construction Method

As the potential for SSG grew, so did demands from the design and construction communities. GE, confident in the science behind its silicone products and the experience and knowledge of its experts, forged ahead with more innovations. When many in the silicone industry judged SSG too great a liability, GE leveraged its expertise in silicones to develop products that would realize the full potential of SSG as a reliable, durable and safe construction method.

First Four-Sided SSG Project without Safety Mechanisms

A notable first, from 1973–1975, GE worked with famed architects Skidmore Owings & Merrill and the respected curtainwall constructors Flour City, to complete the Chicago Art Institute, the world's first four-sided SSG project that did not incorporate safety mechanisms. Nothing but GE structural silicone holds the glass to the building, a feat others in the industry would not attempt at the time. A previous design incorporated "rosettes" as holding devices at all four corners of each piece of glass, not completely liberating the SSG method as a reliable option. At that time, there was great reservation to construct an all-glass-bonded façade. However, during the project "mock-up" tests prior to construction, a collective sigh of relief was heard when the glass fractured during full-scale load testing showing that the strength of the bonded silicone rubber was stronger than the glass itself.

Since those pioneering days, a site extraction of structural silicone for lab testing from the project after 20 years in-service and subsequent repeated visits have shown that the silicone rubber is still intact and performing as expected today. The lasting performance of the world's very first true four-sided SSG project (without contribution from rosettes to withstand repeated wind pressures) is living proof that SSG is a durable construction method.

Catapulting SSG to another Level

After the success of the Chicago Art Institute, GE silicone played a role in catapulting SSG design to an even more complex level. Architects such as Reel Grobman & Associates carried the all-glass design further, incorporating outward-sloped segments in the 1976–1977 Ernie H. Hahn Building (U.S.), for which GE silicone was used. At the same time, Architect Charles Luckman integrated curved glass into his Warner Brothers SSG design of 1978–1979, where GE silicone was also used. Situated in the greater Los Angeles (U.S.) area, both of these early successes are still standing today and have withstood multiple earthquakes over the years. Both architectural styles can still be seen incorporated in today's taller and grander designs.

Following these breakthroughs, a slew of four-sided SSG projects were completed in the mid-to late 1970s, many of which are still intact and performing today.

Reaching New Heights with GE Silicone

In the 1980s, buildings got taller and GE experts continued to work with designers and architects to advance the SSG concept. Working with the architectural firm Ferendino, Gosfton, Spillis & Candela and curtainwall design experts Glassalum, the 18-story building at 800 Brickell Avenue (formerly known as Barnett Bank) was erected in Miami, Fla., between 1979 and 1980 using GE structural silicone. Upon completion, the building became the world's first four-sided "high-rise," marking a major milestone in the evolution of SSG.

GE sealants' contribution to modern construction is truly remarkable. From pioneering firsts to breaking barriers, the sealants team's role in creating innovative solutions can be seen in its many successful projects from around the globe. Today, GE sealants and adhesive products continue to address the needs of increasingly demanding and imaginative designs.

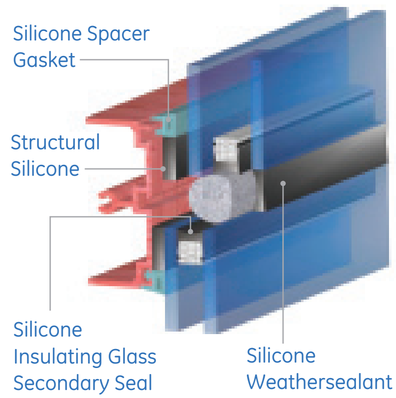
What is SSG?

- Silicone Structural Glazing is a process where silicone—not metal hardware—is used to attach façade panels such as glass or other composites to a building's frame (see diagram 1).
- The most common SSG systems are two-sided or four-sided. Two-sided SSG is when two opposing glass edges are bonded with silicone while the remaining edges are affixed with metal and rubber gasket anchorage devices. Four-sided is when all four sides of the panel are structurally bonded with silicone, which, in essence, creates a wall of glass.

4-sided SSG

2-sided SSG

diagram 1



Why Silicone?

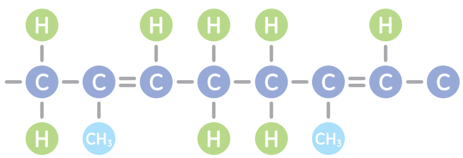
One look around some of the world's most notable buildings and the conditions they endure and it is easy to understand why GE silicone's robust protective properties make it one of the most advanced compounds for modern day construction, remediation, and protection of existing buildings.

Chemically, silicone is quite different from all other materials; it is comprised of a Silicon-Oxygen chemical backbone instead of a Carbon-Carbon linkage of most other rubber types. It is this fundamental difference that gives silicone its unique combination of properties:

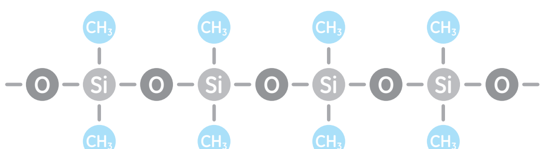
- **Low temperature flexibility**
- **High temperature stability**
- **UV stability**
- **Seismic-capable flexibility**
- **Durability**

These properties allow silicone to perform in many applications where no other elastomer can be used.

Organic Polymer:
Natural Rubber



Silicone Polymer:
Dimethyl Polysiloxane

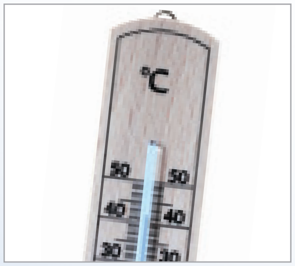


SSG: Maximizing Silicone's Inert Flexibility and Durability

Silicone structural glazing, the ability to safely use adhesively-bonded glass as a means to construct a curtainwall, forever changed modern construction, providing architects with the opportunity to create unprecedented designs. Of course, architects seized the opportunity and went to task erecting ever-more-impressive and complex buildings and structures.

Today, GE structural glazing silicone sealants' impact to modern architecture can be seen across the world's most impressive skylines; mirrored skyscrapers soar to unprecedented heights accomplishing shapes and angles never before imagined.

Low Temperature Flexibility– Silicone rubber's inherent ability to remain flexible without hardening at extremely low temperatures is an important consideration when bonding two materials together with differing coefficients of thermal expansion. This characteristic allows the adhesive bond stress to remain virtually unaffected and without restriction of system flexibility no matter the working environment and/or seasonal temperature variations. Low temperature flexibility is just one of the reasons that some sealant types are not allowed for use in structural silicone bonding as certain non-silicones can stiffen under cold conditions creating additional unwanted stress that could compromise the safety of the system.



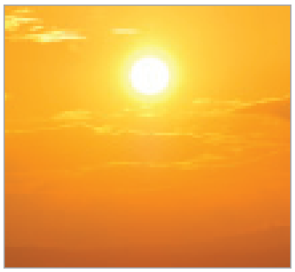
High Temperature Stability– GE silicone rubber offers excellent thermal stability even at elevated temperatures, which is certainly a critical design item considering that surface temperatures experienced on sun-facing facade elements can easily approach 15–20°C higher than the surrounding ambient climate. Even at elevated temperatures, the properties of the rubber show little change and maintain the ability to continue performing the job of flexible adhesive bonding even after decades of constant loading from wind and building movements, according to a recent company study.[1]

CASE STUDY

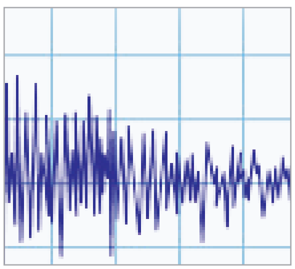
Setting the Tone on the Vegas "Strip"

In the late 1980s, Las Vegas, Nev., was just starting to boom as a travel destination, and the MGM Grand Hotel was in the process of becoming a landmark building on the infamous Las Vegas "strip," setting the tone for future hotels to follow. **GE SSG4000 UltraGlaze*** played a pivotal role in constructing the MGM. Completed in 1990, it looked like a green glass wall of beauty. But, it was also resistant enough to withstand the harsh UV exposure and extreme heat of its desert climate.

Samples retrieved after 20 years in a subtropical outdoor test exposure facility as a part of a recent company study show that GE silicone rubber outperformed a competing polyurethane rubber sealant product in durability to weathering.[3] The polyurethane on the left snapped in half upon flexing while the silicone bead on the right remains entirely flexible and intact with negligible change in hardness and flexibility.



UV Stability– GE silicone rubber is permanently waterproof where some rubber sealant types can show cracking and degradation in as little as one year in accelerated weathering simulation testing.[2] According to a recent company study, GE silicone rubber resists degradation even after decades of sun exposure and natural weathering, far surpassing the performance of some competing sealant chemistries.



Seismic-Capable Flexibility– GE silicone's resilient flexibility provides a cushioned foundation when bonding glass to aluminum curtainwalls, reducing the potential of glass breakage making it an exceptional choice for many structures within "earthquake zones." Furthermore, due to the elastic property of GE structural silicone products, it exhibits very high fatigue endurance when tested to cyclic strain. Even after 35,000 strain cycles—simulating 50 years of thermal expansion and contraction—the rubber properties show little change. This tested performance lends credence to the longevity of current 30+ year-old SSG projects, many of them in seismic zones, which are performing after years of seismic activity.

Durability (endures high wind)– The physical properties inherent in silicone are derived from its unique chemical structure and provide the basis for lasting strength and durability. With high cohesive and bonding strength, silicone is capable of withstanding repeated stresses in shear, tension and rotation without tearing or rupturing. Silicone can withstand not just "normal" everyday wind buffeting, but also more extreme winds, precipitation and a range of seismic activity. What's more, silicone's rugged inner-tear strength makes it capable of resisting tear propagation and maintaining performance integrity if inadvertently damaged.

SSG Products with European Technical Approval (ETA)

GE structural glazing silicone sealants have evolved from a history of excellent performance on complex and unique building structures around the globe, meeting a multitude of schedule and performance needs. One-part and two-part silicone structural glazing sealants recently obtained ETA, and are available for the European façade market. Now when innovative, world-class architecture in Europe requires structural glazing silicone systems to achieve awe-inspiring results, GE sealants can deliver with the same solid strength and proven reliability as they have in projects around the world.

Product Portfolio: Europe/Middle East/Africa/India

GE SSG4400 UltraGlaze*

Two-part, high-strength silicone elastomeric adhesive that provides outstanding strength, rapid hardness and mechanical property build and 12.5 percent joint movement capability.

GE SSG4000E UltraGlaze*

One-part, high-strength silicone elastomeric adhesive with 25 percent joint movement capability for use in a multitude of field and in-shop glazing applications.

Outstanding Products Require Outstanding Technical Support

Significant design challenges undoubtedly require a product with excellent performance characteristics. They also require world-class implementation. From lab to job site, the company offers a diverse group of seasoned technical experts who customize each project regardless of location to help make the designer's dream a reality. We believe technical expertise is essential to a project's success. And we think our customer's agree.

For more information about GE Construction Sealants or to see a detailed description of GE sealants and adhesives available in Europe/Middle East/Africa/India, visit www.ge.com/silicones.
For global product availability, please contact customer service. A GE Construction Sealants product catalog is available by request from your sales representative.
Customer Service: 00 800 4321 1000 | Technical Services: Europe & Africa: +31 164 292 600, Middle East: +971 4 886 2070, India: +91 44 304 120 77

[1] Bull, E., and Lucas, G., April, 2009, "Long-Term Outdoor Weathering Study of Construction Sealants," Journal of ASTM International, Volume 6, Issue 4.

[2] Id.

[3] Id.