WACKER

CREATING TOMORROW'S SOLUTIONS

ELASTOSIL®

LUMISIL®

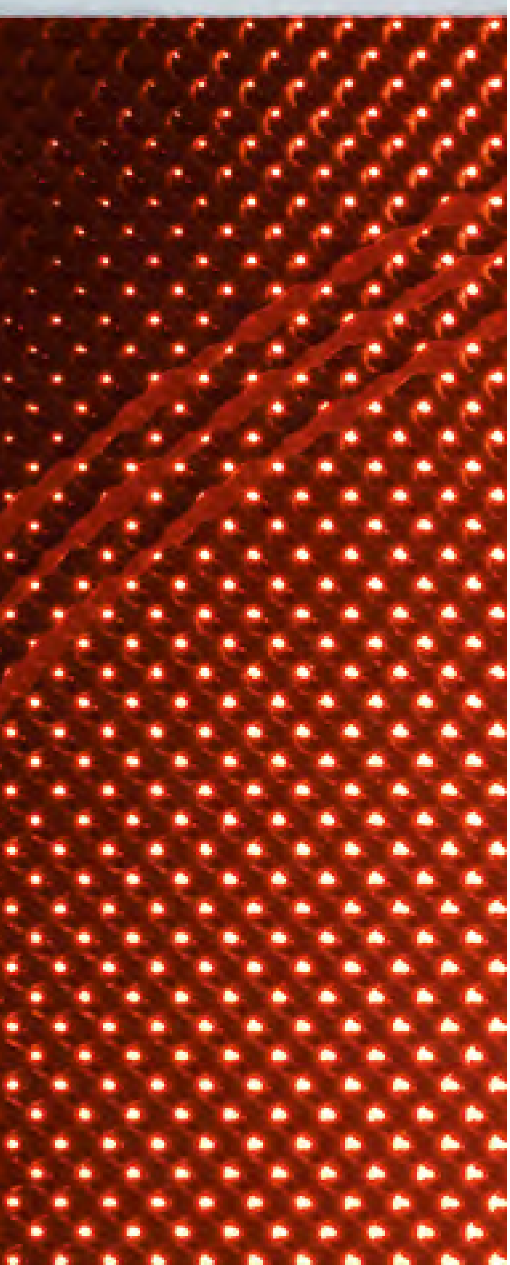
SEMICOSIL®

SILPURAN®

WACKER SilGel®

ROOM TEMPERATURE VULCANIZING (RTV) SILICONES

Material and Processing Guidelines



WELCOME TO THE WORLD OF RTV SILICONES

Contents

SECTION 1:
DISCOVER DIVERSITY

Contents

Why WACKER silicones optimize the properties and process technologies of products in all major industries worldwide.

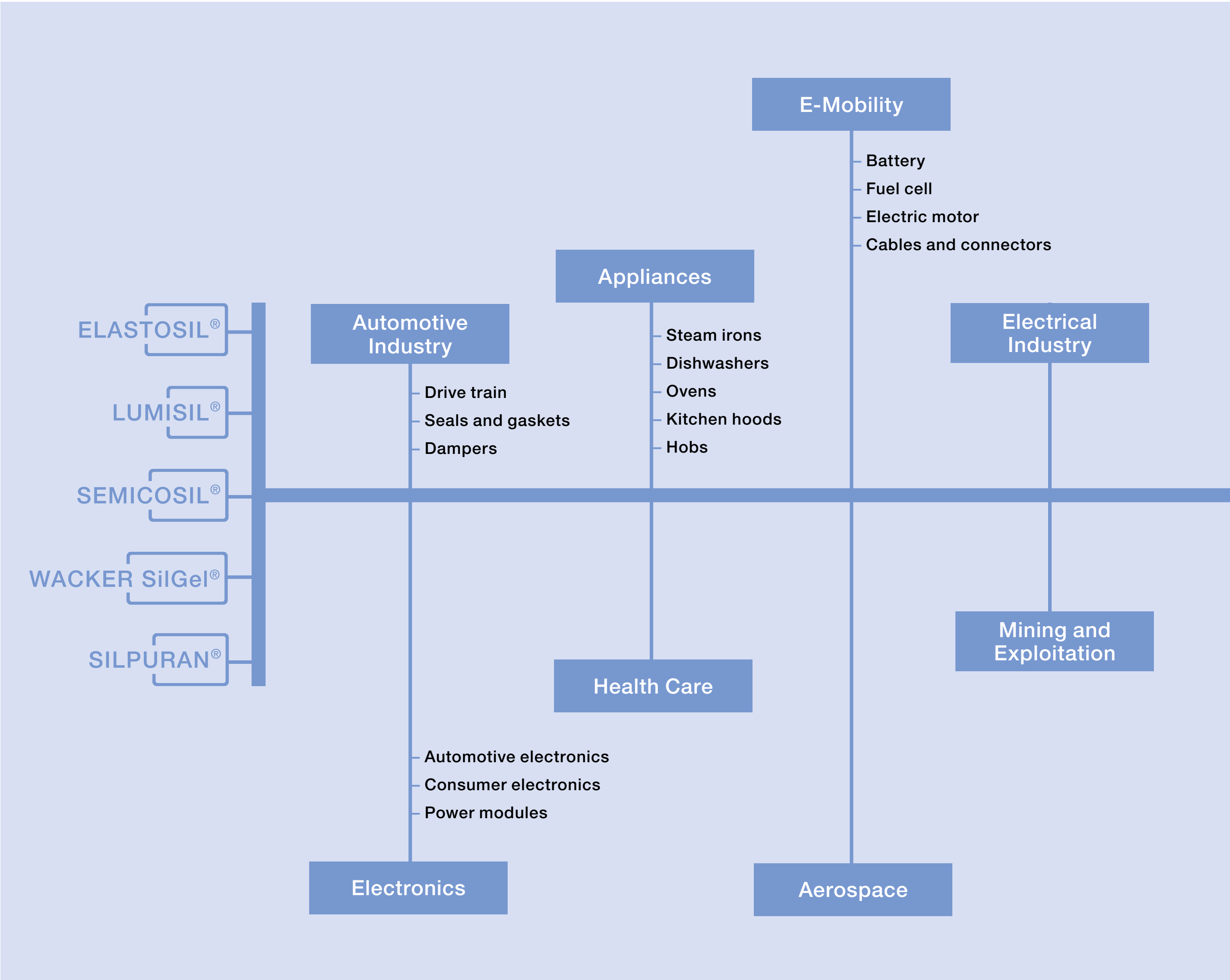
1.1 DIVERSITY OF SILICONES

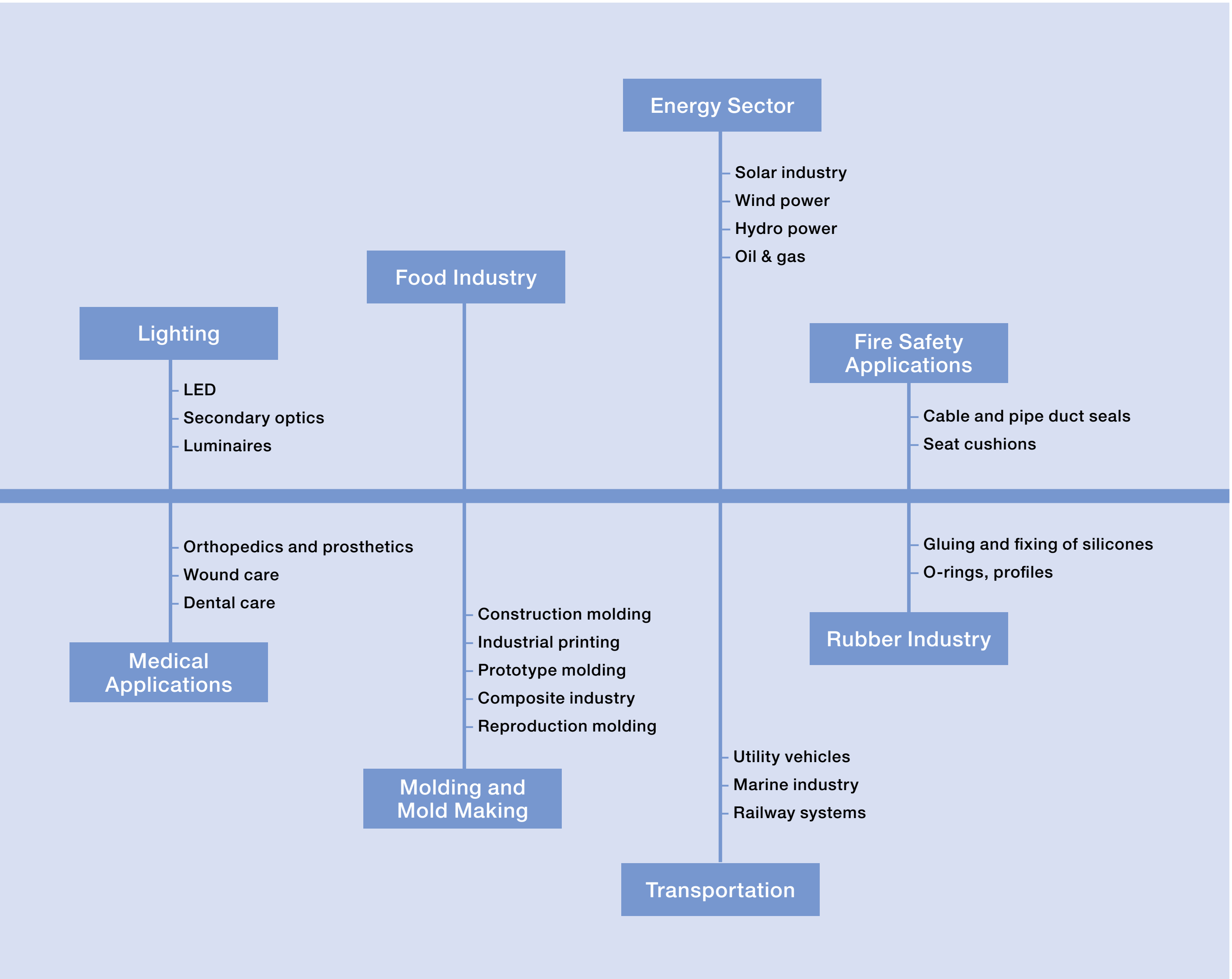
Technical innovations and rapid production development cycles are routine in specialized industries. However, to achieve market leadership in the long-term, it is necessary to set standards. Modern silicone-based materials increasingly play a key role in achieving such goals.

Room-temperature-vulcanizing (RTV) silicone rubber compounds are a traditional core competence of WACKER. The range of ready-to-use products focuses on numerous applications in the fields of bonding, sealing, potting, encapsulation, coating and casting. Equally broad is WACKER's experience in processing techniques and material requirements specific to these applications, from DIY-scale right up to industrial production lines.

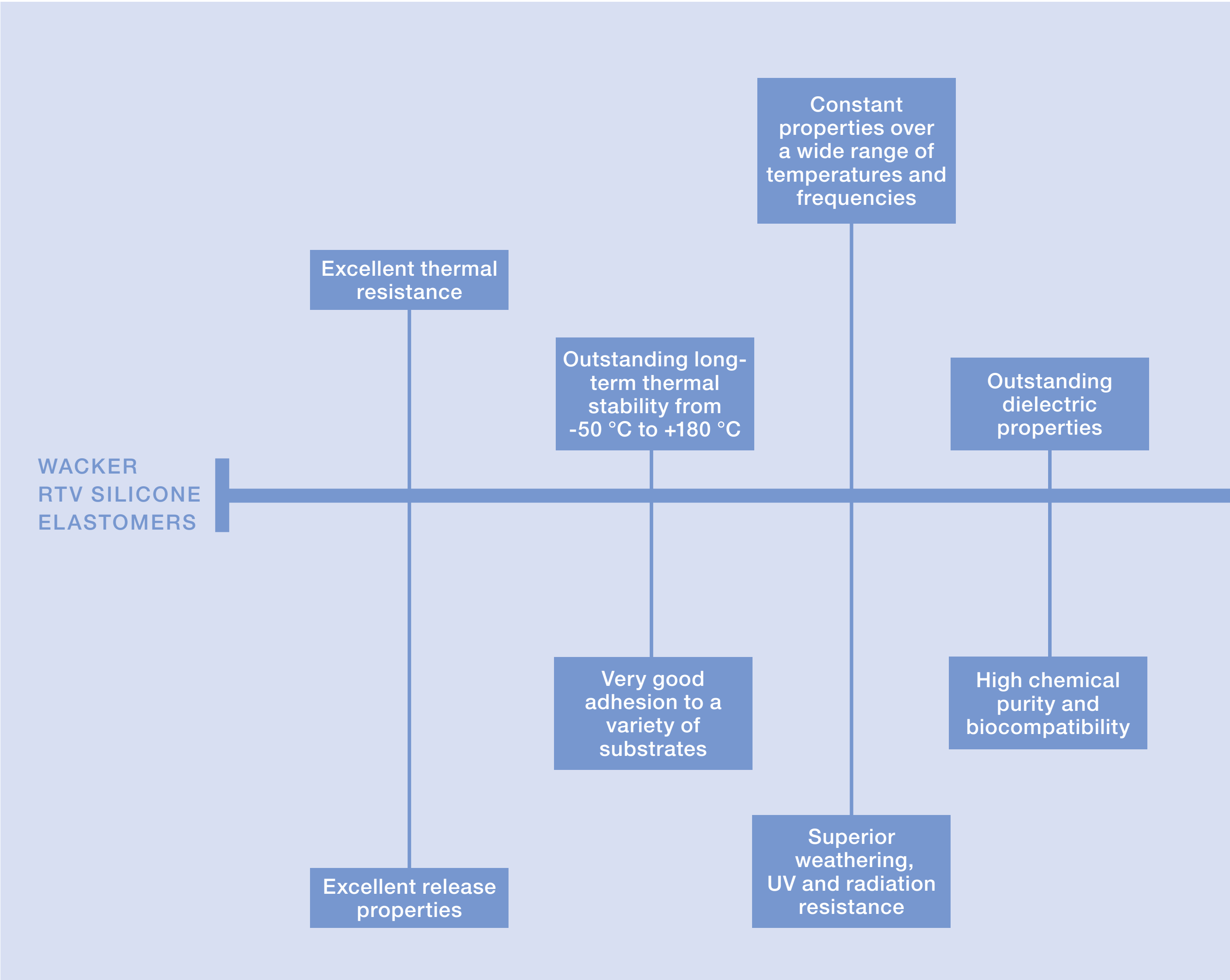
With more than 60 years' experience in silicone technology and an above-average commitment to R&D, WACKER has long become indispensable to its customers and participates in their technical progress. This would not be possible without ongoing, confidential dialog and the exchange of knowledge, experience and ideas, which powers a shared undertaking.

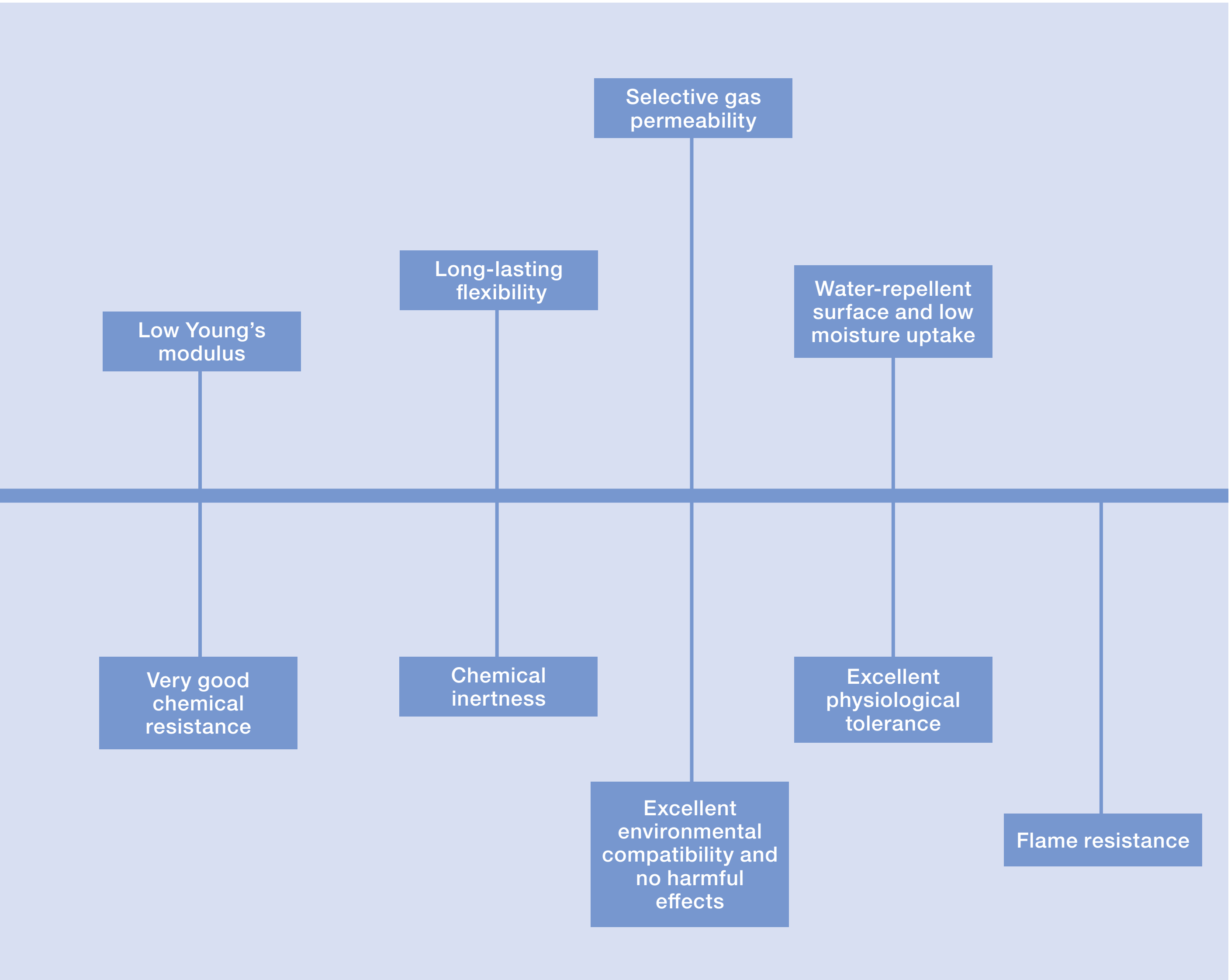
1.2
RELEVANT INDUSTRIES




Energy Sector
Solar industry
Wind power
Hydro power
Oil & gas
Food Industry
Lighting
LED
Secondary optics
Luminaires
Fire Safety Applications
Cable and pipe duct seals
Seat cushions
Orthopedics and prosthetics
Wound care
Dental care
Medical Applications
Construction molding
Industrial printing
Prototype molding
Composite industry
Reproduction molding
Molding and Mold Making
Gluing and fixing of silicones
O-rings, profiles
Rubber Industry
Utility vehicles
Marine industry
Railway systems
Transportation

1.3
GENERAL PROPERTIES OF RTV SILICONE ELASTOMERS




Selective gas permeability
Long-lasting flexibility
Low Young's modulus
Water-repellent surface and low moisture uptake
Very good chemical resistance
Chemical inertness
Excellent physiological tolerance
Excellent environmental compatibility and no harmful effects
Flame resistance

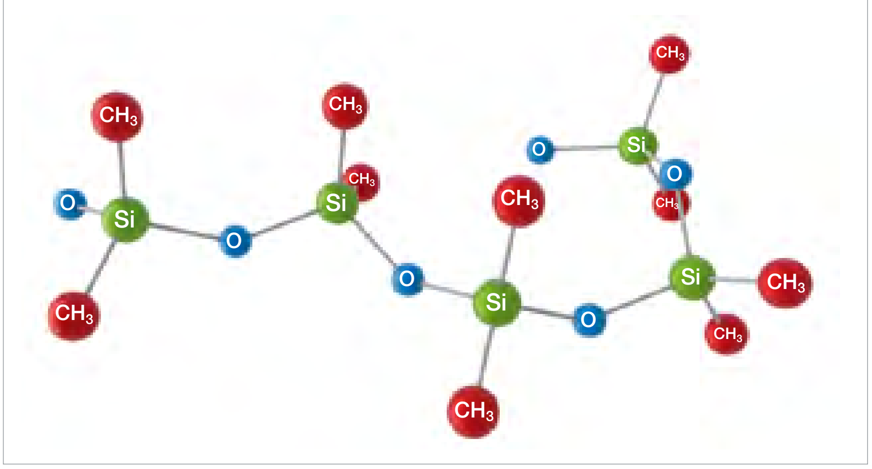
SECTION 2:
SILICONE RUBBER – BASIC PRINCIPLES

Contents

Benefit from the chemical structure, components, classes and property profile of our silicone rubber in your application.

2.1 CHEMICAL STRUCTURE

Section of a Polydimethylsiloxane Chain



From Quartz to Silicone

Silicones are made from quartz. While this raw material is available in practically unlimited quantities, the quality is crucial. WACKER converts quartz into silicon metal (Si) via a metallurgical process. Then silicon metal is transformed into silanes by an integrated production system based on the Müller-Rochow process. These silanes are the precursors of polysiloxanes. Polysiloxanes are macromolecules (polymers) comprised of a silicon-oxygen backbone with an organic moiety bound to the silicon atom. They are the basis for around 3,000 different silicone products.

The properties of silicone rubber vary greatly depending on the organic groups and the chemical structure. The organic groups may be methyl, vinyl, phenyl or other groups. According to DIN EN ISO 1043-1, silicones are classified as follows:

MQ: MQ, or polydimethylsiloxane (PDMS), denotes a polymer in which two methyl groups are bound to the siloxane backbone.

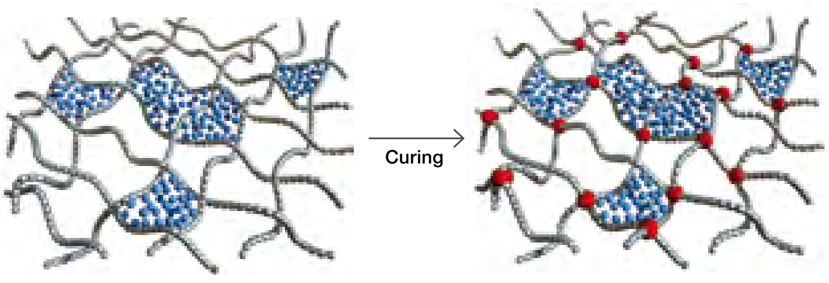
VMQ: VMQ stands for a polydimethylsiloxane in which a number of methyl groups have been replaced by vinyl groups.

PVMQ: PVMQ stands for a VMQ in which a number of methyl groups have been replaced by phenyl groups.

FVMQ: FVMQ stands for a VMQ in which a number of methyl groups have been replaced by fluorinated organic substituents.

2.2
COMPONENTS OF SILICONE RUBBER

Uncured, Filled Polymer Compared with Cured Rubber



Uncured polymer with filler.

Polymer with chemical crosslinks (red) forms a filled, elastic network.

Besides polysiloxanes of different chain lengths, uncured silicone rubber generally contains only a few additional substances, such as crosslinkers, fillers, additives and colorants.

Crosslinkers
A crosslinker is required to convert the uncured rubber into a mechanically stable cured product. Depending on the class of the silicone rubber, peroxides, silanes or SiH-containing polysiloxanes are required for crosslinking, also called curing or vulcanization.

Fillers
Fillers are needed to reinforce the elastic silicone network. The nature, composition and quantity of the fillers have a crucial influence on the properties of the uncured and cured rubber.

Reinforcing fillers

The most frequently used reinforcing filler is pyrogenic silica with very high BET surface areas (higher than 100 m^2/g). WACKER HDK® has proven to be especially effective, although precipitated silica, silicone resins or carbon black can also be used.

Non-reinforcing fillers

These function merely as a fill-up. Quartz, finely powdered calcium carbonate, talcum or diatomaceous earths, for example, increase the cured rubber's resistance to various media.

Additives
Compared with other elastomers, silicone rubber requires few additives because the essential properties are determined by the polysiloxane itself. Thus, a silicone rubber compound may comprise only polymer, cross-linker and filler.

The choice of additives determines the material properties and the processing at the customer. Additives can be catalysts, heat stabilizers, adhesion promoters, rheology modifiers and colorants, for instance. The fact that some of these additives are naturally colored should be taken into account by the customer as this may have an impact on the final color of the compound.

Colorants
Silicone rubber is generally transparent to opaque but can be colored according to customers' requirements. For this purpose, WACKER offers a broad range of pigment pastes that can easily be blended with RTV silicone rubber compounds.

2.3 CLASSES OF SILICONE RUBBER

Uncured silicone rubber is converted into elastomer by vulcanization. Depending on the curing method, the viscosity of the base polymer and the curing temperature, silicones are classified as follows:

- 1-part room-temperature vulcanizing silicone rubber (RTV-1)
- 2-part room-temperature vulcanizing silicone rubber (RTV-2)
- Liquid silicone rubber (LSR)
- High-temperature vulcanizing silicone rubber (HTV).

1-Part Room-Temperature Vulcanizing Silicone Rubber (RTV-1)

RTV-1 silicone rubber formulations are one-part, ready-to-use systems. They consist of polysiloxane, curing agent, fillers and additives. Right after application, the material starts crosslinking on contact with moisture in the air. Byproducts are released during curing. Crosslinking starts with the formation of a skin on the rubber surface and gradually progresses into the compound. Depending on the nature of the crosslinker, a small amount of acetic acid, amine or neutral byproducts, such as alcohol, is released during vulcanization. RTV-1 silicones are ideal for almost all sealing, bonding and coating applications. They are used in the automotive, construction, electrical engineering, electronics, health care, medical and textile sectors, among others, and also for household appliances.

2-Part Room-Temperature Vulcanizing Silicone Rubber (RTV-2)

RTV-2 silicone rubber formulations are two-part pourable, spreadable or kneadable compositions that vulcanize after mixing. They usually cure at room temperature (RTV = room-temperature vulcanizing) and form a highly elastic material. There are two different types of crosslinking reactions, either by condensation or by addition. Condensation curing requires an organotin catalyst and always releases byproducts. Addition curing requires a platinum catalyst and does not generate any byproduct.

Special RTV-2 silicone rubber grades can be flash vulcanized using UV light. The vulcanization time can be controlled by adjusting the UV intensity and exposure time.

For process reasons, addition-curing RTV-2 silicone rubber can be formulated as premixed one-component systems that contain a slow-acting catalyst and only vulcanize at elevated temperatures. These systems are characterized by a long shelf life (up to 12 months) when stored at room temperature (20 °C to 25 °C). This group is known as one-component heat-curing silicones and is classified as RTV-2.

Most RTV-2 silicone elastomers – silicone rubber in a cured stage – retain their full elasticity at up to 180 °C, even after long-term exposure. Some products even withstand short heat exposure up to 300 °C. At low temperature, they retain their flexibility down to -50 °C. Some special grades remain flexible even down to -110 °C. The extensive portfolio of RTV-2 silicone rubber products enables the production of silicone elastomers with extremely versatile and highly specialized properties.

Like RTV-1 silicones, RTV-2 formulations are ideal for almost all sealing, bonding and coating applications. They are used for mold making, household appliances and health-care applications as well as in a number of industries such as mechanical engineering, industrial process engineering, lighting technology electronics, optoelectronics and solar/photovoltaics.

WACKER silicone gels and silicone foams are special types of addition-curing RTV-2 silicones. Silicone gels are characterized by a particularly low crosslinking density and produce very soft vulcanisates below the Shore hardness range. They are suitable for various applications in industries such as: automotive, transmission and distribution, as well as health care or wound care. Specific gels such as low-temperature flexible gels and fluorinated materials were developed especially for the automotive industry. They exert only minimal stress on encapsulated components exposed to temperature fluctuations.

Silicone foam formulations are characterized by a high crosslinker content, namely, an SiH-rich polysiloxane. Its basic function is to crosslink the liquid formulation and release hydrogen, which acts as a blowing agent as curing progresses. Silicone elastomer foams are typically used in applications such as lightweight construction, damping, insulation and fire safety.

High-Temperature Vulcanizing Silicone Rubber (HTV)

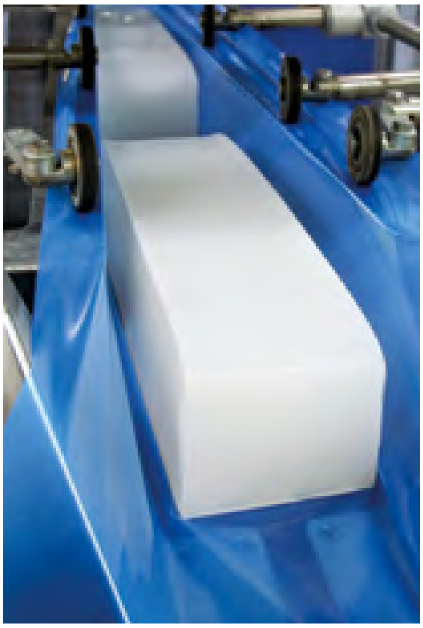
HTV silicone rubber contains long polymer chains with a high molecular weight, which provides the rubber with a solid consistency. For this reason, HTV silicone rubber is also called solid silicone rubber or High Consistency silicone Rubber (HCR). HTV silicone rubber cures by means of organic peroxides or a platinum catalyst at an elevated temperature.

Thanks to their outstanding mechanical properties, HTV silicone elastomers are used in a large variety of applications in the automotive, electrical engineering, transmission and distribution, construction, mechanical and process engineering, food, health-care and medical industries.

Liquid Silicone Rubber (LSR)

Liquid silicone rubbers are high-temperature-vulcanizing silicones. Their consistency and addition-curing mechanism provide them with unique processing advantages. Liquid silicone rubber has a lower viscosity than solid silicone rubber (HTV). It is thus pumpable and delivered as a two-component and ready-to-use system. LSR is an addition-curing silicone, where the curing catalyst in component A is a platinum compound and in component B, the curing agent is an SiH-functional polysiloxane. No byproducts are released during the LSR curing process.

Like all silicones, LSR is also used in a wide range of industries: automotive, mechanical and process engineering, electrical engineering, transmission and distribution, construction, food, health care, baby care and the medical sector. WACKER offers specific automotive applications, like fluorinated LSR, which is highly stable on contact with media such as gasoline, engine and gear oils.



Solid silicone rubber bar (standard supply form)..

2.4

PROPERTIES OF SILICONE RUBBER

Inherent Properties

Silicone elastomers are generally expected to be heat resistant and flexible at both high and low temperatures. In contrast to organic rubbers, this doesn't come at the expense of the other properties. Silicone elastomers keep their excellent mechanical properties over a very wide temperature range. These characteristics, intrinsic to silicone elastomers, are attributable to the polymer and filler structure, not additives or surface treatment.

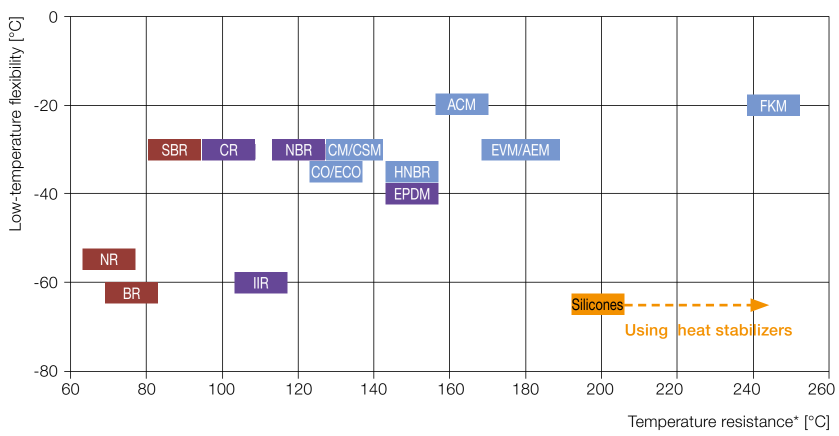
Material Benefits Resulting from the Polymer Structure

Silicones are characterized by a fully saturated backbone of alternating silicon and oxygen atoms. The Si-O links in the chain have an exceptionally high bond energy of 451 kJ/mol. By comparison, C-C links have a bond energy of 352 kJ/mol. At the same time, the Si-O chain mobility is very high. The organic side groups shield the backbone, so that the surface energy is low.

This results in the following properties:

- Excellent high-temperature resistance combined with low-temperature flexibility
- High resistance to chemicals and environmental influences
- Excellent weathering, UV and radiation resistance
- Water-repellent surface.

Low-Temperature Flexibility versus High-Temperature Resistance



* Temperature at which – after 1000 h – half of the initial elongation at break remains

Material Benefits Resulting from the Filler Structure

Silicone rubber usually contains pyrogenic silica as a filler, e.g., HDK® from WACKER. Since pyrogenic silica and polysiloxanes are very similar in structure, high compatibility is a given, resulting in the following characteristics:

- High transparency
- Good mechanical properties thanks to effective polymer-filler interaction
- Flame resistance and non-toxic combustion products in the case of fire.

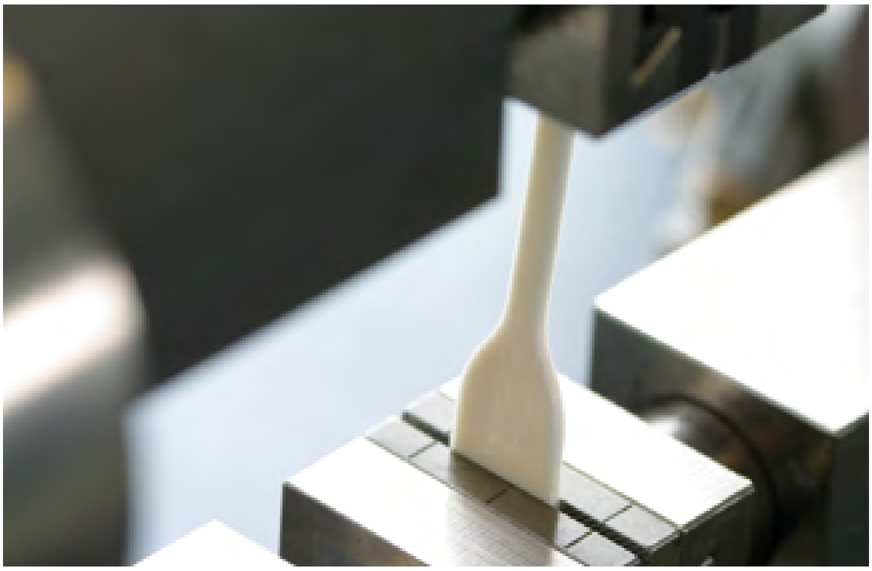
High Purity

Compared to many organic elastomers, silicones are considered exceptionally pure. Thanks to their biocompatibility and physiological inertness, silicone elastomers are highly suitable for applications in the food, medical and electronic sectors. For this purpose, WACKER has developed the SILPURAN® brand and specific products within the ELASTOSIL® and SEMICOSIL® ranges. Some of these products feature an exceptionally low ionic or volatile compound content.

2.5
PROPERTIES OF RTV SILICONE ELASTOMERS

General Properties of RTV Silicone Rubber

- Outstanding long-term thermal resistance from -50 °C to +180 °C; Specialty grades: down to -110 °C or up to 270 °C (peak temperature load may be even lower or higher)
- Only slight changes in physical properties between -50 °C and +180 °C
- Low elasticity modulus
- Coefficient of linear thermal expansion approx. $150 \cdot 10^{-6}$ – $300 \cdot 10^{-6}$ m/(m·K)
- Outstanding dielectric properties
- Constant properties over a wide temperature and frequency range
- Electrically insulating
- High weathering, UV and radiation resistance
- Fire retardant
- Very good chemical resistance
- Easy to process
- Water-repellent surface paired with low moisture uptake
- Odorless and tasteless (many grades are BfR and FDA compliant)
- High chemical purity
- Chemical inertness and biocompatibility
- High gas permeability



Typical Range of Mechanical Properties

- Density: from 0.97 up to over 3 g/cm^3
- Hardness: 20 Shore 00 - 80 Shore A, or jellylike
- Tensile strength: 2 - 10 N/mm^2
- Elongation at break: 100 - 900 %
- Tear strength (ASTM D 624): 5 - 30 N/mm
- Compression set (22 h /175 °C) ≥ 5 %

Main Property Options

- (Self-)Bonding or non-adhesive
- Thermally insulating or thermally conductive
- Electrically insulating or electrically conductive
- Wide range of viscosity and hardness
- Pigmentable

SECTION 3: UNDERSTANDING RTV SILICONES

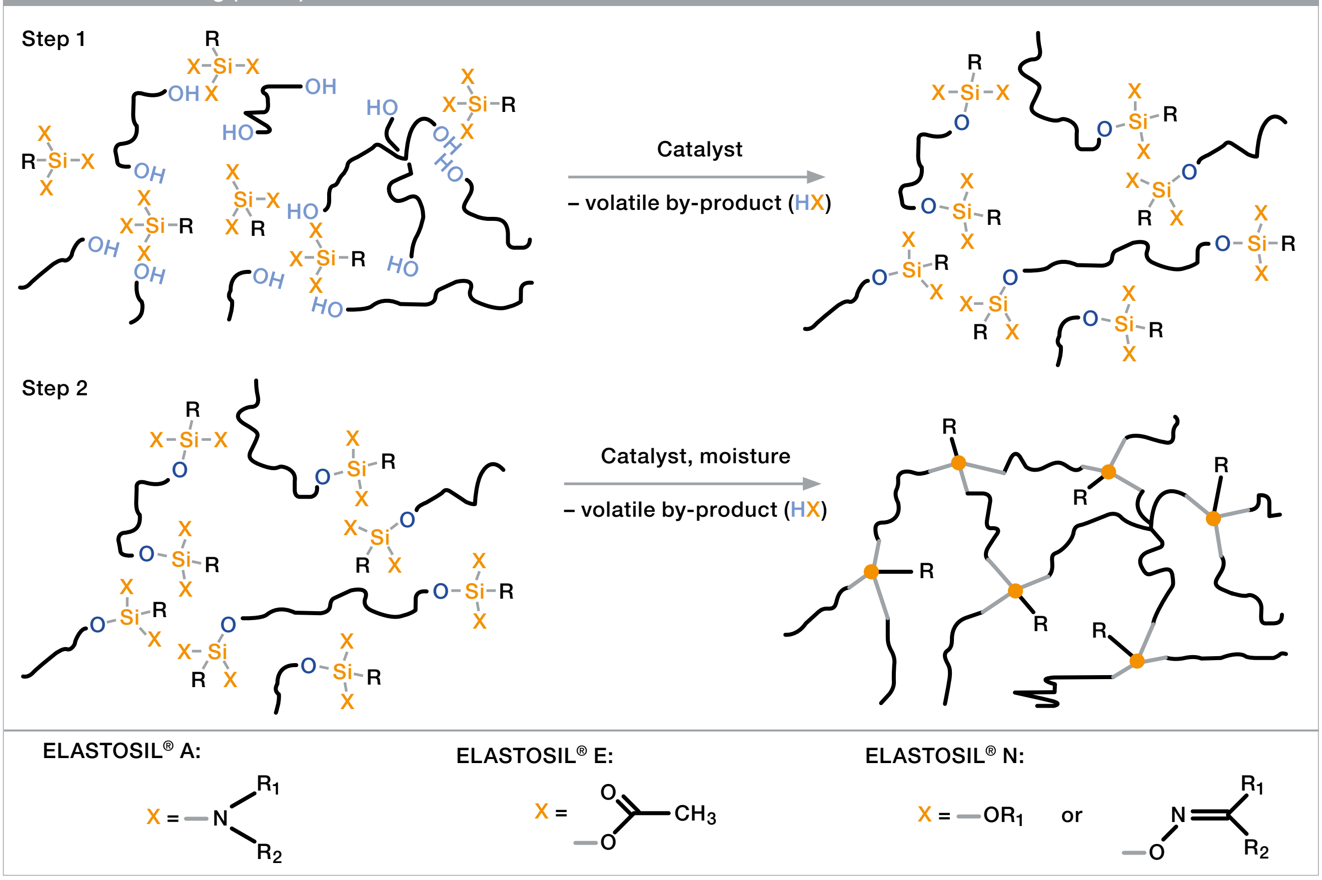
Contents

Short cycle times for mass production or ease of processing with minimal investment – RTV silicones score with advantageous properties.

3.1

RTV-1 SILICONE RUBBER

Condensation Curing (RTV-1)



WACKER's RTV-1 silicone rubber compounds are one-component sytems that cure at room temperature. Thanks to their ease of processing, ELASTOSIL® RTV-1 silicones are preferred for applications involving thin layers and tolerable curing times. However, these grades require long curing times if applied in thick layers. This is not compatible with the short cycle times required in mass production. In such cases, fast-curing RTV-2 systems, one-component heat-curing silicones, or UV-curing grades are more advantageous. In all other cases, RTV-1 is appropriate.

ELASTOSIL® RTV-1 silicones owe their popularity to their advantageous properties in combination with minimal investment.

Benefits at a Glance

- Very easy handling and processing
- Low capital investment for processing equipment
- Very good adhesion to a large variety of substrates
- Insensitive to inhibition by other substances
- Available as flowable, self-levelling or non-sag grades

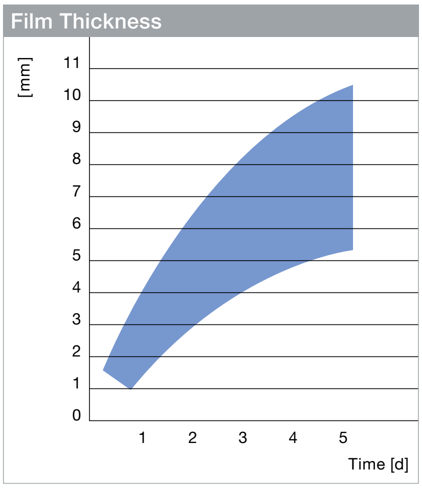
Curing Chemistry

ELASTOSIL® RTV-1 silicone rubber compounds consist of polysiloxanes, curing agents, fillers and, in some cases, solvents and/or additives. RTV-1 silicones require air moisture to cure. Since a small amount of by-products is released during crosslinking, RTV-1 silicones are classified as condensation-curing materials.
The various RTV-1 systems available at WACKER use different types of curing agents. Small amounts of byproduct specific to the curing agent used are released during curing:
ELASTOSIL® E: acetic acid
ELASTOSIL® A: amine
ELASTOSIL® N: oxime or alcohol.

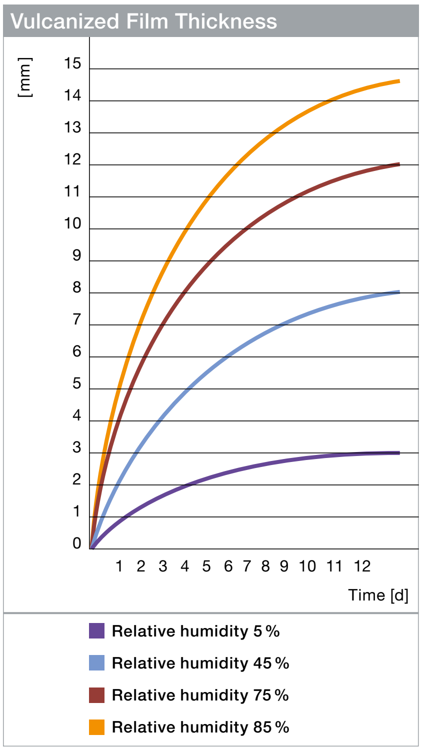
Skin Forming and Curing

The crosslinking of RTV-1 silicone rubber starts on contact with air moisture. Beginning with the formation of a skin on the surface of the silicone rubber, it gradually works its way into the compound. The curing rate of these silicones is limited by the diffusion speed of the moisture, which typically averages 1 – 2 mm per day at 23 °C and 50 % relative humidity. The rule of thumb is: The higher the relative humidity, the faster the curing rate.

If air access is limited or only possible from one side, the thickness of the applied silicone should not exceed 10 mm. In closed configurations without air access, curing is not possible at all. In such cases, addition-curing RTV-2 silicone rubber grades are recommended.



Vulcanization rate of various RTV-1 silicone rubbers at 50% relative humidity and 23 °C in aluminium pans measuring 24 mm in diameter and 18 mm in depth.



Exemplary vulcanization rate of ELASTOSIL® RTV-1 grades as a function of relative humidity at room temperature.

Increasing Curing Speed

Temperature has a minor effect both on the skin forming time and curing speed of RTV-1 silicone rubber. Curing time can be greatly reduced by increasing the relative humidity. In some special cases, increasing the temperature may help to reduce curing time. The temperature should be raised slowly in order to allow the byproducts and solvents to evaporate. The final temperature may be as high as 200 °C provided that the silicone material films are thin (less than 0.5 mm thick). If the films are any thicker, blistering is likely to occur. Curing is still possible down to approx. -15 °C.

The curing rate of ELASTOSIL® A grades can be accelerated by exposure to a humid atmosphere slightly enriched with up to 1 vol. % of carbon dioxide. During exposure, the relative humidity in the curing chamber or curing tunnel must not exceed 60 %. In fact, optimal curing is achieved using 0.3 to 0.5 vol. % ofCO_2 at 30 % to 35 % relative humidity combined with moderate temperature (40 °C to 50 °C, e.g., by using infrared lamps). This method, which is particularly suitable for coating processes, enables full curing of a 500 micron silicone layer within 5 minutes.

3.2
RTV-2 SILICONE RUBBER
CONDENSATION-CURING RTV-2 SILICONES

Depending on the application, WACKER offers different RTV-2 silicone rubber grades under the brand names ELASTOSIL®, SEMICOSIL®, LUMISIL®, SILPURAN®, POWERSIL®, WACKER SilGel® and CENUSIL®. RTV-2 silicone rubber formulations are two-component systems that cure when component A (also called rubber base or base compound) is mixed with component B (also called curing agent). RTV-2 silicones can be further classified by curing systems.

Condensation-curing ELASTOSIL® RTV-2 silicones consist of two components. Component A contains polymer and – if required – fillers and additives. Component B contains crosslinker and a catalyst. When components A and B are mixed, the mixture immediately starts curing to form the elastomer. The mixing ratio A:B varies between 1:1 and 100:1, depending on the selected grade. For non-adhesive potting or mold making grades, the proportion of component B typically ranges from 3 to 5 wt.% based on component A. In contrast, the two components of self-adhesive, condensation-curing ELASTOSIL® RTV-2 silicones typically have an A:B mixing ratio of 8:1 to 12:1.

Important

In condensation-curing RTV-2 silicone , the rubber base (component A) and the curing agent (component B) always have different lot numbers.

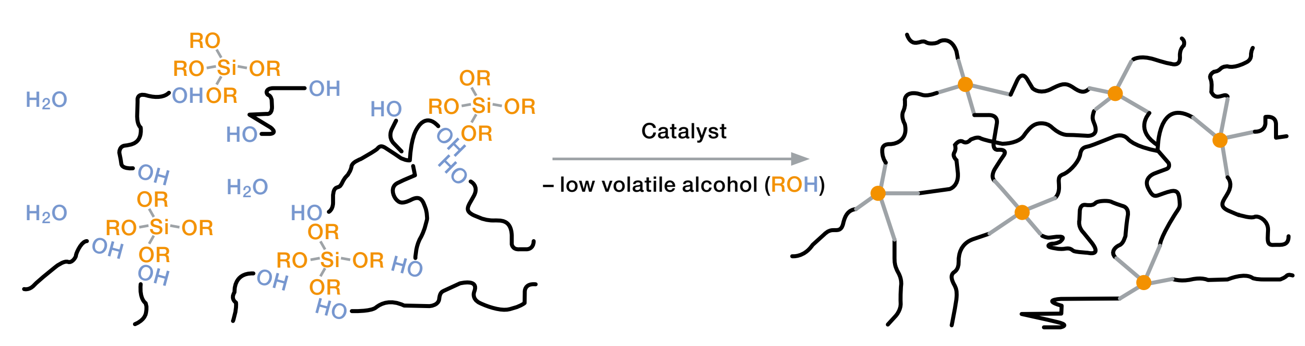
Benefits at a Glance

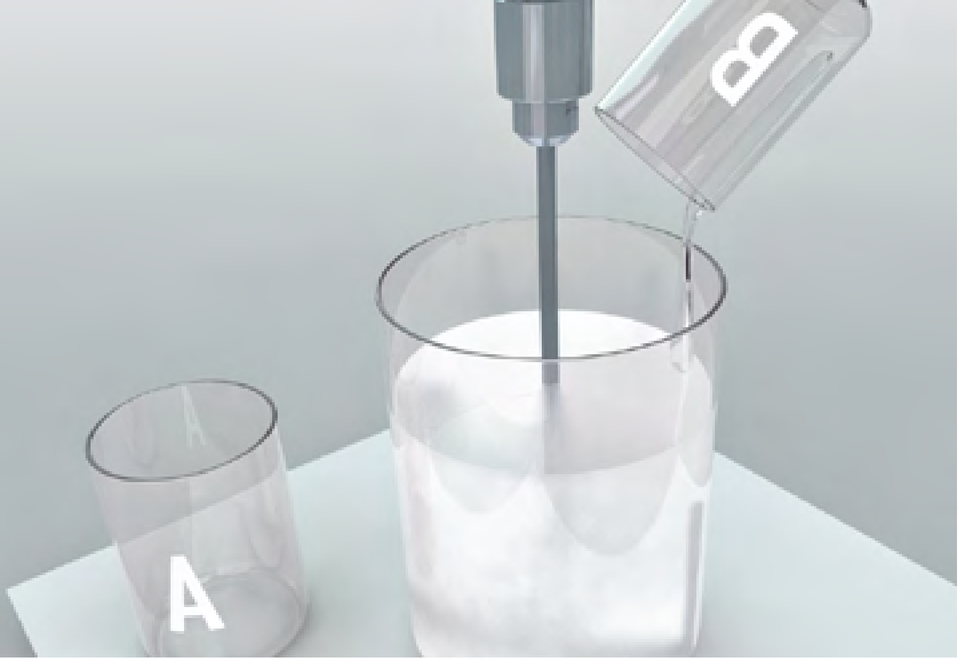
- Rapid curing, compared to RTV-1 silicones
- Crosslinking can be slightly accelerated by raising the temperature
- Curing of thick layers possible
- Flowable, self-leveling or non-sag grades
- Self-adhesive grades with very good adhesion to a large range of substrates
- Almost insensitive to inhibition by the presence of other substances

Curing Chemistry

From the chemical point of view, the crosslinking of condensation-curing RTV-2 silicones is similar to the vulcanization of RTV-1 silicone rubber. However, and in contrast to the latter, the moisture required to properly cure RTV-2 silicones is already included in the base compound (component A). Condensation-curing ELASTOSIL® RTV-2 silicone rubber therefore does not require air moisture to vulcanize, making it suitable for substrate configurations where air access is limited. As the system crosslinks, alcohol is released as a byproduct. This causes a reduction in weight and three-dimensional shrinkage of the vulcanizate to the order of < 3 % by volume.

Condensation Curing (RTV-2)



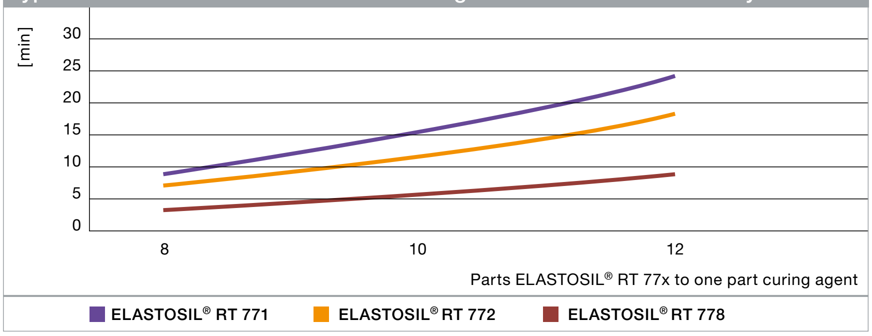


Potlife and Curing Time

The reactivity of condensation-curing RTV-2 silicone rubber is described by the parameters "potlife" and "vulcanizing time" (or "curing time"). The potlife usually indicates the maximum period of time during which the mix of component A and B is still pourable, spreadable or kneadable. For applications in which good flowability is an important requirement (e.g., encapsulating electrical or electronic components with very small gaps), the time required for the initial viscosity value to double is often quoted as the potlife.

Curing is characterized by an increase in viscosity that causes reduced flowability and a decrease in plasticity. Therefore, the material should be used before the potlife has elapsed. The figures for the vulcanizing time quoted in the technical data sheet specify the time for the rubber to cure until it is tack-free, i.e., when it can be touched without feeling sticky (except silicone gels, which remain tacky). The ultimate properties, however, are usually reached after some hours or even days. The cured rubber should not be used until all byproducts formed have completely evaporated.
Potlife and vulcanizing time can be modified within limits by choosing a fast or slow curing agent and by adjusting the ratio of base compound (component A) to curing agent (component B). Catalysts and mixing ratios are specified in the technical data sheets of each rubber grade.

Typical Potlife Values as a Function of Mixing Ratio with WACKER® Catalyst T 77



Modifying Curing Speed

Condensation-curing ELASTOSIL® RTV-2 silicone elastomers typically have a potlife range between 5 and 45 minutes, and take 15 to 90 minutes to cure. Both potlife and curing time can be adjusted by selecting either a "slow" or a "fast" curing agent and by varying the mixing ratio within certain limits. To ensure reliable processing, however, the potlife must not be less than 2 minutes. The more curing agent used, the shorter the curing time.

If the amount of curing agent (component B) is lower than prescribed, incomplete curing will result yielding soft or even tacky rubber with low mechanical strength. The elastomer's resistance to swelling by solvents or casting resin components is also significantly reduced. If the amount of curing agent is higher than prescribed, the resulting elastomer contains an excess of crosslinking agent resulting in the following effects:

- Decreased release properties of the rubber
- Increased hardness
- Reduced elasticity
- Embrittlement (where air moisture is present, the elastomer will carry on curing).

Curing speed can be slightly accelerated by raising the temperature. Heating, however, must not exceed 80 °C before curing is completed, otherwise the silicone rubber could be destroyed. At temperatures above 80 °C, the crosslinking reaction is reversed and the system either remains tacky or the consistency reverts to a soft state.

Modifying Adhesive Properties

Depending on the type of curing agent, condensation-curing ELASTOSIL® RTV-2 silicone elastomers are self-adhesive or non-adhesive. For example, it is possible to transform non-adhesive ELASTOSIL® M grades into self-adhesive material by choosing a curing agent from the WACKER® Catalyst T7x or WACKER® Catalyst T8x series.

3.2
RTV-2 SILICONE RUBBER
ADDITION-CURING RTV-2 SILICONES

Two-Component Silicones
Addition-curing RTV-2 silicone rubber compounds consist of two components (A and B), one of which contains polymer and crosslinker, the other, polymer and a platinum catalyst. When the two components are mixed, they cure to form the elastomer product.

The mixing ratio of addition-curing RTV-2 silicone rubber components is typically 1:1, 9:1 or 10:1 by weight, depending on the chosen product. A different ratio of A:B generally can lead to incomplete curing or to significant changes in the product properties. Unless otherwise specified, the two components must always have the same batch number.

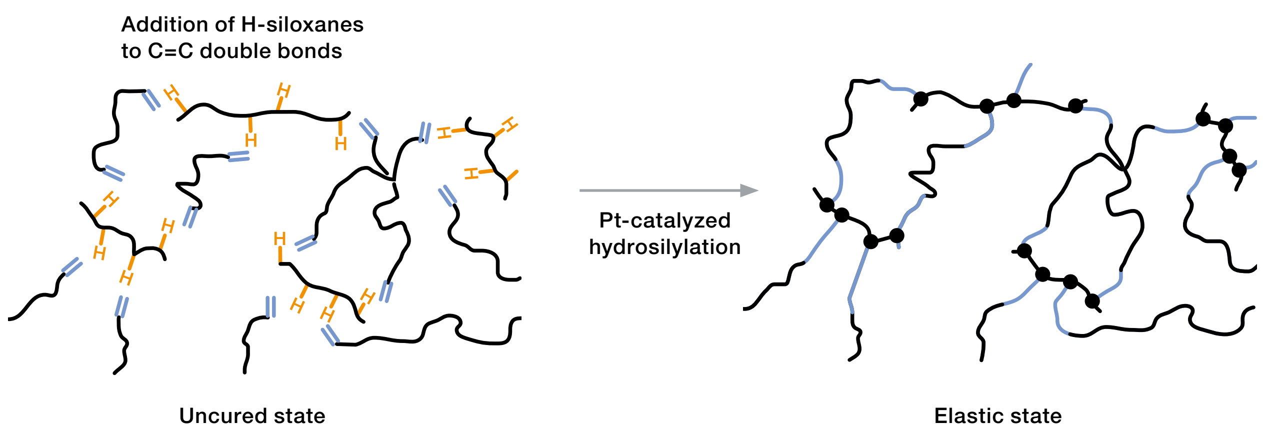
Benefits at a Glance

- Rapid curing at room temperature, even of thick layers
- Crosslinking is significantly accelerated by raising the temperature
- No byproducts, no weight loss and practically no shrinkage (< 0.1 %) on curing
- Self-adhesive grades show very good adhesion to a large variety of substrates
- Low compression set
- Excellent media resistance
- Outstanding heat resistance
- Available as flowable, self-levelling and non-sag grades

Curing Chemistry

Addition-curing RTV-2 silicones cure via a completely different mechanism to that of condensation-curing systems: when the two components are mixed, the polymer, a platinum catalyst and the curing agent are brought into contact with each other. During this reaction, the polymer chains crosslink through hydrosilylation of the vinyl groups by means of the hydrogen-containing crosslinker. Since no volatile byproducts are formed during crosslinking, there is neither a risk of reversion of the crosslinking reaction at elevated temperature, nor chemical shrinkage of the vulcanizate due to weight loss.

Addition Curing



Potlife and Curing Time

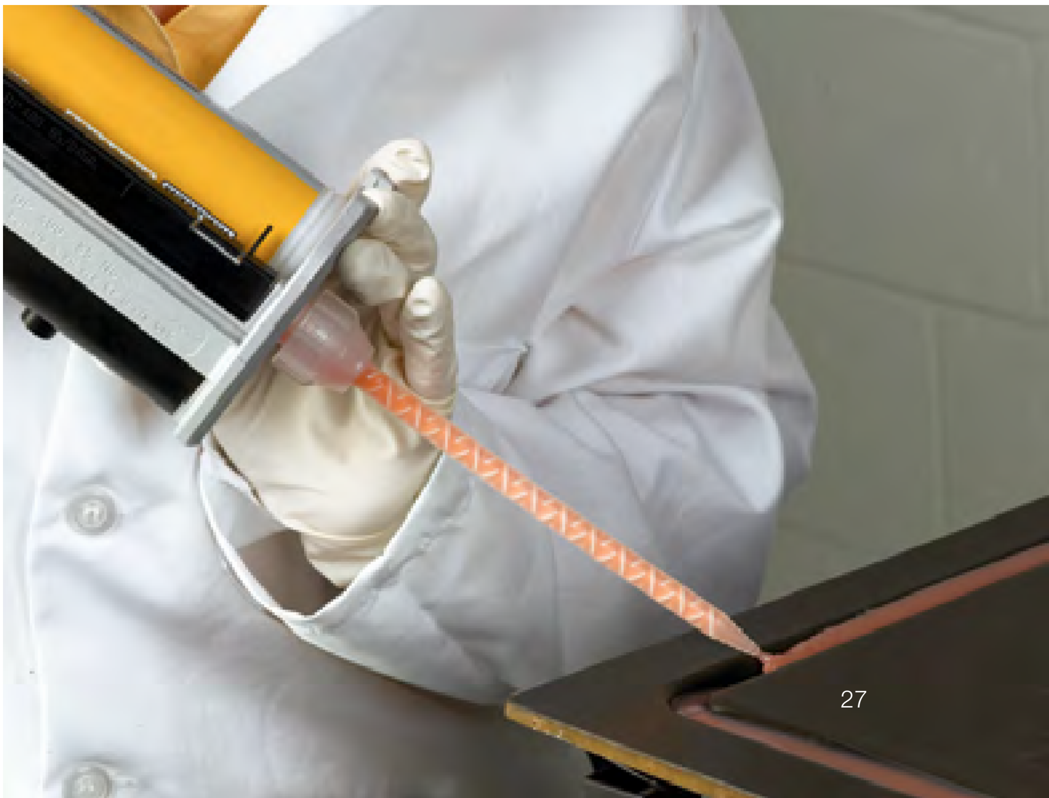
As with condensation-curing RTV-2 silicones, the reactivity of addition-curing RTV-2 silicone rubber formulations is described by the parameters "potlife" and "vulcanizing time". The potlife usually indicates the maximum period of time during which the catalyzed mix of A and B is processible (or during which the initial viscosity has doubled in value). The figures quoted for the vulcanizing time specify the time to cure until tack-free. The average potlife of RTV-2 silicones typically varies between 30 minutes and 6 hours. For specific grades it can be a few minutes.

Room-temperature-vulcanized addition-curing silicone elastomers reach their ultimate properties after some days. Even vulcanizates produced at a relatively high temperature and therefore usually presumed usable immediately after curing, sometimes continue to crosslink to a certain extent during the subsequent room-temperature ageing. However, the ultimate properties of the vulcanizate can be reached fastest by ageing the cured RTV-2 silicone rubber for several hours at relatively moderate temperatures (100 °C - 120 °C), also known as post-curing.

Modifying Curing Speed

Unlike condensation-curing RTV-2 silicone elastomers, the curing rate of addition-curing RTV-2 silicones can be controlled additionally by altering the temperature, but not by changing the mixing ratio. Therefore, increasing or decreasing the temperature shortens or prolongs both the potlife and curing time. As a rule of thumb, a temperature change of approx. 10 °C halves or doubles potlife and curing speed.

As an alternative, the potlife and curing time can be modified within wide limits by adding WACKER® Inhibitor PT 88 (longer potlife), or WACKER® Catalyst EP (shorter potlife). For further information, please refer to the respective flyer.



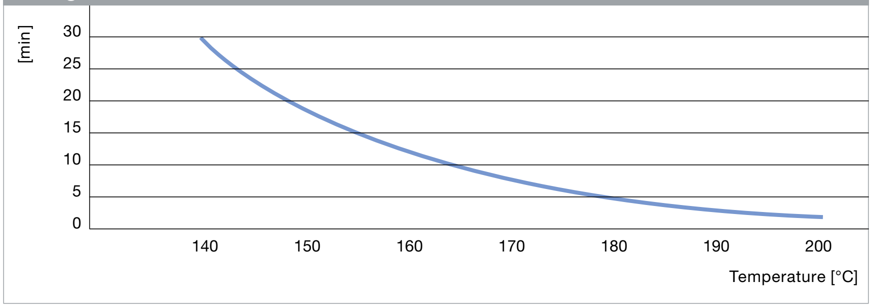
3.2
RTV-2 SILICONE RUBBER
ADDITION-CURING RTV-2 SILICONES

One-Component Heat-Curing Silicones
One-component, heat-curing silicones contain the same components as the two-component addition-curing silicones, but they are supplied as one-part products with an appropriately long shelf life at ambient temperature. Consequently, they cure by the same chemical reaction, but they need to be heated to the kick-off temperature in order to start the curing process.

The obvious advantage of one-component, heat-curing silicone rubbers is that they can be processed without mixing equipment, making them suitable for both short and long production runs. They should be favored over two-component addition-curing silicones if mixing equipment for two-component products cannot be purchased for technical or financial reasons.

The curing speed of one-component heat-curing silicones depends only on temperature. They are typically cured between 130 °C – 200 °C. Below this range, crosslinking takes much longer or doesn't even start. This may result in poor adhesion, depending on the nature of the substrates. Conversely, excessive temperature disturbs the vulcanization process and impairs the properties of the vulcanized material.

Curing ELASTOSIL® RT 70x Grades

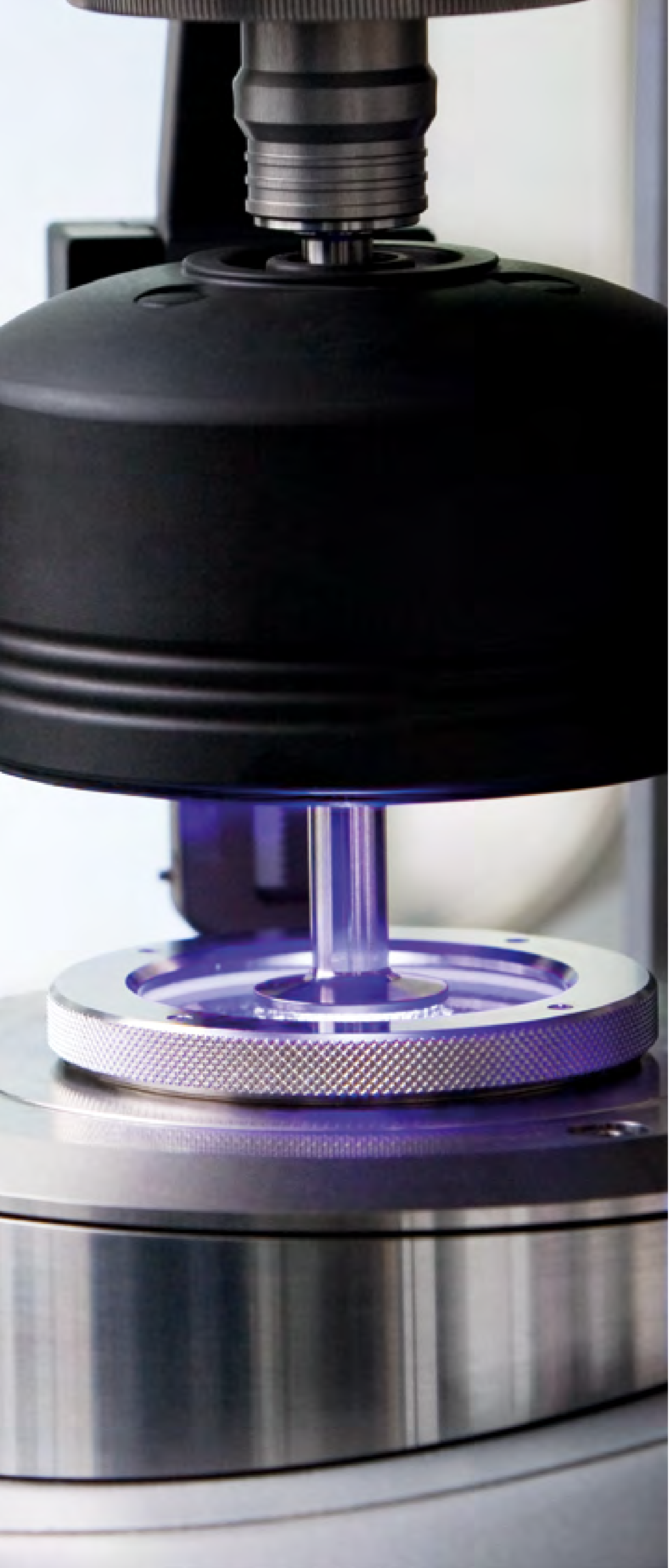


Please Note

These products are ready to use and do not accommodate fine adjustments of curing speed by adding inhibitor or platinum catalyst. Detailed information about kick-off temperature and curing speed at various temperature levels are shown in the corresponding technical data sheet.

Benefits at a Glance

- Low capital investment
- Suitable for short production runs
- Long potlife at room temperature
- Short curing time at elevated temperature
- Very good adhesion to many substrates
- Available as flowable, self-levelling and non-sag grades



UV-Curing Silicones
In order to support high productivity for large-scale series in customer processes, WACKER has developed UV-curing silicones. These addition-curing silicones contain a unique catalyst that is inactive in the dark. UV light is required to activate the catalyst that triggers the crosslinking reaction. This is basically the same chemical reaction as for addition-curing RTV-2 silicones.

WACKER's UV grades only need to be irradiated for a few seconds. They then cure completely and rapidly – within a few seconds to a few minutes – at room temperature. The higher the irradiation intensity, the greater the number of active catalyst molecules and the faster the silicone's curing speed. As long as the material is not exposed to UV light, it remains processible. However, once active catalyst molecules have been generated, curing willcontinue even if the UV light is switched off.

Please Note
The UV catalyst is also sensitive to daylight.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SECTION 4:
PREPARING FOR PRODUCTION

Contents

Well begun is half done: From safety, systematic selection and working with RTV silicones to physical and chemical surface-preparation methods.

4.1
SAFETY FIRST

Safety Precautions
Before processing WACKER products, please carefully read the corresponding material safety datasheet available from WACKER subsidiaries on request or visit WACKER's website (www.wacker.com) where detailed information on all safety matters can be found.

For most WACKER silicone rubber products, standard industrial hygiene precautions are adequate for handling and processing. However, a few products are classified as hazardous and therefore require special safety measures.

For example, curing agents for condensation-curing RTV rubber formulations may cause skin or eye irritation after direct contact. Therefore, appropriate protective measures have to be taken. Additionally, condensation-curing RTV silicones release small amounts of amine, acetic acid, oxime or alcohol during vulcanization.

Some RTV silicone rubber grades may also contain volatile solvents. Vapor formed during vulcanization should not be inhaled. Additionally, the flammability of all volatile compounds must be taken into account. The work place should be well ventilated in accordance with the threshold limit values (TLV) of the respective country.

If, despite all protective measures, skin contact with uncured RTV silicone rubber occurs, clean the affected area immediately with soap and water. If uncured silicone rubber comes into contact with the eyes, irrigate them immediately with copious amounts of water for several minutes. If the irritation continues, immediately seek medical advice.

Cleaning
In the case of spillage, remove the bulk of unvulcanized RTV silicone with a spatula, paper or a rag. Residues can then be washed off with a grease-dissolving solvent, such as acetone, methyl ethyl ketone (MEK), isopropanol, white spirit or a similar isoaliphatic solvent. All tools should likewise be cleaned immediately after use before the silicone rubber has vulcanized. When machines or dispensing equipment are cleaned, white spirit or similar non-polar solvents are recommended. Ideally, cleaning should take place before the rubber is fully vulcanized.

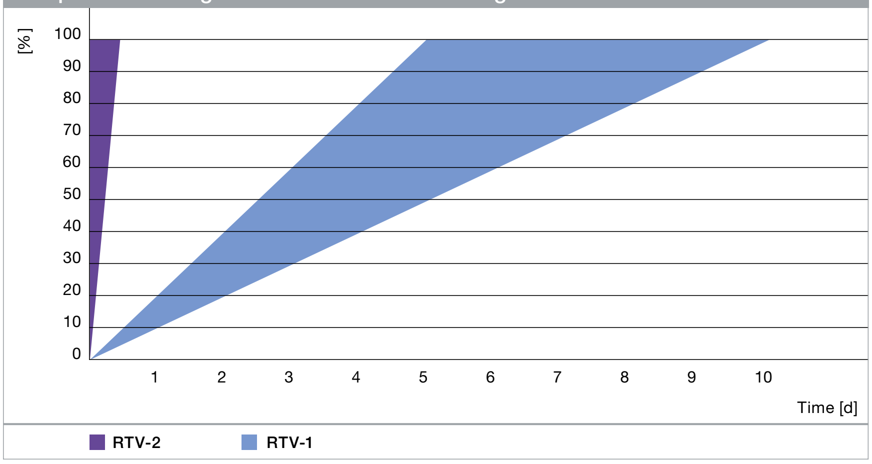
Fully cured silicone rubber is removed mechanically, if necessary, after using a non-polar solvent to swell it. It can also be removed with any commercially available silicone remover or by pyrolysis. It is best to allow surplus catalyzed mix to cure in the containers, after which it can be readily removed.

Instructions for proper disposal of the uncured components and vulcanizates are also included in the respective safety data sheet.

4.2
SYSTEMATIC SELECTION

WACKER offers different RTV silicones marketed under the brand names ELASTOSIL®, SEMICOSIL®, LUMISIL®, SILPURAN®, POWERSIL®, WACKER SilGel® and CENUSIL®. The processing properties may differ substantially. It is essential to select the silicone system that suits the customer's production requirements best.

Comparative Curing of a 10-mm Silicone Coating



Silicone Systems and Production Requirements

Fast curing ↑

RTV-2 Silicones
- Addition-curing and condensation-curing 2-part systems that vulcanize at room temperature
- Dual-component metering equipment is needed to process them
- Rapid curing time of a few minutes is achieved by working at elevated temperatures or selecting a suitable curing agent

One-Component Systems
- One-component systems that cure exclusively at high temperature
- Simple metering equipment suffices to process them
- Curing is fast, sometimes only minutes

RTV-1 Silicones
- One-component systems that cure at room temperature
- Simple metering equipment suffices to process them; these rubber grades can even be applied manually
- Air moisture is needed for curing

Easy processing →

4.3

WORKING WITH RTV SILICONES

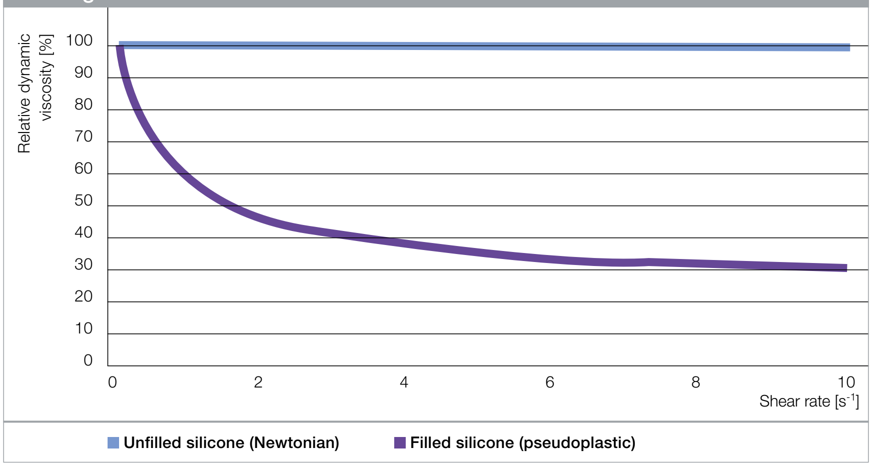
The essential features of room-temperature curing silicone rubber are:

- Consistency
- Viscosity
- Reactivity
- Mechanical properties
- Dielectric properties
- Heat resistance

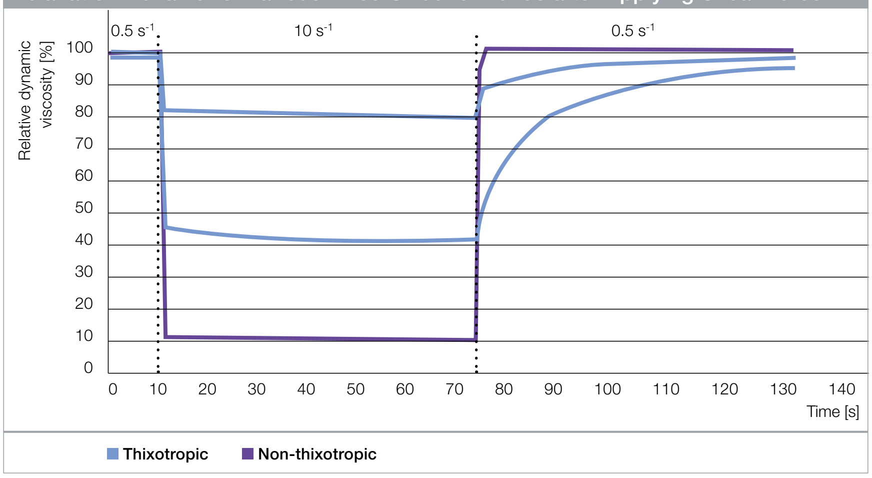
Consistency

According to the type, WACKER RTV silicone rubber compounds can be pourable, spreadable, non-sag or kneadable. Depending on their consistency, they are suitable for a large number of processing techniques, including spraying, dipping, potting, encapsulating, silk-screen printing and automated application of sealing beads. Non-sag (also called non-slump) grades differ from spreadable grades in their reduced flowability: up to a specific maximum thickness (usually 10 mm), they neither sag nor run off from a vertical or inclined surface. The consistency of kneadable compounds is usually characterized by quoting the penetration. It is determined by using a standard cone under a specific load and given in mm/10. The higher the penetration value, the softer the compound.

Rheological Behavior of Silicones



Relaxation Behavior of Various Filled Silicone Blends after Applying Shear Force



Viscosity

The suitability of a compound for a particular processing method is dictated by its rheological properties, for example, its viscosity. The viscosity of a material describes its flow characteristics. The higher the viscosity, the less pourable or the stiffer the compound. The viscosity of RTV silicone rubber compounds is usually between 500 and 2,000,000 mPa·s. The viscosity further depends on the temperature. Precise temperature control during measurement is therefore essential.

Newtonian fluids have a constant viscosity independent from the shearing. In non-Newtonian fluids, the viscosity depends on the shearing and therefore the viscosity needs to be quoted for specific shear rates.

The compression set is defined as the permanent deformation remaining when a force is removed and it is given as the percentage of original specimen thickness. The lower the value, the higher the resilience of the silicone elastomer. Condensation-curing silicones usually exhibit a high compression set, whereas addition-curing grades show values below 20 %.

The viscosity given for high shear-rates characterizes the flow properties of the compound under intense shearing, for example during metering, extrusion, stirring, knife-coating, etc. The viscosity given for low shear rates describes the performance under low or zero shearing, for example the flow of the compound after application. Many RTV silicone rubber formulations show non-Newtonian and shear thinning behavior. In such cases, it is always necessary to quote the viscosity together with the shear rate at which it has been measured.

If viscosity doesn't recover immediately after shearing, but is retarded over time, this behavior is called thixotropic. The rheological properties of thixotropic silicone rubber formulations therefore depend on the preliminary treatment, e.g., pumping, stirring, or mixing.

Reactivity

As described above, the reactivity of RTV silicones is characterized by either skin-forming time (RTV-1) or potlife / curing time (RTV-2) or kick-off temperature (one-component heat curing grades). The reactivity of RTV-2 silicone rubber formulations can be modified by the choice of catalyst, mixing ratio and temperature, whereas the curing of RTV-1 grades can be accelerated by increasing relative humidity up to 80%.

Mechanical Properties

The properties of vulcanized silicones are determined to some extent by the type of curing system. For applications causing high mechanical stress, addition-curing grades are more suitable than their condensation-curing counterparts.

The most relevant mechanical properties of cured RTV silicones are hardness, tensile strength, tear resistance, elongation at break and compression set.

The hardness is measured by indentation and is usually quoted on the Shore A scale: the higher the Shore A value, the harder the cured rubber. However, the hardness of printing pads or silicone gels is too low to allow measurement of the Shore A hardness. The Shore 00 indentation scale is used for very soft materials and the penetration is quoted for even softer materials. Whereas higher values mean greater hardness for both Shore 00 and Shore A hardness, the reverse is true for penetration: the higher the value, the softer the vulcanizate.

Tensile strength, tear resistance and elongation at break are derived from stress-strain graphs determined by standardized tensile tests. Materials with a tear strength of >10 N/mm and a tensile strength of >5 MPa are so-called high-strength silicones.

Dielectric Properties

Silicones are basically not electrically conductive. The dielectric properties of silicone elastomers are largely independent of consistency, reactivity, mechanical properties and curing system. The breakdown voltage of a cured silicone specimen (1mm thickness) ranges from 20 kV/mm to 100 kV/mm (IEC 60243-1).

Heat Resistance

The heat resistance of silicones is far superior to that of most organic elastomers. Properly cured RTV silicone rubber easily withstands continuous high temperatures of up to 180 °C: the mechanical properties do not alter significantly, and heat stress has no considerable influence on the bonding strength of RTV silicone joints. For particularly demanding applications, where parts are exposed to a temperature higher than 200 °C, even for prolonged periods, RTV silicones need to be heat-stabilized. Metal oxides (such as of iron or titanium) and some carbon black grades are particularly suitable for this purpose. Heat-stable WACKER RTV silicone grades show remarkable stability in the long-term at temperatures of up to 270 °C.

These grades can be exposed to even higher temperatures but then degradation, discoloration or loss in mechanical strength must be taken into consideration.

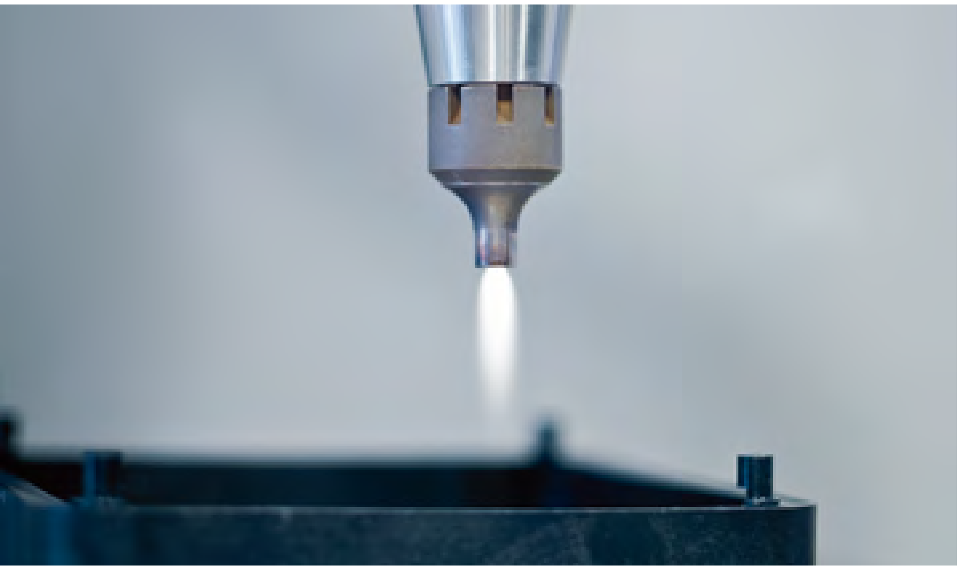
4.4
PHYSICAL SURFACE-PREPARATION METHODS

Surface Cleaning

The crosslinking agents used in condensation-curing silicones often act as adhesion promoters. Therefore RTV-1 silicones and condensation-curing RTV-2 silicones are robust adhesives or sealants: they adhere very well to many substrates and are relatively tolerant to surface contamination.

Addition-curing RTV silicones, however, are much more sensitive. Small amounts of surface contaminants may cause adhesion problems or even inhibition. Examples of inhibiting pollutants are materials containing sulfur or amino groups, plasticizers, urethanes and organometallic compounds – especially organotin compounds. If a substrate's ability to inhibit the silicone's cure is unknown, a small-scale test should be run to assess compatibility.

Regardless of the type of silicone to be used, the surfaces to be bonded must be clean, dry and free from grease, waxes or other contaminants. Suitable cleaners include low-boiling solvents (caution: flammable) that evaporate without leaving any residue, e.g., acetone, isopropanol or aliphatic solvents. Modern cleaning techniques, such as dry-ice blasting or laser cleaning, are also applicable.



Surface Pretreatment

Usually pretreatment is not needed when glass, ceramic materials, aluminum, stainless steel or selected thermoplastics with polar surfaces (PA, PBT, polyester grades, etc.) are to be bonded with a self-adhesive RTV silicone. However, more demanding substrates, such as polyaliphatic polymers, polycarbonate, ABS, PMMA or PPS compounds, require pretreatment (corona discharge, low pressure plasma, flame treatment or Pyrosil® treatment) to obtain reliable bonding. This is also mandatory when joining substrates by means of addition-curing RTV-2 silicones, which are not self-adhesive.

Very smooth plastic and metal surfaces may require slight roughening with sandpaper or, in the case of metal, sandblasting. After removing the abrasive dust, the surface should be cleaned with e.g., isopropanol, white spirit or a similar aliphatic solvent.

Please Note

Despite physical pretreatment, it still might be challenging to achieve a permanent bond with some substrates that contain plasticizers, anti-oxidants, bitumen or oils with a tendency to migrate.

4.5
CHEMICAL SURFACE-PREPARATION METHODS

Perfect Adhesion
Some ELASTOSIL® RTV silicone rubber formulations are inherently self-adhesive, such as all RTV-1 silicone rubber grades. Others contain adhesion promoters to facilitate adhesion to a wide range of substrates. Sometimes, though, priming is advisable and even essential for perfect results.

Primer
The adhesion of RTV silicones can be enhanced by preparing the surfaces beforehand with a primer. Primers are low viscous formulations of reactive silanes and/or siloxanes. While drying, they form a resinous silicone film, to which the RTV silicone rubber bonds during curing. Primers thus promote adhesion between the RTV silicone and the substrate.

Special Characteristics
- Excellent adhesion promotion to various substrates
- Solvent based, thus suitable for various coating techniques like dipping, brushing or spraying
- Miscible with organic solvents for further dilution

There is no "universal primer" suitable for every kind of application. To make a proper choice, both the kind of substrate and the RTV silicone rubber grade must be considered

Please Note

A too-thick primer layer can reduce adhesion. In order to reduce the layer thickness, it is recommend to dilute the primer directly before use with a nonpolar solvent (white spirit or a similar aliphatic solvent) in a 1:1 or 1:2 ratio (primer : solvent).

Primer Application Step by Step
1. The substrate must be clean (free of dust, grease, oils or other contaminants) and dry. Very smooth surfaces should be roughened, cleaned and degreased as described above.
2. The (diluted) primer is applied by spraying, dipping or brushing (thin coat with no bubbles). For absorbent surfaces, priming must be repeated several times.
3. The primed parts must be air dried for at least 15 minutes.
4. The pretreated surfaces are stored in a clean and dust-free place for minimum 1 hour and maximum 12 hours in order to allow the crosslinking of the primer. Alternatively, the primer can be baked for 15 to 40 minutes at 100 to 150 °C.

Please Note

Primers are sensitive to moisture. Opened containers should always be stored in a cool, dry place with regular checks for cloudiness or white sediment. If there is a white precipitate, the primer should not be used.

Primer Selection

	Kinematic Viscosity in mm^2/s	Color	Solvent	Suitable for
WACKER® Primer G 790	1	Yellowish	Isoalkanes/ Toluene	General purpose
WACKER® Primer G 790 TOLUENE FREE	1	Yellowish	Isoalkanes	General purpose
WACKER® Primer G 791	5,200 / 120	Opaque	Isoalkanes	Silicone-to-silicone bonding
WACKER® Primer G 795	2	Yellowish	Isoalkanes	General purpose (preferably for addition-curing RTV-2 silicones)
WACKER® Primer G 718	1	Orange	Acetone/ Toluene	Bonding RTV-1 silicones to thermoplastics and metals
WACKER® Primer FD	2	Yellowish	Acetone/ Toluene	Porous, absorbent surfaces
WACKER® Primer FMP HC	0.8	Yellowish	Isoalkanes	Substrates with Zn-based coatings
WACKER® Primer AV A/B	5 / 100	Yellowish	Isopropanol	Wood and aluminum (preferably for addition-curing RTV-2 silicones)

Multicomponent Techniques

Similar to primers, RTV-1 silicone rubber compounds can be used to pre-coat surfaces, thus creating the prerequisite for a durable, firm bond. These materials are supplied ready-to-process in tubes, cartridges or pails, and they cure on exposure to air moisture.

Step by Step Application

1. Substrate must be carefully cleaned and degreased if necessary.
2. If required, the RTV-1 silicone rubber can be diluted with a non-polar, water-free solvent (white spirit or a similar aliphatic grade) in order to ease processing.
3. The (diluted) RTV-1 silicone rubber should be applied to a maximum thickness of 0.5 mm, for example with a coating knife, by brushing, screen printing or spraying.
4. If a solvent has been used, the coated parts must be air dried for at least 15 minutes.
5. The pretreated surfaces are stored in a clean and dust-free place. Depending on the air humidity, the optimum bond strength at room temperature is achieved within 12 to 15 hours. The process is much faster between 50 °C and 80 °C and at high humidity. The material must be fully cured prior to further processing.

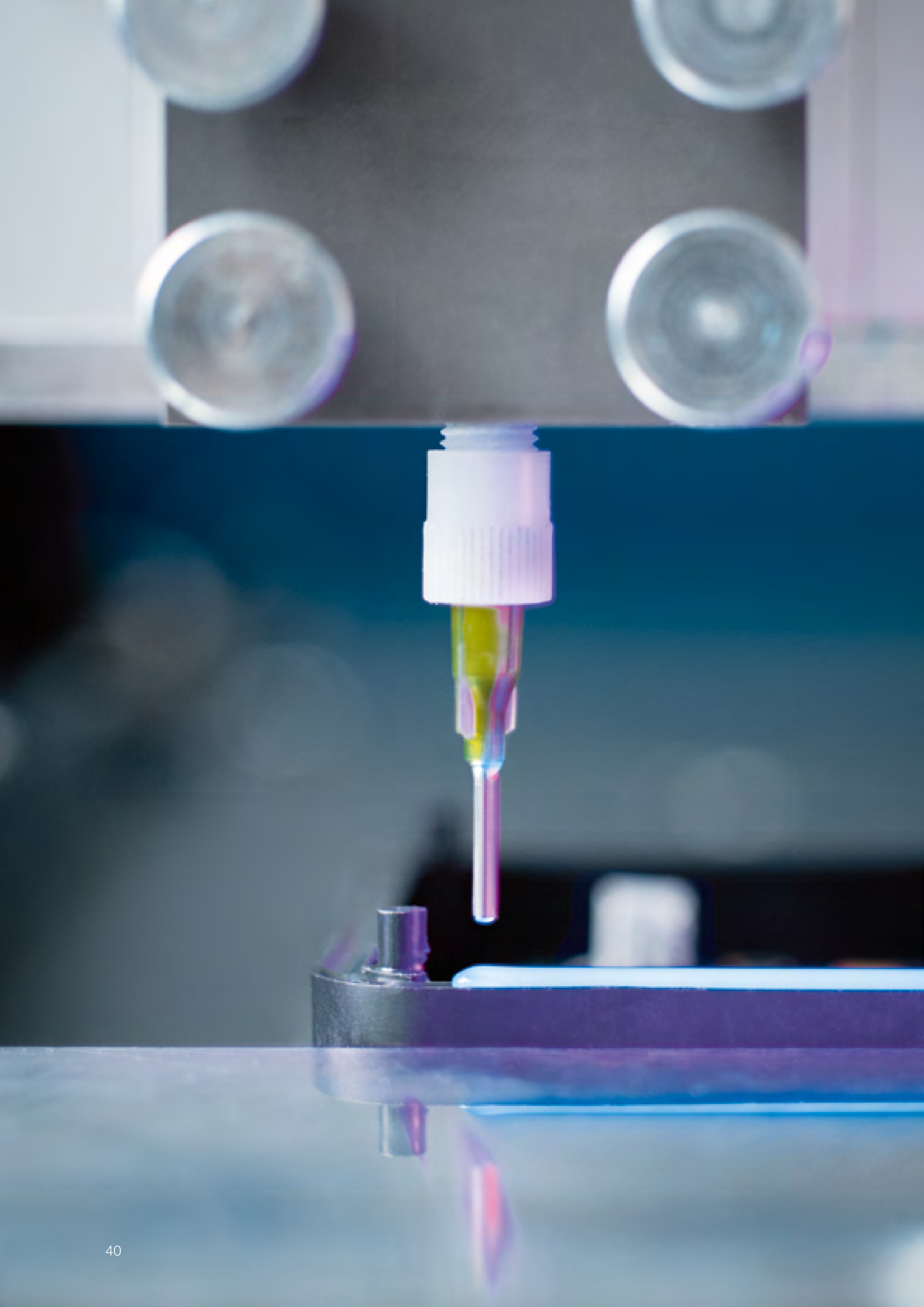
Please Note

Fluorinated thermoplastics require special pre-treatment methods, such as chemical etching. Furthermore, it still might be challenging to achieve a permanent bond with some substrates that contain substances such as plasticizers, antioxidants, bitumen and oils with a tendency to migrate.

RTV-1 Silicones Suitable for Multicomponent Techniques

	Consistency	Type	Color	Solvent	Not recommended for
ELASTOSIL® E 41	Flowable	Acetoxy	Transparent	Toluene	Addition-curing RTV-2 silicones Surfaces prone to corrosion
ELASTOSIL® E 43 N	Self-levelling	Acetoxy	Translucent	None	Surfaces prone to corrosion
ELASTOSIL® N 2010	Flowable	Alkoxy	Translucent	None	Addition-curing RTV-2 silicones
ELASTOSIL® N 10	Flowable	Oxime	Translucent	None	Addition-curing RTV-2 silicones
SILPURAN® 4200*	Self-levelling	Acetoxy	Translucent	None	Surfaces prone to corrosion

* for medical applications



SECTION 5:
PROCESSING RTV SILICONES

Contents

How to process, modify and store silicones to achieve best results for industrial scale production.

5.1
BASIC GUIDELINES

WACKER RTV silicones can be processed in many different ways. Since the choice of material, application method and processing equipment always depends on a number of factors, the following questions should be clarified first:

- What is the application?
- What are the substrates involved?
- What are the material requirements in terms of the chemical and physical properties of the cured rubber?
- Is a liquid, self-levelling or non-sag RTV silicone formulation the right choice?
- Can a two-component grade be processed, or is a one-component material mandatory?
- Which curing temperature is preferred? Do the substrates involved allow curing at temperature levels higher than room temperature?
- Is adhesion required? If so, will a surface pre-treatment be necessary?
- What equipment is available and how much investment is required, if any?
- What experience/expertise is available for the particular process?
- What type of geometry does the part have? Complex or simple?
- How large is the required production series?

Manual Equipment

For manual processing of smaller quantities, we recommend the following basic equipment:

- Balance
- Clean beaker made of metal or plastic (preferably polyethylene)
- Pipette or disposable syringe
- Metal or plastic spatula
- Brush to apply low viscous formulations
- Mechanical stirrer, e.g., electric drill with paddle stirrer (for kneadable compounds: roll mill or kneader)
- Vacuum pump (oil or water-jet pump) and vacuum box (e.g., glass or plastic desiccator)
- Grease-dissolving solvent (e.g., white spirit, acetone, methyl-ethyl-ketone, isopropanol).

Automatic Metering Equipment

Depending on their specific rheological properties, RTV silicone rubber compounds can be processed using automatic metering systems at low pressure. Automated dip coating, casting, dispensing, screen printing and spraying is likewise possible with modern application techniques, such as jetting, vacuum potting or vacuum bonding.

A large number of manufacturers offer automatic mixing and metering equipment for WACKER RTV silicones. A comprehensive list is available on request.

Preparing the Components for Processing

Some pourable RTV silicone grades contain large quantities of fillers in order to obtain high thermal conductivity, elevated hardness or improved oil resistance, etc. Depending on the formulation, such fillers may slowly sediment during storage. The same applies to pigments which have been used to color liquid grades. To ensure uniform distribution of the fillers or pigments, the compounds must be thoroughly stirred:

- Prior to processing once removed from the original packaging, preferably using a mechanical stirrer
- Prior to transfer from the original packaging into the metering equipment
- During the time spent in the supply vessels of the metering equipment.

Some grades may thicken slightly during long storage. Stirring prior to use is beneficial and can often restore their optimum flow properties.

5.2
MANUAL MIXING

Flowable RTV-2 Silicone Grades

Manual mixing of two-component RTV silicones is only recommended for flowable compounds. For economical, large-scale processing, the use of automatic metering equipment, which includes static or dynamic mixers, is recommended.

To mix small quantities, a spatula is adequate. If the amount is relatively large, a mechanical stirrer has to be employed. Suitable stirring tools are paddle stirrers with perforated, inclined blades. High-speed stirrers using toothed discs (dissolvers) are also suitable.

The equipment employed must always be scrupulously cleaned before processing addition-curing RTV-2 silicones. It is mandatory to use different equipment for component A and B, as even traces of catalyst will cause the component containing the crosslinker to cure.

It is also mandatory that the two components are thoroughly mixed in the prescribed ratio to form a homogeneous compound. If the components have different colors, they should be mixed until the compound is totally streak free.

Important

If the viscosity of the two components differs greatly, the less viscous component tends to accumulate on the wall of the beaker during mixing. This might result in an unevenly cured product. Therefore, it is necessary to scrape the beaker wall with a spatula at short intervals. This also applies when a mechanical stirrer is used for mixing.

Non-Slump RTV-2 Silicone Grades

Small quantities of non-sag grades are best processed from side-by-side cartridges using a pneumatic gun and a static mixer. Small-scale trial mixtures can be prepared in the same way as described above for flowable grades. However, the risk of entrapping air and thus creating blistered vulcanizates has to be taken into account. For processing large quantities of shear thinning/thixotropic grades, we recommend using automatic dosing equipment, which can be run with either static mixers or dynamic mixing heads, depending on the RTV silicone grade.

5.3
AIR REMOVAL

Air is readily soluble in silicones, which often is the root cause for blistered vulcanizates. Further, if mixing is not done under vacuum or in a closed system, a certain amount of air is unavoidably introduced into the rubber compound. RTV silicone rubber compounds only occasionally present a low enough viscosity to be self-deaerating, allowing entrapped air to escape within the respective potlife.

If voids or bubbles appear during crosslinking, absorbed and entrapped air must be removed from the rubber compound prior to curing. Pourable RTV silicone rubber compounds (i.e., products with a viscosity of up to 200,000 mPa·s) can be deaerated in a vacuum box or a vacuum cabinet at reduced pressure (10 - 20 mbar). An oil pump should be used to obtain such low pressure. If tap water at very low temperature (less than 10 °C) is available, a water-jet pump might also suffuce.

The capacity of the container for deaeration should be four times the volume of the product, as the silicone rubber will foam extensively when the vacuum is applied. If the volume of the container is adequate, the rising mix usually collapses before it reaches the rim. However, if it appears likely to overflow, the vacuum can be broken slightly by a small shot of air. This step should be repeated until the mix collapses completely under full vacuum.

The deaeration process should not take more than 10 minutes, otherwise some volatile compounds essential for curing might escape. If the mix has not collapsed completely by then, either the container was too small or the vacuum was not strong enough to remove all the air trapped in the rubber.

Automatic dosing systems for processing flowable two-component silicones are often equipped with automatic deaeration devices. For demanding applications requiring the complete absence of any voids, dispensing in a vacuum cabinet is recommended.

In contrast to pourable compounds, high viscous or non-sag compounds cannot be de-aerated by evacuation. Using automatic dispensing lines or side-by-side cartridges equipped with static mixers prevents air entrapment during mixing.

5.4
FULLY AUTOMATED MATERIAL PROCESSING

Processing large quantities on an industrial scale requires automatic metering equipment fitted with follower plates allowing the dispensing directly from the original container. Despite their widely differing viscosity, flowable as well as non-slump RTV silicones can be metered and mixed, if applicable, in the same way.

Important

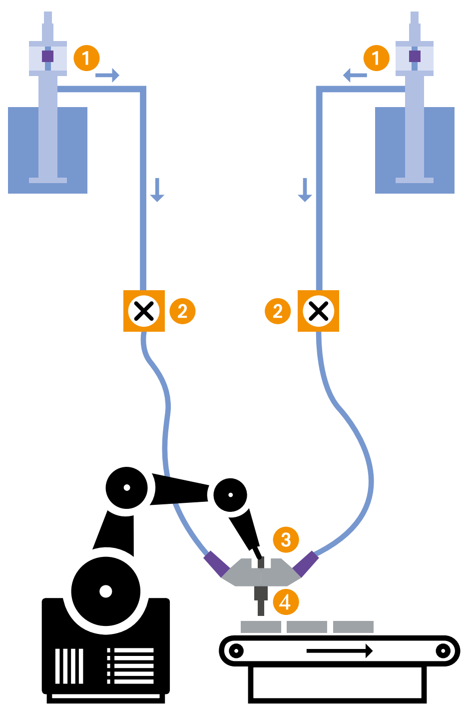
Metering equipment using pressurized air is disadvantageous. There is a significant risk of generating bubbles in the vulcanizate due to the high solubility of air in silicone. For silicone foams, however, the admixing of air to the components can improve the silicone foam structure.

Mixing

RTV-2 silicones require mixing systems. The metering units pump component A and component B in the specified ratio directly from the pails or drums and feed them, supported by additional gear pumps, helical pumps or volumetric piston systems, to the mixing unit, which can be either a static or a dynamic mixer.

Static mixers do not have moving parts, and the material is homogenized via fixed mixing elements on the interior. Dynamic mixers support homogenization with moving parts. The length and diameter of the static mixer as well as the number and shape of the mixing elements influence the mixing quality. The most suitable mixer should be chosen, depending on the rheological properties and the flow rate of the RTV silicone grade.
The homogeneous color of the compound helps identify problems arising when feeding one of the two components or with the mixing element. In case of prolonged production breaks, flushing the mixing unit with the base component, which does not contain the crosslinker is recommended.

Mixing and Metering Equipment for RTV Silicone Rubber



1 **Material supply units for component A and component B (including piston pumps and follower plates, if necessary)**

2 **Metering pumps (e.g., gear pump or helical pump)**

3 **Dosing unit with mixing device (e.g., dynamic mixing head or static mixer)**

4 **Metering nozzle**

Dosing

The (mixed) material is applied to a substrate via a robot-mounted dispensing nozzle. Dispensing systems with fixed nozzles, where a robot moves the construction parts, are also commercially available, as are multi-nozzle or jetting systems. Modern dosing machines offer accurate control of both the metering and dispensing process.

Vulcanization

The applicable temperature and resulting curing time strongly depend on the type of RTV silicone, the volume of material applied and the assembly configuration. RTV-1 silicone rubber is usually cured at room temperature (20 °C to 25 °C) and 40 % to 60 % relative air humidity. Due to the low vulcanization speed and the small amount of by-products released, ventilated curing cabinets with air moisture control are recommended. Process cycle time may vary between a couple of minutes and days.
Condensation-curing RTV-2 silicones usually don't require air moisture control. They are preferably cured at room temperature. Optionally, curing speed can be slightly accelerated by heating up to a maximum of 70 °C. Ventilation of the curing site is recommended to ensure the safe removal of the evaporated by-products. The process cycle time typically ranges from minutes to hours. Addition-curing RTV silicones can have a different curing time and curing temperature. Some grades can be cured at room-temperature within hours, while others are preferably vulcanized at a higher temperature (80 °C to 200 °C) in order to substantially shorten the curing time down to minutes. Exactly how much time is required depends on the grade, on the heat capacity of the substrate(s) and on the heat transfer rate. Suitable heat sources include heated metal molds, circulating air ovens and IR tunnels.

5.5
POST-TREATMENT

Post-treatment usually means either ageing at room temperature for several days, or exposure to high temperature for a defined time (post-curing). This is performed not only to achieve improved mechanical properties but also to remove volatiles (e.g., byproducts resulting from condensation-curing, or low-molecular polymer components), which is essential in order to meet legal requirements for food-contact or medical applications, for example. In such cases, the relevant FDA, BfR or E.P. 3.1.9
recommendations must be followed.

Condensation-Curing Silicone Rubber

During crosslinking, some volatile byproducts may remain entrapped in the vulcanizate, causing following typical effects:

- Reversion when the silicone rubber is exposed to elevated temperature (> 90 °C)
- A low level of resilience, paired with a compression set of up to 100%
- Significantly reduced media resistance
- The risk of plastics and metal corrosion (due to amines or acetic acid)
- Long-term weight loss and permanent shrinkage, even at room temperature.

Volatile byproducts are completely removed from freshly cured vulcanizates by ageing them for several days at room temperature (rule of thumb: approx. 24 hours per cm thickness to the nearest exposed surface) or for several hours at a maximum of 70 °C (rule of thumb: approx. 6 hours per cm thickness to the nearest exposed surface). During this ageing period, the vulcanizate should be stored open with as much of the surface exposed as possible.

Addition-Curing Silicone Rubber

Since the vulcanizates of addition-curing rubber do not contain volatile byproducts, they can be used immediately after heat-curing. Post-curing is nevertheless recommended if an improvement of the elastomer's mechanical properties, especially a minimal compression set, is required.

In such cases, it is advisable to carry out additional heat treatment for a number of hours after the silicone rubber has set. During post-curing, exposing the cured silicone to a temperature similar to the future temperature of use is recommended, but it should not fall below 100 °C or exceed 200 °C.

The Right Way to Post-Cure

1. Fresh-air supply

Post-curing must be done in a circulating-air oven with fresh air supply. The volatile components consist predominantly of low molecular siloxanes or other flammable volatiles (e.g., alcohol, amines, acetic acid, oximes etc.), which also have to be removed from the oven during post-curing. To ensure reliable operation, fresh air must be supplied at a rate of 100 - 120 l per minute and kg of silicone to prevent a risk of deflagration (the explosion limits must be considered). Most of the volatile components escape within the initial post-curing period. Good ventilation must be ensured during this time.

2. Placing the parts in the oven

The parts should be positioned with the silicone side facing the hot air flow. Large silicone items should be put on a perforated plate or wire mesh, if possible without contact to each other and such that they are not deformed by their inherent weight.

3. Post-curing time

Tests should be performed to define the optimum conditions for the parts. The volatiles content should be checked by measuring the weight loss. The required post-curing time increases with the thickness of the silicone part. However, following the heating-up phase, post-curing should be conducted for not more than 8 hours, otherwise undesirable thermal aging and/or embrittlement can occur.

5.6
MODIFYING SILICONE RUBBER

WACKER offers various additives in order to modify properties such as viscosity or reactivity or to adjust the elastomer's properties.

Viscosity

The rheological properties of RTV silicones can be altered over a wide range using various additives. For example, viscosity can be lowered by adding a low-viscous WACKER® AK silicone fluid. The viscosity decreases in proportion to the amount of fluid added.

Important

WACKER® AK silicone fluids do not crosslink and therefore behave like a plasticizer, changing the cured silicone rubber's mechanical properties to a certain extent. Adding silicone fluids in large quantities (over 20 %) may reduce the vulcanizates' resistance to swelling agents (solvents, oil, lubricants), while potlife and curing time can increase as a result of the crosslinker dilution. However, if not more than 5 % by weight is added, the influence of the silicone fluids is generally modest.

For addition-curing RTV silicones, WACKER has developed WACKER® VISCOREGLER 64 DILUTING AGENT in order to minimize the impact of the diluent on the mechanical properties. This solvent-free, rheologically effective additive contains reactive groups and is incorporated into the silicone network during addition-curing. It facilitates significant lowering of the addition-curing RTV silicone rubber formulations' viscosity, while the mechanical properties of their vulcanizates remain more or less constant.

In order to increase the viscosity of flowable RTV silicone formulations, a few percent by weight of pyrogenic silica (such as WACKER HDK® N 20) can be added. A more convenient method is to use thickening additives, thereby transforming certain readily flowable formulations into nonsag ones. While adding 0.3 - 0.5 % WACKER® STABILIZER 43 confers excellent non-sag properties to addition-curing RTV silicones, 1 - 2 % of WACKER® THIXOTROPIC ADDITIVE C is required for condensation-curing RTV silicone grades. The corresponding TDS display all relevant details.

Properties of Silicone Elastomers

Usually WACKER® AK silicone fluids are intentionally added to reduce the original hardness of a cured rubber for a specific purpose, for example to obtain a very soft vulcanizate for printing pads. By increasing the quantity of silicone fluid, hardness, tensile strength and tear strength decrease, while elongation at break increases.

Depending on their viscosity, the silicone fluids have a tendency to separate, since they cannot chemically link to the vulcanized silicone rubber network. As a rule of thumb, the highest migration rate is observed for silicone fluids with a viscosity between 10,000 mm^2/s and 50,000 mm^2/s. In contrast, silicone fluids with a viscosity below 200 mm^2/s show a very low tendency to bleed. Hence, it is possible to tune the vulcanizate's properties not only in terms of hardness, but also in regard to its oil bleeding capability, just by choosing a silicone fluid with the "right" viscosity.

Additives that Modify the Viscosity and Consistency of RTV Silicone Rubber

Product	Increasing Viscosity	Lowering Viscosity	Softening Effect	Oil Bleeding Effect
WACKER® AK 35		●	●	
WACKER® AK 1000		●	●	○
WACKER® AK 20000			●	●
WACKER® VISCOREGLER 64[1]		●		
WACKER HDK® N 20	●			
WACKER® STABILIZER 43[1]	●			
WACKER® THIXOTROPIC ADDITIVE C[2]	●			

1) For addition-curing RTV silicone rubber formulations only
2) For RTV silicone rubber formulations only

Curing Properties

The vulcanization characteristics of condensation-curing RTV silicone rubber grades cannot be modified by additives. In order to speed up or slow down the curing process, the curing conditions (RTV-1: level of relative air humidity; RTV-2: temperature), the mixing ratio (RTV-2) or the T-series curing catalyst (component B of RTV-2) need to be changed.
The potlife and vulcanization time of addition-curing RTV silicone rubber formulations can be varied within broad limits by adding WACKER® Inhibitor PT 88 or additional WACKER® Catalyst EP. The corresponding TDS display all relevant details including graphs.

WACKER® Catalyst EP

Adding WACKER® Catalyst EP to addition-curing silicone rubber formulations increases their curing speed, i. e., potlife and curing time decrease. As a positive side-effect, the risk of inhibition is reduced at the same time. In many cases, adding up to 0.25 wt. % of WACKER® Catalyst EP (based on the total weight of the silicone rubber mixture) is sufficient to significantly increase curing speed and the formulation's robustness towards inhibition.

Please Note

WACKER® Catalyst EP should be added either to the component containing the platinum catalyst, or – alternatively – to the catalysed mixture made from component A and component B. Transparent compounds may discolor yellow or slightly brownish upon adding WACKER® Catalyst EP, depending on the quantity used.

WACKER® Inhibitor PT 88

WACKER® Inhibitor PT 88 is a potlife extender that diminishes the reactivity of addition-curing silicone rubber formulations. Consequently, potlife and curing time increase. In most cases, adding up to 0.5 wt. % of WACKER® Inhibitor PT 88 (based on the total weight of the silicone rubber mixture) is sufficient to significantly reduce curing speed. We strongly discourage exceeding the upper limit of 1 wt. %, because large quantities of WACKER® Inhibitor PT 88 result in very long pot lives and might delay the curing of the modified RTV-2 silicone compound at room-temperature for days. Where strongly retarded curing occurs, an elevated temperature is necessary to ensure complete vulcanization.

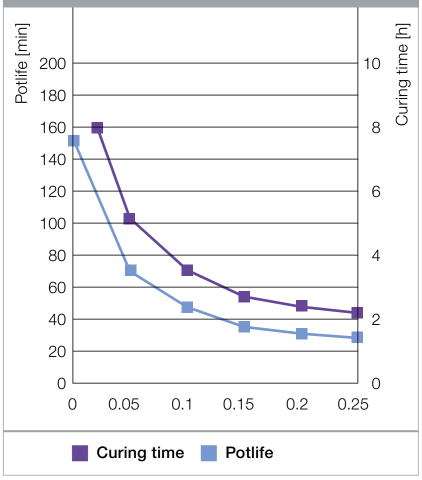
Please Note

WACKER® Inhibitor PT 88 should be added either to the component containing the crosslinker, or – alternatively – to the catalysed mixture made from component A and component B. WACKER® Inhibitor PT 88 must not be added to the component containing the platinum catalyst, because otherwise the compound will turn brownish.

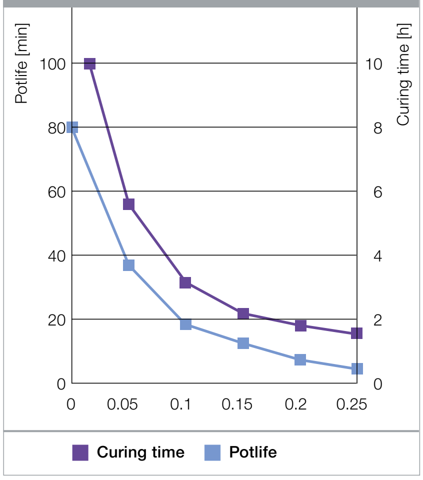
Examples of Use

The graphs shown below illustrate the usage of WACKER® Catalyst EP or WACKER® Inhibitor PT 88 on the basis of selected addition-curing RTV-2 silicones. The data given is only intended as a guide and should not be used for preparing specifications.

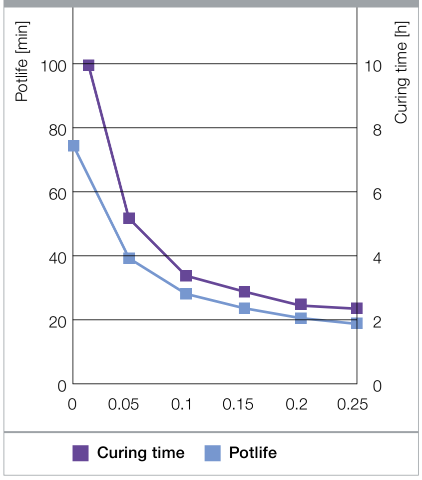
% WACKER® Catalyst EP in WACKER SilGel® 612



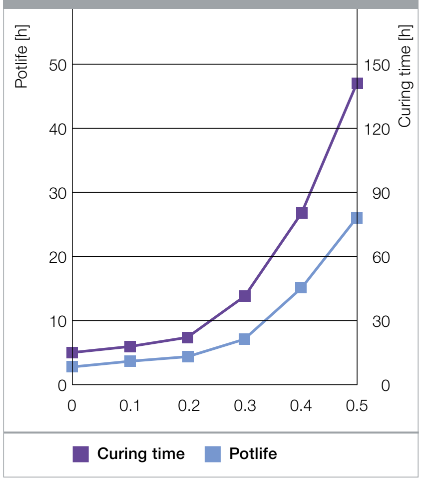
% WACKER® Catalyst EP in ELASTOSIL® RT 607



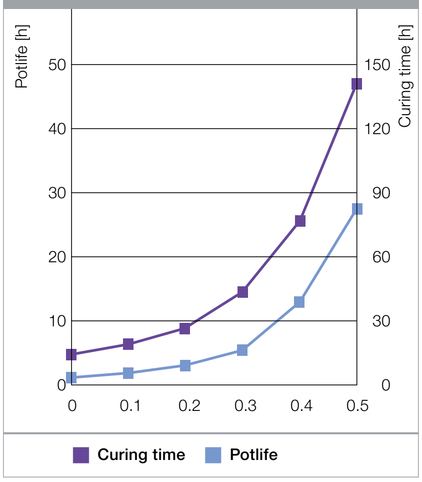
% WACKER® Catalyst EP in ELASTOSIL® RT 622



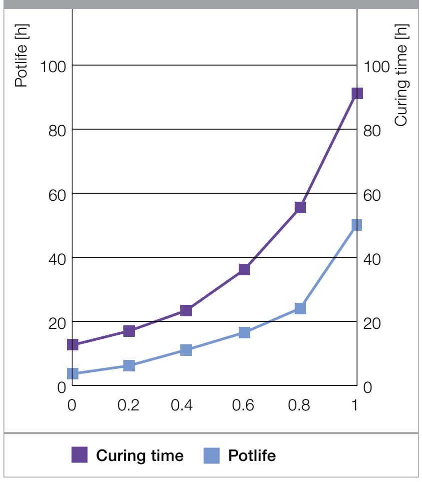
% WACKER® Inhibitor PT 88 in WACKER SilGel® 612



% WACKER® Inhibitor PT 88 in ELASTOSIL® RT 607



% WACKER® Inhibitor PT 88 in ELASTOSIL® RT 622



Coloring and Heat Stability

Our pigment pastes don't just look good. They offer outstanding performance, too. Available in many different colors, ELASTOSIL® Color Pastes FL provide hues that are resistant to light, UV and hot air. And as the color pastes can be mixed together in any ratio, almost any desired color can be obtained.

ELASTOSIL® Color Pastes FL are ready-to-mix preparations comprising very finely powdered pigments and a silicone polymer. For maximum compatibility, the pigments are prepared from similar silicone polymers to those used in RTV silicone rubbers.

ELASTOSIL® Color Paste FL grades are easy to process and allow the cured RTV silicone elastomer to retain its color for a long time, even under adverse conditions. Besides their intensive color, with specific grades, such as ELASTOSIL® Color Paste FL Ivory RAL 1014, ELASTOSIL® Color Paste FL Red Iron Oxide RAL 3013, or ELASTOSIL® Color Paste FL Deep Black RAL 9005, the heat stability of the RTV silicones significantly exceeds the 200 °C limit.

Advantages at a glance

- A modular color scheme composed of 24 basic colors, which provides access to some 80% of the color space just by mixing.
- Highly compatible and easy to mix with WACKER's RTV silicone rubber
- No adverse effects on the silicone rubber processing
- High color retention, even when exposed to heat, light and weathering
- Most of our color pastes comply with BfR and/or FDA regulations regarding food contact.

Processing

The color of RTV silicones can be modified by adding up to 2 % by weight of one or several ELASTOSIL® Color Paste FL grades. They are most effective for transparent, translucent or white base compounds.

Standard mixing devices can be used for homogenization with the silicone rubber. However, manual mixing is recommended for flowable RTV silicone grades or small material quantities. Also, the risk of entrapping air has to be taken into account for non-sag silicone grades. For economical, large-scale processing, the use of automatic metering equipment, which includes static or dynamic mixers, is appropriate.

Please Note

RTV-1 silicone rubber is sensitive to moisture. All modification must be done under strict exclusion of humidity, which requires special mixing equipment and skilled personnel. For the same reason, ELASTOSIL® Color Pastes FL should not be mixed with the curing agent (component B) of condensation-curing RTV-2 silicone rubber, but always with the rubber base (component A).

Furthermore, ELASTOSIL® Color Paste FL should be homogenized by stirring before use.

In order to obtain a homogeneous mixture, it is mandatory to thoroughly mix ELASTOSIL® Color Paste FL with the RTV silicone rubber until the compound mix is totally streak free and uniform in color. If the viscosity of the respective components differs greatly, the beaker wall must be scraped with a spatula at short intervals. This also applies when a mechanical stirrer is used for mixing. Otherwise, the less viscous component tends to accumulate on the wall of the beaker during mixing, resulting in an unevenly mixed compound.

5.7
STORAGE

If stored in the original closed containers at 5 °C to 30 °C, ELASTOSIL®, SEMICOSIL®, LUMISIL®, SILPURAN®, POWERSIL®, WACKER SilGel® and CENUSIL® silicone rubber formulations have a shelf life of 3 to 24 months, from the delivery date, depending on the grade.

Storage-Induced Increase in Viscosity

For some RTV silicone rubber, storage may cause an increase in viscosity. This is due to a particular polymer/filler orientation that can be reversed at any time by shearing. Hence, the viscosity is automatically reduced when the rubber is processed with automatic dispensing machines, for instance. Mixing or stirring the respective compound prior to use also helps to restore the original viscosity level. Therefore, such RTV silicone rubber formulations can be processed in the normal way within the given shelf life.

Special Requirements for Condensation-Curing Grades (RTV-1, RTV-2 Silicones)

As mentioned above, RTV-1 silicone rubber formulations start curing in the presence of moisture. In a similar manner, WACKER® T-series catalysts of condensation-curing RTV-2 silicones react with air humidity and form siliceous compounds. Condensation-curing RTV-2 silicone rubber formulations require small amounts of moisture (present in the rubber base), which may escape from the packaging when stored open or with a loose lid for a long time. It is important that only the original, sealed containers are used to store condensation-curing silicone rubber formulations and that the packaging is tightly closed for storage once opened.

Special Requirements for Addition-Curing Grades

Even tiny amounts of the platinum catalyst are sufficient to start a reaction on contact with the component containing the crosslinking agent. This type of contamination may be caused just by storing open drums of A and B component next to each other. As a result, the uncured material may form cured particles, or hydrogen might be released. Consequently, the drums must be tightly sealed after use.

General Information on Storing ELASTOSIL® RTV Silicone Rubber

- Store in closed containers in a dry place at 5 – 30 °C
- Higher average temperatures may shorten the shelf life
- Do not expose to direct sunlight
- When opening the container, make sure that no dirt falls onto the surface of the rubber

Safety Information:
Please consult our safety data sheets if you require additional safety information.

5.8
TROUBLE SHOOTING

Vulcanization Problems of Condensation-Curing Silicones

In general, condensation-curing silicones are not sensitive to inhibition. Most of their curing problems originate from inappropriate curing conditions such as low levels of relative humidity (RTV-1), mismatches in mixing ratio (RTV-2) or using excessive heat for curing. Unfavorable assembly configurations can impede the access of air moisture or the release of the condensation reaction's byproducts and result in improper curing.

Retarded vulcanization of condensation-curing RTV-2 silicone rubber may also occur when the level of water vapor, which is necessary for a proper curing and which therefore is part of the base compound (part A), has dropped below a critical level, e.g., after storing the packaging open or with a loose lid. In such cases, the original curing properties can be restored easily by adding a small quantity of water (1-2 grams per kilogram of base compound) to the base compound (part A) and stirring up thoroughly. The mixture is stored in a tightly closed drum for at least 24 hours at room temperature. During this time, the water evaporates and the rubber becomes saturated with sufficient moisture for proper curing. The compound can then be used.

Important for RTV-1 Silicone Rubber

If the level of relative humidity falls below 30 %, the vulcanizate's surface may remain tacky. At a relative humidity of 5 % or below, curing may even stop completely. The humidity must be raised by means of evaporators, atomizers, or a climate chamber must be used for curing. Humidity can be easily monitored using a hygrometer. Adding water to the silicone rubber is unsuitable.

Vulcanization Problems of Addition-Curing Silicones (Inhibition)

In contrast to condensation-curing silicones, the vulcanization of addition-curing silicone rubber may be substantially impaired by a number of substances or materials. Such curing inhibition is usually indicated by a permanent surface tackiness, the presence of liquid rubber at the interface to the substrate, or significantly delayed curing.

Typical inhibitors are:

- Sulfur compounds such as sulfides, sulfones and sulfur-containing substances such as natural or certain synthetic rubbers (e.g., EPDM).
- Amines and amine containing substances such as polyurethanes or amine-cured epoxy resins.
- Organo-tin compounds and substances that contain them, e.g., vulcanizates and catalysts of condensation-curing RTV-2 silicone rubber formulations.
- Various natural and synthetic oils, greases, waxes and resins, as well as substances containing such materials, for example, many release agents and almost all types of plasticine.

The inhibiting compounds may be present either on the substrate, or in the mixing and dosing equipment. Further sources of inhibiting compounds can be post-curing ovens, drying cabinets used for curing organic rubber, or casting resins.

It is strongly recommended to carry out preliminary trials in order to determine whether inhibiting compounds are present. Methods for removing inhibiting compounds from surfaces are identical to those described for cleaning and preparing the substrates (see above).

Problems Linked to Mixing Ratio

It is absolutely essential to accurately meter two-component RTV silicones in the recommended mixing ratio. Only a firm ratio of A:B guarantees a stable dispensing process and reproducible results. Metering is possible either by weight or by volume.

Important

In general, the TDS state the mixing ratio in parts by weight. If mixing by volume is requested, the mixing ratio by volume must be calculated using the density of the respective component.

Depending on the type of RTV-2 silicone, improper mixing ratio may cause one or several of the following effects:

Situation 1

Excess amount of the component containing the crosslinker

- Reduced potlife
- Increased hardness and tensile strength
- Reduced maximum elongation and tear resistance
- Post-curing effects at room temperature (embrittlement)

Situation 2

Insufficient amount of the component containing the crosslinker

- Delayed or incomplete crosslinking
- Soft, limp vulcanizates
- Low mechanical strength of the vulcanizates
- Increased susceptibility to swelling
- Poor adhesion.

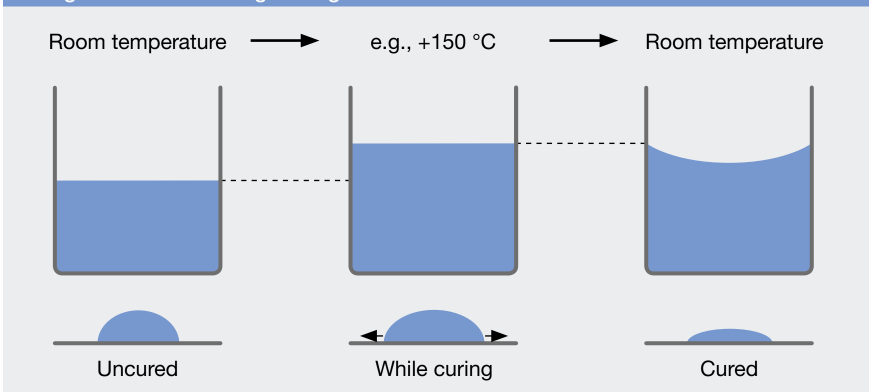
Problems Linked to Temperature

When accelerating the vulcanization of condensation-curing silicones, the temperature should not exceed 70 °C. Otherwise, the result will be a limp, putty and sticky vulcanizate. Further defects such as bubble formation, blistering or uneven surfaces (orange peel, pinholes) may arise. Addition-curing silicones can be heat cured (up to 250 °C). It is important to keep in mind that increasing temperature will cause a corresponding decrease in the potlife. To prevent premature vulcanization during processing, it is advisable to control the temperature both of the production place and the metering and mixing device.

If curing is accelerated by heat, the volume of curing rubber increases due to thermal expansion. During cool-down of the cured rubber to room temperature, shrinkage will occur. This can result in a distortion of the vulcanizate's geometry and applies both to condensation- and addition-curing RTV. Furthermore, it is important to keep in mind that condensation-curing RTVs are generally prone to chemical shrinkage, irrespective of the curing temperature. Therefore, if dimensional accuracy is required, either curing has to be carried out at the temperature at which the rubber will subsequently be employed or the dimensional change has to be calculated, or determined experimentally, and taken into account accordingly.

It is also important to calculate space for thermal expansion of the silicone during heat cure, especially when vulcanizing takes place in a closed system. Since silicone elastomers can only be compressed by applying extremely high pressure, thermal expansion of the rubber without an "escape" provision can also cause very high pressure with a highly destructive effect.

Change in Volume During Curing



Trouble Shooting

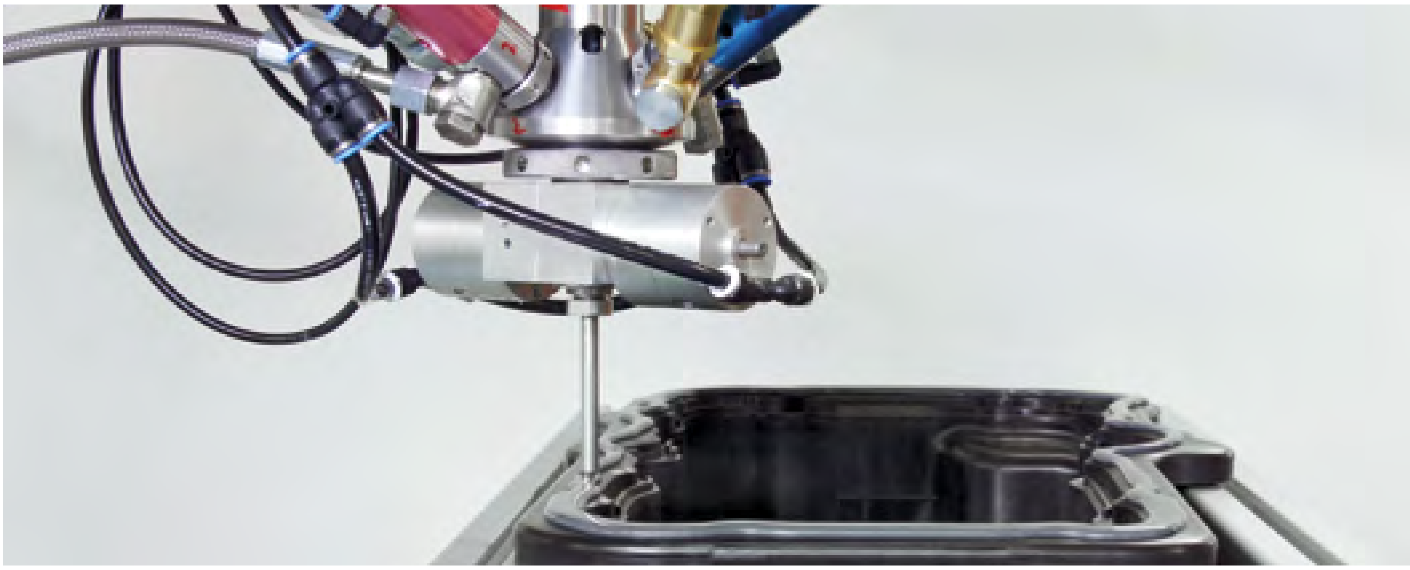
	Issue	Possible Root Cause
All RTV Silicones	• Delayed curing	• Processing temperature too low
	• Bubbles, blisters and voids	• Insufficient level of de-aeration
RTV-1 Silicones	• Delayed curing	• Low level of air humidity • Inappropriate assembly configuration
	• Tacky surface	• Low level of air humidity • Use of heat while curing
	• Bubbles, blisters and voids	• Use of heat while curing
	• White spots on the surface	• Contact to water while curing
RTV-2 Silicones, Condensation Curing	• Premature curing	• Incorrect mixing ratio
	• Delayed curing	• Incorrect mixing ratio • Lack of moisture in component A
	• Limp and sticky vulcanizate	• Limited/no possibility for byproducts to escape • Incorrect mixing ratio • Excessive heat while curing • Lack of moisture in component A
	• Bubbles, blisters and voids	• Excessive heat while curing
	• Inhomogeneous vulcanizate	• Improper mixing
RTV-2 Silicones, Addition Curing	• Delayed curing	• Incorrect mixing ratio • Inhibition
	• Improper vulcanizate properties	• Incorrect mixing ratio • Inhibition
	• Premature curing	• Incorrect mixing ratio
	• Sticky vulcanizate	• Inhibition
	• Uncured material on substrate interface	• Surface inhibition
	• Bubbles, blisters and voids	• Humid substrate • Contamination with water
	• Inhomogeneous vulcanizate	• Improper mixing
One-Component Heat-Curing Silicones	• Delayed curing	• Curing temperature too low • Inhibition
	• Sticky vulcanizate	• Curing temperature too low • Curing time too short • Inhibition
	• Uncured material on substrate interface	• Surface inhibition
	• Bubbles, blisters and voids	• Excessive heat while curing • Humid substrate • Contamination with water
UV-Curing Silicones	• Delayed curing	• Insufficient irradiation level • Inhibition
	• Limp and sticky vulcanizate	• Insufficient irradiation level • Inhibition
	• Uncured material on substrate interface	• Surface inhibition
	• Bubbles, blisters and voids	• Humid substrate • Contamination with water
	• Inhomogeneous vulcanizate	• Improper mixing

SECTION 6:
SPECTRUM OF TECHNICAL APPLICATIONS

Contents

Sealant adhesives, silicone gaskets, potting, encapsulation, coating and casting.

6.1
SEALANT ADHESIVES



Traditional mechanical joining technologies, such as screwing, soldering, seaming, welding, or riveting, are progressively being superseded by modern adhesive bonding methods, such as sealant adhesives. The reasons are obvious: elastic bonding with silicone sealant adhesives has decisive advantages in terms of handling, functionality, durability and cost efficiency.

Handling

WACKER silicone sealant adhesives can be applied easily and economically either manually or with automated dispensing equipment. Compared to mechanical joining methods, sealant adhesives significantly reduce not only the quantity of parts (e.g., screws, rivets, etc.), but also the number of process steps. Hence, silicone sealant adhesives help to reduce process cycle time.

Functionality

- **Bonding efficiency**
  A sealant adhesive acts as glue and sealant at the same time. The need for additional mechanical safeguarding measures often becomes obsolete.
- **High joint reliability**
  Thanks to the good electrical insulating properties of silicones, different metals can be bonded without the risk of galvanic corrosion.
- **Uniform stress distribution**
  Sealant adhesives distribute mechanical strain over the entire bonding area and thus minimize the risk of localized excessive stress.
- **Perfect stress relaxation**
  Thanks to their low Young's modulus, silicone sealant adhesives effectively compensate thermo-mechanical loads resulting from substrates with a different coefficient of thermal expansion.
- **Versatile applicability**
  Silicone sealant adhesives have a high ability to bond dissimilar materials.

Cost Effectiveness

Using silicone sealant adhesives saves costs at different levels of the manufacturing process, for instance by:

- A low level of warehousing due to the small number of parts (e.g., screws, rivets, etc.) to be handled for the joint
- Reduced costs for labor due to fully automated adhesive application
- Wide machining tolerances for the parts to be bonded.

6.2 SILICONE GASKETS

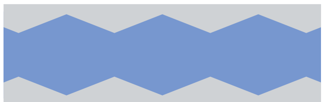
Since gaskets operate at the interface between interior and exterior, hot and cold, or wet and dry, they are frequently exposed to extreme conditions. These severe physical challenges are met perfectly by WACKER silicone gaskets, which perform with absolute reliability.

The respective silicone seals are either manufactured in a separate injection-molding process, or subsequently inserted into the multi-component assembly, or they are "cured in place". Curing can also take place before the components have been assembled.

Preformed Gaskets

Preformed gaskets (O-rings, surface seals, and profile gaskets) are typically manufactured from liquid silicone rubber (LSR) or high consistency rubber (HCR) in a separate process. There is no adhesion between the inserted gasket and the joint parts. Sealing is achieved solely by compression, making disassembly possible at any time.

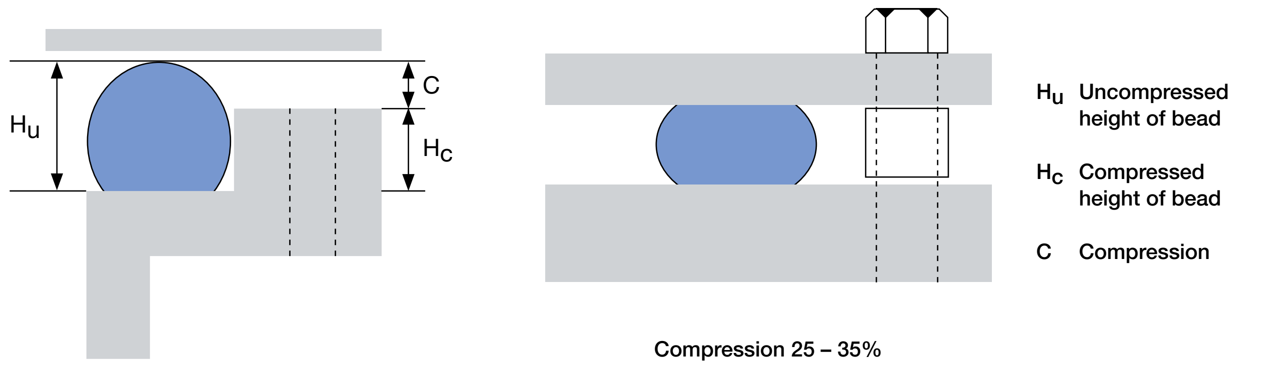
Sealing Technology

	Preformed Gasket	**Cured-In-Place Gasket (CIPG)**	**Formed-In-Place Gasket (FIPG)**
			
Silicone type	LSR, HTV	RTV-1, RTV-2	RTV-1, RTV-2
Application method	Insert	Dispensing	Dispensing
Time of assembly	After curing	After curing	Before curing
Adhesion to substrates	None	Only to one part	To both parts
Disassembly	Possible	Possible	Impossible
Mode of sealing	Compression	Compression	Adhesive bonding
Products	ELASTOSIL® LR ELASTOSIL® R	ELASTOSIL® E ELASTOSIL® A ELASTOSIL® N ELASTOSIL® LR ELASTOSIL® RT ELASTOSIL® SC ELASTOSIL® Solar SEMICOSIL®	ELASTOSIL® E ELASTOSIL® A ELASTOSIL® N ELASTOSIL® LR ELASTOSIL® RT ELASTOSIL® Solar SEMICOSIL®

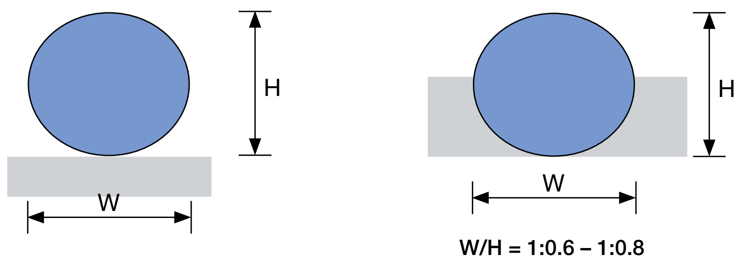
Cured-In-Place Gaskets (CIPG)

CIPG (also known as “dry assembly”) is a typical sealing technology for non-slump RTV silicones. The silicone gasket is applied and adheres only to one of the substrates and thus stays in place without being secured in any way. The parts to be sealed are assembled after the RTV silicone rubber has cured. The sealing effect towards the second joint member is achieved by compression, which calls for silicones with excellent compression set properties. The parts sealed via CIPG can be disassembled at any time. In general, tightness of a CIP gasket is assured on compression of 25 % to a maximum of 35 %. Limiting compression by suitable constructive measures, for example, by applying spacers or by proper groove design is recommended. In principle, the cross section of a silicone bead is not perfectly round-shaped, as the ratio of width (W) to height (H) typically ranges from 1:0.6 to 1:0.8. In order to prevent a CIP gasket from rolling off under load and to stabilize the silicone bead’s position, at least one of the two substrates should be equipped with a groove. Preparatory tooling of the groove is not required, however a clean and oil-free surface is necessary for successful sealing.

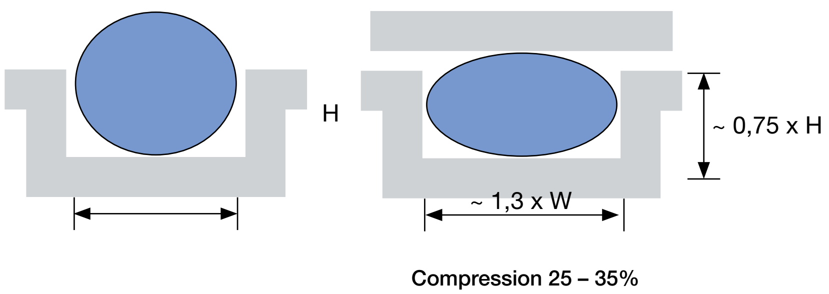
Maximum Compression of a CIP Gasket



Cross-Section and Height-to-Width Ratio of a Silicone Bead



Calculation of Minimum Width of the Groove



As silicones are not compressible, the groove must provide sufficient additional space for the silicone to deform under compression. When in contact with chemicals and fluids, an additional volume increase by swelling needs to be taken into account. The width of the groove should therefore be about the 1.3 to 1.4-fold the silicone bead’s height. It is strongly recommended not to fill the entire groove with silicone.

When assembling parts, it is important to evenly distribute the compression force. Furthermore, distortion of the assembly parts must be avoided in order to keep the assembly tight. For this reason, the parts have to be properly dimensioned and the contact force must be calculated accordingly. Fixing bolts or screws must be placed a suitable distance from each other in order to allow for even distribution of the compression force.

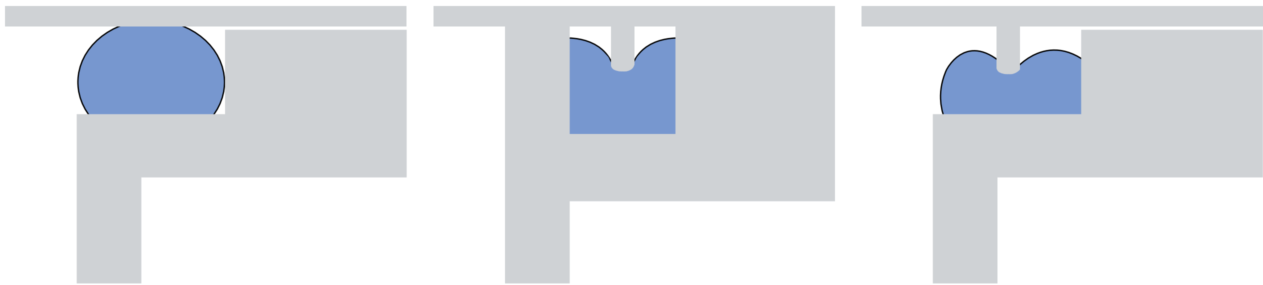
Foam Gaskets

RTV-2 silicone foam gaskets are similar to CIP gaskets but they permit higher component tolerances and require less compression force. They are particularly suitable for applications where either pressure can't be applied evenly (e.g., due to constructional constraints) or the assembly parts can't withstand high compression force.

The following conditions should be observed:

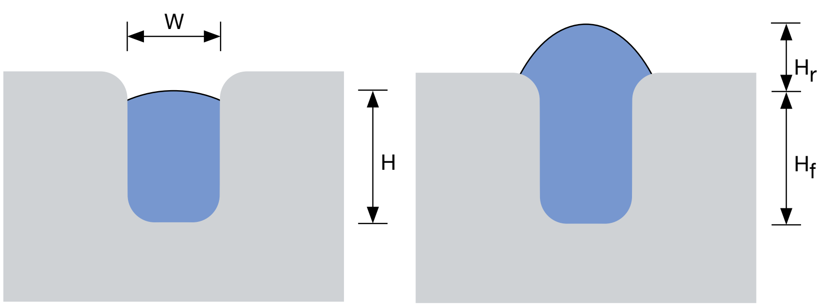
- Silicone foam gaskets require a compression level of about 30 % to 50 %.
- The compression of the bead must be controlled by suitable measures, such as spacers or ridges, in order to maintain a constant compression level in the long term.
- Preferably one of the substrates should be equipped with a groove.
- In order to avoid permanent deformation, silicone foam beads must completely cure before they are compressed.
- Post-curing can help to improve the silicone foam gasket's resilience.

Foam Gasket Designs



During the curing process, RTV-2 silicone foam rubber expands to 2 to 4-fold of its initial volume. When the space for this expansion process is limited, e.g., in deep slots or cavities, significant pressure is created on the cavity's walls. As a result, deformation of the assembly parts can occur, and the foam density is higher than it would be in open conditions (no cavity). Therefore, when foaming RTV-2 silicone rubber in cavities, the ratio of width (W) to height (H) should range from 1:1 to 1:2. For all other configurations, the recommendations described for CIPG apply.

Calculation of Foam Gaskets



W : H = 1:1 to 1:2

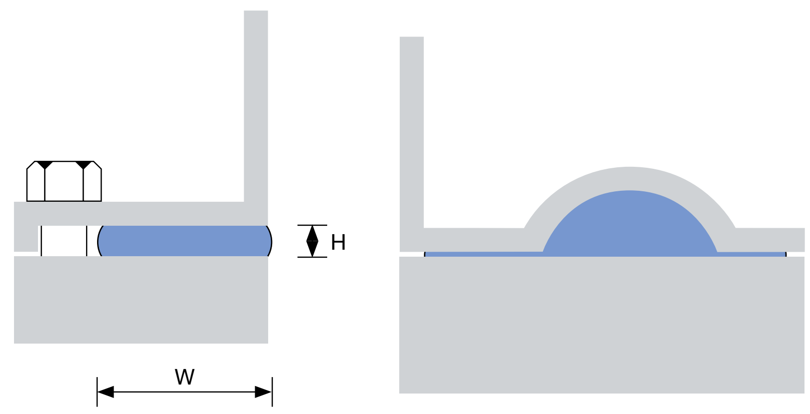
H_r Height of rise
H_f Height of fill

Formed-In-Place Gaskets (FIPG)
In FIPG (also known as “wet assembly”), the parts to be sealed are assembled before the non-slump RTV silicone rubber cures. Therefore, the gasket material adheres to both sides after curing, which enhances the reliability of the seal, but excludes the possibility of posterior disassembly.

Compared to inserted gaskets, FIPG do not require the joint parts to have such high dimensional accuracy. In addition, the cured gasket material stays firmly in place without fixing. Both permit simpler parts design and reduce development costs.

Parts sealed by FIPG are often compressed up to a direct metal-to-metal contact (also called zero gap).

FIP Gasket Designs



However, the sealing effect is improved when the assembly parts are kept at a distance H of 0.1 to 1.5 mm in order to compensate relative movements (e.g., vibration, different thermal expansion coefficient, shear load, etc.). This can be achieved by either spacers, external fixtures, or by adding glass beads of specific size to the silicone. Embossing a groove is also a suitable method. Depending on the substrate design and the joining distance, silicone beads of 1.5 - 3.0 mm usually result in sufficiently wide FIP gaskets. For an optimum sealing result, the silicone should have a width (W) of 15 - 20 mm after assembling the parts, and must not fall below 6 - 8 mm to ensure tightness.

Since adhesion is crucial for FIPG, the surfaces must be clean and free of grease. Before applying the silicone, contaminations have to be removed. In many cases, unprocessed surfaces provide better conditions for FIPG. Rough surfaces and gaps of up to 3 mm (depending on the silicone grade used) can be sealed.

Using RTV Silicones as FIPG and CIPG

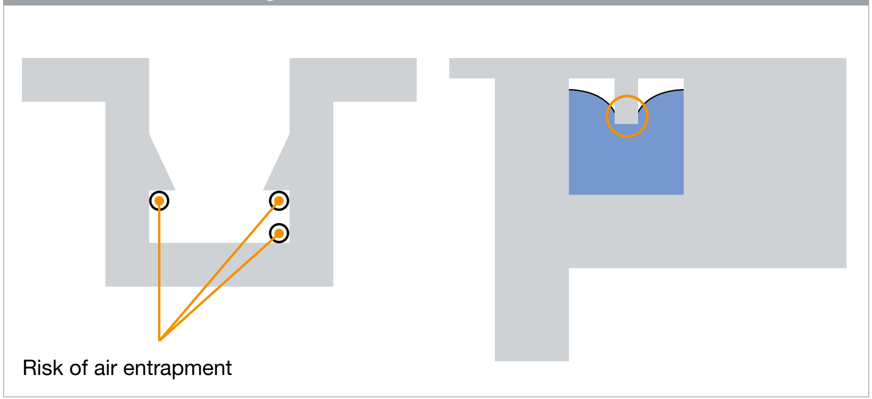
Proper component design, in particular of the grooves and/or fixation points, is decisive for the tightness of FIP and CIP gaskets. For instance, in order to reduce the risk of air entrapment, the groove should not have any undercuts, and the corners should be rounded. The presence of ridges or sharp edges, which may corrupt the silicone bead, must also be avoided.

To ensure a proper application process, the nozzle design, the distance between nozzle and substrate, the extrusion speed, and the moving speed of the nozzle must be optimized in pre-trials. Generally, the dimension of the groove determines the type of the dispensing unit and the size of the dispensing nozzle.

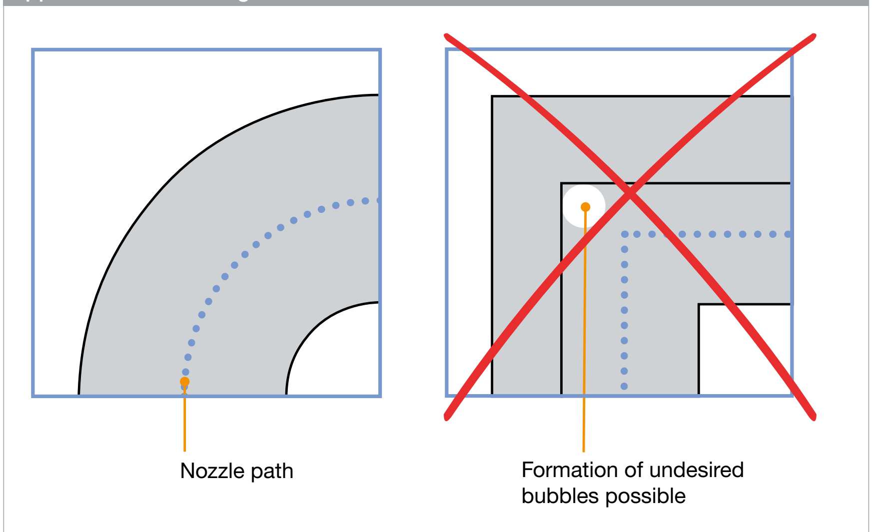
Optimal application requires positioning the nozzle close to the substrate, i.e., at a distance of just a few mm from the bottom of the groove. The silicone bead should be applied in the middle of the groove, which must not run at sharp angles but in curves.

When substrates are additionally fixed with bolts or screws, it is important to keep a specific distance between silicone bead and the bolt holes. The distance is determined by the flexibility of the substrate, the hardness and compressibility of the silicone, and the compression force applied.

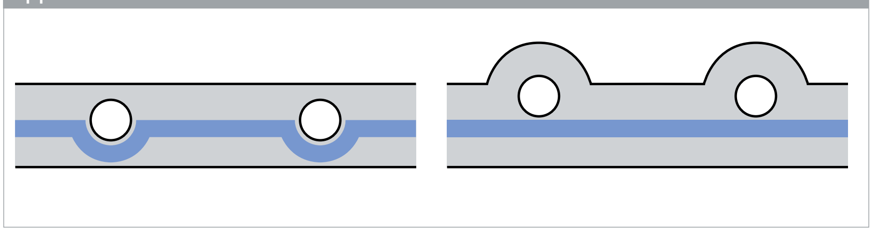
Unfavorable Groove Designs



Application Path at Edges



Applicaton Path for Substrates Fixed with Bolts or Screws



6.3
POTTING AND ENCAPSULATION

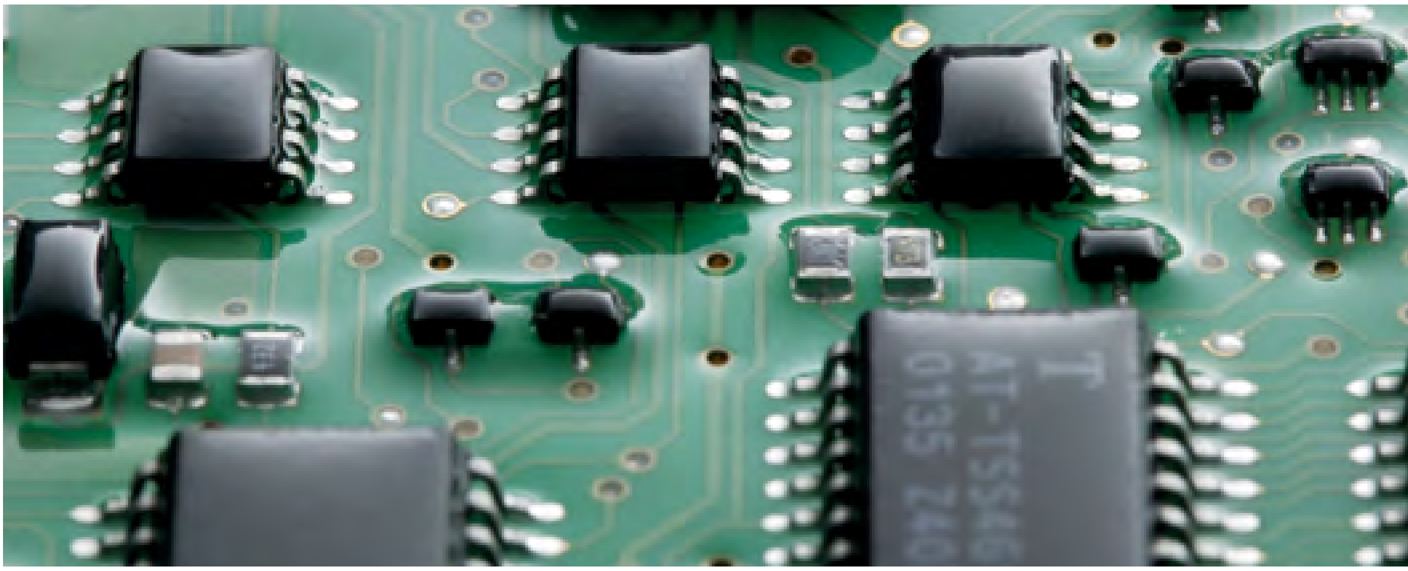
Reliable operation and the lifetime of electronic devices in different application fields depend on efficient protection from the environment. Potting and encapsulation of electronic control units, sensors, printed circuit boards, semiconductor devices or microchips is accomplished by using silicone encapsulants. With its unique manufacturing process for the silicone raw material polydimethylsiloxane, WACKER is excellently positioned for this market.

WACKER offers a wide range of one- and two-component products for potting and encapsulation applications. Silicone gels offer minimum thermal stress on sensitive parts and ensure that the device will work properly even when exposed to extreme temperature fluctuations or strong vibrations. For sensor applications, gels characterized by particularly low volatility and low bleed are becoming increasingly important. Extra-soft gels are available for sensitive electronic devices such as bonded ICs (Integrated Circuit).

Material Property Options

- Low viscosity or shear diluting
- Variable processing and curing times
- Soft to hard
- Transparent to opaque
- High flame resistance
- High thermal conductivity
- Fuel resistance and NO_x resistance e.g., fluoro silicones
- Remarkable low-temperature flexibility (down to -100 °C)
- High thermal shock resistance
- Low shrinkage
- Good adhesion to polymer housings
- Low outgassing
- Low uncured-silicone bleed
- Pronounced damping property
- Specified low ion content

6.4
COATING AND CASTING
COATING APPLICATIONS



Low viscous RTV silicones can be applied with all common coating methods, such as spray coating, knife coating, dip coating, brush coating or transfer roller coating. The following section gives an overview of the most relevant industrial coating techniques.

Conformal Coating

Thin coatings or protective lacquers for PCBs (Printed Circuit Board) or hybrid devices are known as "conformal coatings". They provide protection against external influences such as dust, light, aggressive media, temperature fluctuations and mechanical stress. They also enhance the dielectric strength of highly complex electronic modules. In mass production, conformal coatings are typically applied by spraying or dispensing. Selective parts of a PCB can even be coated separately ("partial cover by selective coating").

The above-mentioned methods require specific RTV silicone properties in terms of rheology, potlife and curing characteristics to achieve uniform coating of the protective lacquer. For this purpose, WACKER offers customized silicones, either solvent based or solvent-free. Dedicated SEMICOSIL® and ELASTOSIL® silicone rubber grades meet challenging requirements in terms of productivity, quality, reliability and cost-efficiency.

Spray Coating

Spray coating is particularly suitable for parts with complex geometry or for large surfaces. In sectors such as the electrical industry or the food industry, spraying silicones is a common process to equip insulators, electrical coils, baking trays, baking molds, or other devices with a protective silicone layer. Typical objectives are improving hydrophobicity, protection against moisture and atmospheric pollutants and better release.

Since silicones can absorb air, airless spraying systems – as used for high-quality paintwork – are mandatory for spray coating. This avoids unsatisfactory results such as blistering and orange peel. The surfaces to be coated should be thoroughly cleaned beforehand to ensure good adhesion to the substrate.

Spray coating can be used for:
- Low viscous, flowable RTV silicones or
- Solvent-based RTV silicone emulsions or
- Shear thinning, self-levelling RTV silicones

Coatings based on RTV-1 start vulcanizing during spraying due to contact with air moisture. RTV-2 silicone coatings are usually cured by heating, e.g., in an oven or a heating tunnel, after the spraying process.

Knife Coating or Roller Coating

Knife coating and roller coating are preferred for roll-to-roll processes involving flexible substrates. Both processes are ideal for applying an RTV silicone on textile, plastic film, or non-woven fabrics. For these coating methods, either shear thinning grades or those with medium to high viscosity are required.

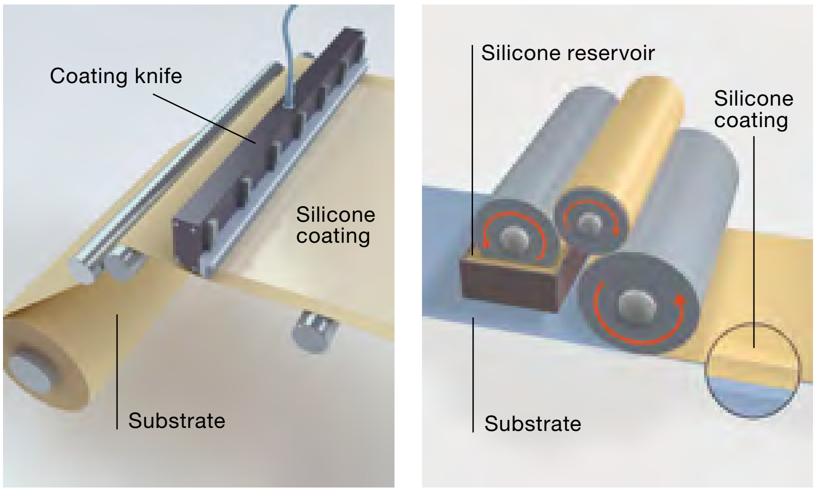
With knife coating, the silicone is applied in front of a coating knife or a doctor blade. The shear force applied by the blade lowers the silicone's viscosity. As a result, the silicone is evenly distributed and its spreadability on the substrate is ensured, which facilitates permeation into the fabric, if applicable. The distance between the blade and the substrate determines the coating thickness – the greater the distance, the higher the thickness. To achieve a very thin coating (approx. 10 µm) the blade is pressed directly onto the substrate. The RTV silicone’s rheology is key to obtaining excellent results with knife coating.

Roller coating is comparable to knife coating in terms of process. The difference is that a transfer roller is used to apply the silicone instead of a knife.

Examples of knife or roller coating applications are:

- Fabrics coatings e.g., for wound dressings, airbags, or baking mats
- Release liner on plastic films or paper
- Silicone laminated plastic films
- Silicone-based skin adhesives

Knife Coating and Roller Coating



WACKER's dedicated brand for the health- and wound-care market is SILPURAN®. For knife and roller coating applications, SILPURAN® RTV grades are typically used in

- Traditional wound care
- Advanced wound care
- Scar treatment
- Ostomy care
- Medical tapes

SILPURAN® products fulfill the most rigorous medical demands: They are free of organic plasticizers, can be sterilized and carry a number of certificates. Selected tests according to ISO 10993 and USP Class VI certification ensure biocompatibility and the highest safety levels for both users and processors. Cleanroom dispensing and packaging in accordance with WACKER Clean Operations standards ensure consistently high product quality.

Dip Coating

In this process, the part to be coated is dipped into uncured RTV silicone. After removing the part from the coating bath, excess silicone must drip off. Then the vulcanization process can start. Better coating results are achieved by rotating the part during the curing process to prevent coating sags. Depending on the silicone type, the coated material is vulcanized by exposure to air (RTV-1) or by exposure to heat (RTV-2 or one-component heat curing grades). Typically, silicones used for dip coating are either low viscous or solvent-based.

Dip coating is a cost-efficient method adapted for small series or prototyping. It is rarely used for mass production as the dip process requires a silicone with a long pot life, whereas mass production usually means fast curing silicones with a short pot life. Dip coating is used, for example, to coat chokes, the coil head of electrical machines, or electrical coils of transformers.

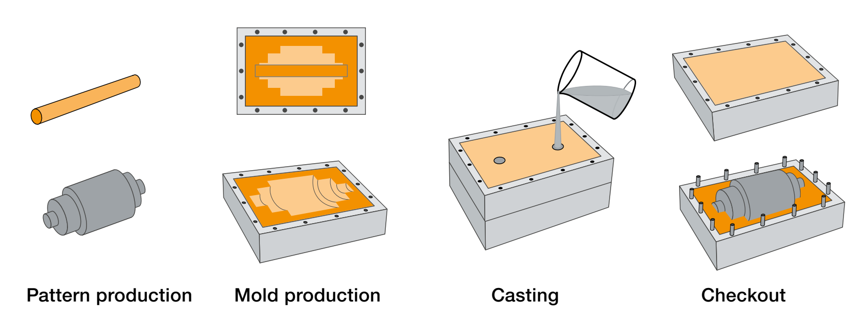
6.4
COATING AND CASTING
CASTING APPLICATIONS

Casting is a process in which uncured material is poured into a silicone mold where it crosslinks. Flowable RTV-2 silicones are often processed by casting, typically for manufacturing
- Printing pads
- Embossing rollers
- Printer rollers
- Prosthetic and orthopedic items
- Ostomy care items.

In this case, the silicone rubber is infused into a mold as a casting compound in order to obtain a shaped elastomer part. Casting is usually used for complex shapes, small-scale production or where investment is limited.

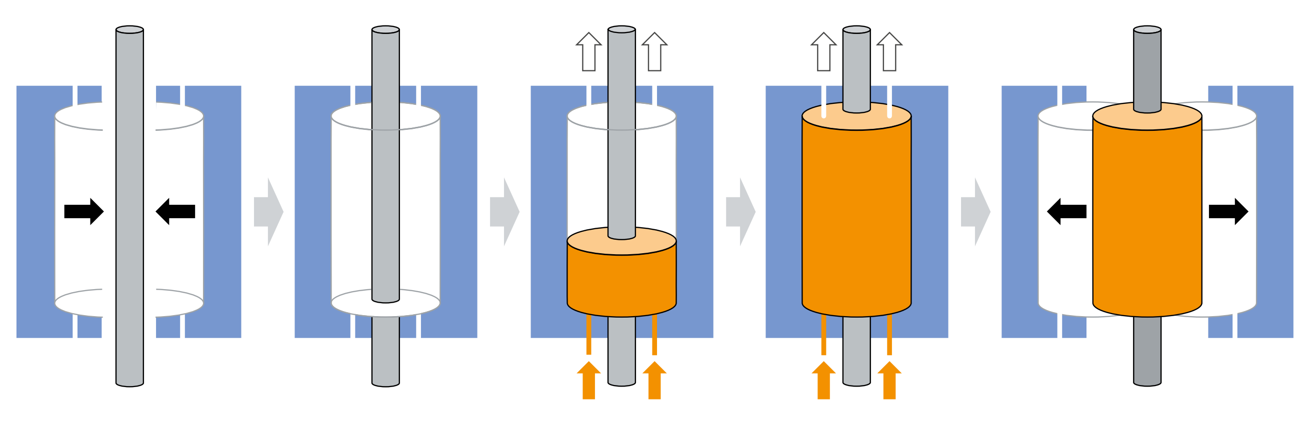
WACKER silicones for casting applications offer valuable and unique advantages with optimal results:
- Excellent processability and degassing properties
- Low viscosity to allow for a high level of precision in detail reproduction
- High flowability that permits fast mold filling, no matter how intricate the mold is
- Fast curing to enable short demolding times
- High level of tear resistance and release for easy and safe demolding
- Long-term consistency and fatigue resistance for mechanically stressed silicone items
- Excellent resistance to chemicals, such as printing inks, wax, plaster, casting resins or concrete.

Reusable Silicone Elastomer Molds Produced by Casting



RTV silicone rubber is used to manufacture reusable molds, e.g., for molding applications, replica production or rapid prototyping.

Silicone Printer Roller Produced by a Casting Process



The open mold (1) has to be closed (2). Silicone (yellow) is introduced from the bottom so that air (white) can escape from the mold (3) and is not entrapped. After the mold is filled completely (4), the curing process can start. As soon as the material is cured, the mold can be (5) removed.

6.4
COATING AND CASTING
WACKER BRANDS

WACKER brands for reproduction and printing applications

ELASTOSIL® M
Molds for rapid prototyping, industrial mass production, concrete moldings, restoration and reproduction, decorative arts, or the composites industry require the highest level of precision, accuracy and reusability. ELASTOSIL® M-series casting silicones have long been recognized as the ideal solution for making all types of silicone rubber molds. Their high elasticity, excellent release properties and optimal durability make ELASTOSIL® M casting grades indispensable for both industrial and artisan mold makers.

ELASTOSIL® RT
In order to print on different surfaces such as paper, porcelain, plastics, or other uneven surfaces, the printing device (printing pad or printer roller) must have constant mechanical properties and outstanding ink-transfer. ELASTOSIL® RT-series casting silicones provide precisely these qualities, making them essential for any printing application. They produce superior print results, even for large print runs.

ELASTOSIL® C
In the composite industry, reusable vacuum bags are manufactured with chemically resistant ELASTOSIL® C silicones. Their fast-curing property permits short production cycles, thus ensuring cost-effective and efficient production of fiber-composite items.

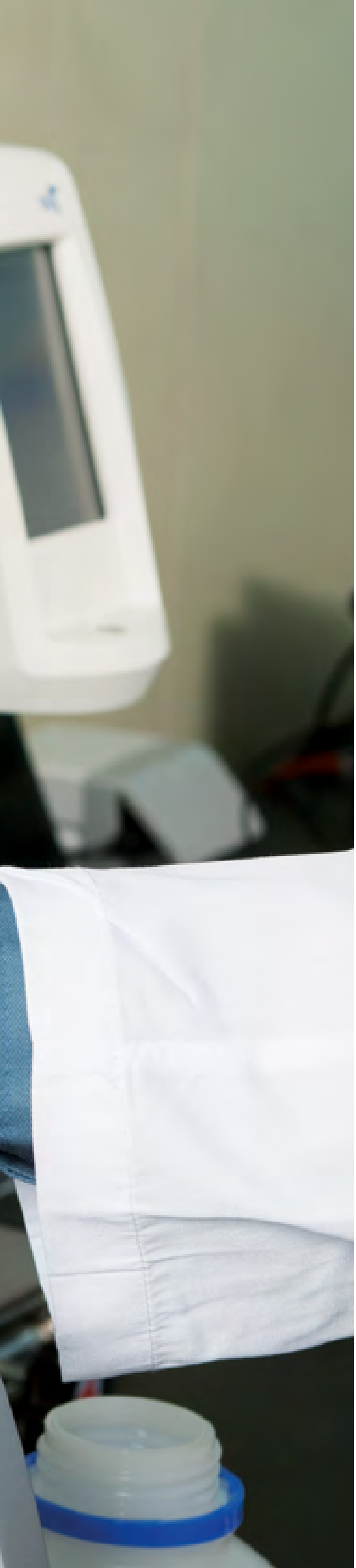
WACKER brands for medical, prosthetic and orthopedic applications

SILPURAN®
WACKER's dedicated products not only cover knife-coating and roller-coating applications, but also casting applications for the medical industry: SILPURAN® RTV grades are used, for instance, for ostomy care. Here too, SILPURAN® products fulfill the most rigorous medical demands.

ELASTOSIL® P
WACKER silicones are used in many prosthetic applications such as the manufacture of:
- Functional prostheses for fingers, hands and partial-foot prostheses
- Orthoses
- Epitheses
- External breast prostheses
- Liners
- Face masks tailored to fit the wearer perfectly.

ELASTOSIL® P-series silicones are ready-to-use and offer customized solutions for the prosthetic industry.


Anton Paar



SECTION 7: SERVICE

Contents

Excellent technologies need best-in-class services.
Our WACKER ACADEMY, technical centers and e-business offer you extraordinary expertise and support.

7.1
TECHNICAL SERVICE AND EXPERTISE

Our application chemists and engineers work closely with our customers, dealing with specific questions from the field. We will support you by finding the optimum product for your specific requirements and by assisting your product development, from material selection to industrial production – worldwide. Our laboratories deal with key issues from specific industrial sectors and have extensive expertise in various application fields.

WACKER SILICONES stands for 360°-silicone expertise and over 50 years of market experience:

- Deep understanding of silicones and silicone processing
- Local technical centers worldwide with experienced laboratory technicians
- Technical consultancy for product selection
- Adjusting standard formulations and customizing to specific requirements
- State-of-the-art analytical equipment to perform tests according to international and local standards and regulations
- Active network of specialists and cross-functional cooperation with other labs and departments
- Consistent product quality worldwide

Thanks to our RTV Clean Operations plant, WACKER is able to produce according to selected GMP criteria and provide clean-room packing classified according to EN ISO 14644-1 Class 8 for high-end health care and electronics applications. Furthermore, UV-curing silicone rubber can be processed under controlled lighting conditions.

Some of our Laboratory Services

- Product adaptation/development
- Range of lab tests:
  - Mechanical properties
  - Adhesion
  - Chemical resistance
  - Thermal, UV and climate ageing
  - Electrical properties.
- In-house application of our RTV silicone rubber formulations on original assembly parts by fully automated metering & dispensing equipment, e.g., for testing or approval series

7.2
E-BUSINESS

E-Business

WACKER e-solutions simplify business between our customers and WACKER, and offer many possibilities: from global searches and reporting options in our Login4More customer portal to fast order processing solutions and vendor-managed inventory. We compile a tailored service package for you, adapted to the size of your company, your profile and specific wishes.

You can gain considerably greater efficiency through:
- 24/7 availability
- Automatic order processing
- Easy order changes
- Fast processing with far fewer errors
- Maximum planning reliability
- Full transparency
- Paperless invoicing
- Automatic inventory monitoring

7.3 REGULATORY SUPPORT

To ensure product safety, we offer you regulatory support. Our experts handle your enquiries on environmental, health and regulatory matters.

This includes the following topics:

- Food contact applications (e.g., BfR, FDA)
- Drinking water approval (e.g., KTW, WRAS, ACS)
- Pharmaceutical and medical applications (e.g., European Pharmacopeia and U.S. Pharmacopeia USP)
- National and international regulations and provisions (e. g., EU directive 2002/95/ EC – RoHS, REACH)
- Specific industry requirements (e.g., GADSL, IMDS, automotive industry)
- Specific customer requirements (e.g., banned-substance and substance-avoidance lists)
- Toxicology and ecotoxicology
- Risk assessment
- Organizational assistance.

7.4

THE WACKER ACADEMY

To transfer its own expertise and market experience, WACKER has founded a unique institution, the WACKER ACADEMY. Here, at a number of sites worldwide, you can take advantage of a versatile, industry-specific seminar program.

This includes:
- Introductory chemistry seminars
- Training programs on particular application fields
- Introductory seminar on silicone rubber for newcomers to the field
- Customized training programs and events, specific to your needs.

You can find the current program at: www.wacker.com/wacker-academy. WACKER ACADEMY centers are located in different regions, exemplifying our policy of making global expertise available right on your doorstep. As a result, we can offer you a seminar program tailored to your needs and your specific markets.

All our seminars are held by experienced specialists – chiefly in-house experts. To make our program even more attractive and ensure it remains up to date, we work closely with universities and research institutes.

SECTION 8:
SILICONES A–Z

Contents

A list of frequently used technical terms is given below.

8.0
SILICONES A – Z

Adhesion
- Self-adhesive RTV silicone rubber is suitable for many substrates
- The quality of adhesion depends on the nature of the materials to be bonded, the mechanical stress, and possibly a surface treatment (primer, plasma, corona).
- Most superior bonds are obtained on oxidic and siliceous surfaces.

Coefficient of Linear Thermal Expansion
- Coefficient of linear thermal expansion approx. $150 \cdot 10^{-6} – 300 \cdot 10^{-6}$ m/(m·K)
- RTV silicone rubber expands during heat curing, resulting into an “apparent” shrinkage on cooling
- The coefficient of linear thermal expansion depends on the filler content.

Compression Set
- Compression set determined as per ISO 815-B (ASTM D395 B-2) for storage lasting 22h/175 °C, or 22h/125 °C in the case of self-adhesive grades.
- Compression set describes the elastic recovery of a cured rubber, an important characteristic for gasket applications.
- Typical values for RTV silicone rubber: down to 5 %.

Density
- Determined as per ISO 1183-1 A (buoyancy method).
- Typical range for specific density 0.95 – 1.50 g/cm^3.
- When using additional inactive fillers (e.g., quartz), values of over 3 g/cm^3 can be achieved, for example, to improve swelling resistance or thermal conductivity.

Dielectric Constant ε_r
- Dielectric constant ε_r determined as per DIN 53 482 or VDE 0303.
- Typical values for silicone rubber: ε_r = 2.7 - 3.3 (at 25 °C and 50 Hz).
- This property can be increased up to 150 by using suitable fillers.

Dielectric Strength
- Dielectric strength determined as per IEC 60243-1.
- Typical value for RTV silicone rubber > 20 kV/mm (1 mm sheet, IEC 60243-1).

Dissipation Factor Tan δ
- Dielectric dissipation factor tan δ
  - Dissipation factor determined as per VDE 0303.
  - Typical values for loss angle tan δ ~10^{-3}.
  - tan δ is raised by increasing the filler content/density.
- Mechanical dissipation factor tan δ
  - Determined via measurement of the silicone’s storage modulus and loss modulus.
  - Typical values for gels: tan δ < 0.1; typical values for silicone elastomers tan δ >1.
  - tan δ is raised by increasing the crosslinking density or by filler content.

Environmental Compatibility
- Since silicones have the same basic chemical structure as quartz, cured RTV silicone rubber poses no known ecological or physiological risks.

Fire Behavior
- The auto-ignition temperature of cured products is about 430 °C.
- Silicone rubber burns to form a white non-toxic ash of silicon dioxide
- The resultant combustion gases are usually non-corrosive.
- Specialty grades form a ceramic layer in the case of fire.

Flame Resistance

- Flame resistance determined acc. to ASTM D 2863 test standard by determining the limiting oxygen index (LOI) or acc. to Underwriters Laboratory fire standard (UL 94).
- Typical LOI values of flame retardant grades 27 % to 35 %
- Standard grades normally achieve UL 94 HB (0.5 – 1.0 mm thickness)
- Specialty grades with additives reach UL 94 V0 (1.0 – 4.0 mm thickness).

Gas Permeability

- Determined as per DIN 53 536
- Very high gas permeability compared to other elastomers, e.g., for air 30 times higher than for natural rubber (NR) or 400 times higher than butyl rubber (IIR) (measured at 25 °C)
- The absolute value of a 50 Shore A grade for air at 20 °C and 80 °C is 570 and 1.330 $cm^3 \cdot mm \cdot m^{-2} \cdot h^{-1} \cdot bar^{-1}$ (volume of air measured in cm^3, that penetrates a membrane of 1 m^2 area per hour at a pressure difference of 1 bar and 1 mm thickness)
- Technical advantage, e.g., for contact lenses, textile coatings and some medical applications
- At high temperatures, silicone has similar values to organic elastomers

Relative Permeability of Gases at 25 °C (%)	
Air	100
Hydrogen	190
Oxygen	170
Nitrogen	80
Carbon dioxide	1.000
Ethylene	390

Hardness

- Hardness of silicone rubber determined in Shore 00 (ASTM D 2240 / Type 00), Shore A (ISO 7619-1) or in IRHD units (DIN 53 519).
- Typical range: 20 Shore 00 – 80 Shore A.
- See penetration for silicone gels

High-Energy Radiation

- Outstanding resistance of silicone rubber (VMQ, PVMQ) to high-energy radiation in combination with hot-air resistance in comparison to other elastomers.
- With VMQ silicone rubber grades, only high radiation doses of 400–800 kGy lead to a reduction of 50 % in the elongation at break.
- Phenyl-containing PVMQ silicone rubber, such as ELASTOSIL® RTV-S 691, has higher resistance.
- Properties not severely affected by gamma and beta radiation (25 – 75 kGy), as widely used for sterilizing medical equipment.
- Very good resistance to microwaves, since silicone parts are not microwave-active and therefore not heated.

Heat Resistance

- The mechanical properties of WACKER silicone rubber are retained even at high temperature stress.
- The heat resistance is thereby clearly superior to that of most organic elastomers (cf. ASTM Charta D2000)

Ozone Resistance

- Outstanding resistance of silicone rubber to ozone
- Ozone resistance determined as per DIN 53509

Optical Properties

- The light permeability of unfilled RTV silicone rubber materials is almost 100 % in the visible range from 400 to 760 nm (1 mm layer thickness).
- The cut-off region of highly transparent RTV silicones ranges from 220–230 nm.
- The appearance of RTV silicone rubber is determined by fillers. Fumed silica as filler makes the respective grades become translucent due to light scattering.
- The refractive index nD25 is between 1.404 and 1.410 for standard RTV silicone rubber. High refractive index grades achieve values of up to 1.5 and higher.

* dep. on grade

Penetration

- The consistency of silicone gels is usually characterized by quoting the penetration. It is determined by use of a standard cone under a specific load and given in mm/10.
- The higher the penetration value, the softer the compound.
- Typical values for soft gels: 300-100 mm/10
- Typical values for tough gels: 30-10 mm/10.

Rebound Resilience

- Rebound resilience determined as per DIN 53 512
- Also commonly known as “snap”
- Measured on 6 mm samples as a ratio of rebound height to the drop height of a pendulum
- Typical values 30 – 70%.

Release Properties

- RTV silicone rubber shows a pronounced release effect versus inorganic and organic materials such as gypsum, concrete, polyester, epoxide, polyurethane, polyamide, polystyrene, PVC, wax and metal alloys.
- This effect is exploited where RTV silicone rubber is used in mold-making compounds to make molded parts or reproductions.

Reversion

- Degradation of the crosslinking network in the cured rubber as a result of chemical or thermal effects. This leads to a permanent decrease of hardness (softening)
- In silicone rubber, at high temperatures (> 200 °C) traces of moisture or free hydroxyl groups in fillers cause cleavage of the Si-O bond in the polymer chain and ultimately the above-mentioned decrease in hardness due to depolymerization
- This process is inhibited by the presence of air
- High heat resistance therefore requires unrestricted access of atmospheric oxygen, and must be taken into account in the design of gasket parts

• Solvent and Chemical Resistance

- The chemical resistance of WACKER silicone rubber generally depends on the crosslinking density, filler used, and filler content.
- With higher filler levels in the silicone rubber, the swelling tendency decreases and resistance is improved.
- High swelling tendency to non-polar liquids such as hydrocarbons, mineral oils and greases.
- Low swelling tendency to polar liquids, such as alcohols, low-molecular ketones, and therefore no negative effect on seal quality.
- Strongly attacked by concentrated acids and alkalis, particularly by oxidizing acids such as sulfuric or nitric acid.
- Silicone rubber has good resistance to aqueous solutions of weak acids, alkalis or salts, which are commonly used as cleaning solutions for lines / tubing at 70 – 80 °C in the food industry.

Shrinkage

- Condensation-curing RTV silicones show a volume shrinkage of up to 3 % due to the liberation of volatile by-products.
- Addition-curing RTV silicones cure almost shrink-free (approx. 0.1%).

Surface Resistivity

- Surface resistivity determined as per VDE 0303
- Typical values for insulating silicone compounds: approx. $10^{12} – 10^{13}$ Ω.

Tear Propagation and Notch Resistance

- Tear strength depends on which particular standard is used.
- Typical values when determined as per ASTM D 624 B (crescent): 5 – 30 N/mm.

Tensile Strength and Elongation at Break

- Tensile strength and elongation at break determined as per ISO 37
- Standard test on S1 bar. In some cases, also measurements on small S2 and S3 test specimens, though the values deviate correspondingly
- Typical RTV silicone values: tensile strength — approx. 2 – 8 N/mm^2 (or MPa); elongation at break — approx. 100 % – 900 %

Temperature Behavior

- Mechanical properties of silicone elastomers determined at 23 °C (room temperature) as per DIN 53503 or DIN 53505 respectively.
- The change in the mechanical properties is small compared to organic elastomers.
- Typical service temperature range: –50 to +180 °C. Specialty grades: down to -110 °C or up to 270 °C (peak temperature load may be even lower or higher).
- Standard grades harden at very low temperatures (below -45 °C) due to reversible crystallization.
- There is a slow increase in hardness at very high temperatures (> 200 °C) as a result of heat aging.
- At high temperatures (> 180 °C), the organic side groups attached to the silicon atom undergo free-radical cleavage. The resulting free radicals can cause post-curing of the polymer chains, thereby increasing hardness and decreasing tensile strength and elongation at break (embrittlement).
- The simultaneous weight decrease of the vulcanizate leads to shrinkage.
- The lifetime of the RTV silicone vulcanizate can be increased by the use of heat stabilizers
- The increased crosslinking density as a result of prolonged thermal loading has a positive effect on the rebound resilience.
- Excellent stable, long-term behavior for electrical insulation at high temperatures is obtained, as oxidative degradation produces quartz-like properties.

Thermal Conductivity and Specific Heat Capacity

- Determined as per DIN 52 612
- The thermal conductivity depends on the type and amount of fillers used.
- Typical value for standard grades at 50 °C: approx. 0.2 – 0.3 W/(m·K).
- Special thermally conductive compounds achieve values of up to 3 W/(m·K).
- Typical values for specific heat capacity: approx. 1.25 kJ/(kg·K).

Tracking Resistance

- Silicone rubber generally features high tracking resistance (e.g., CTI 600 as per IEC 60112).

Viscosity

- Determined as per DIN EN ISO 3219.
- The viscosity of RTV silicone rubber compounds is usually between 500 and 2,000,000 mPa·s.
- Viscosity depends on temperature and can depend on shear rate.

Volume Resistivity

- Determined as per IEC 60093.
- Typical values for insulating silicone rubber grades approx. 10^{15} Ω·cm.
- Typical values for conductive RTV grades approx. 50 Ω·cm.

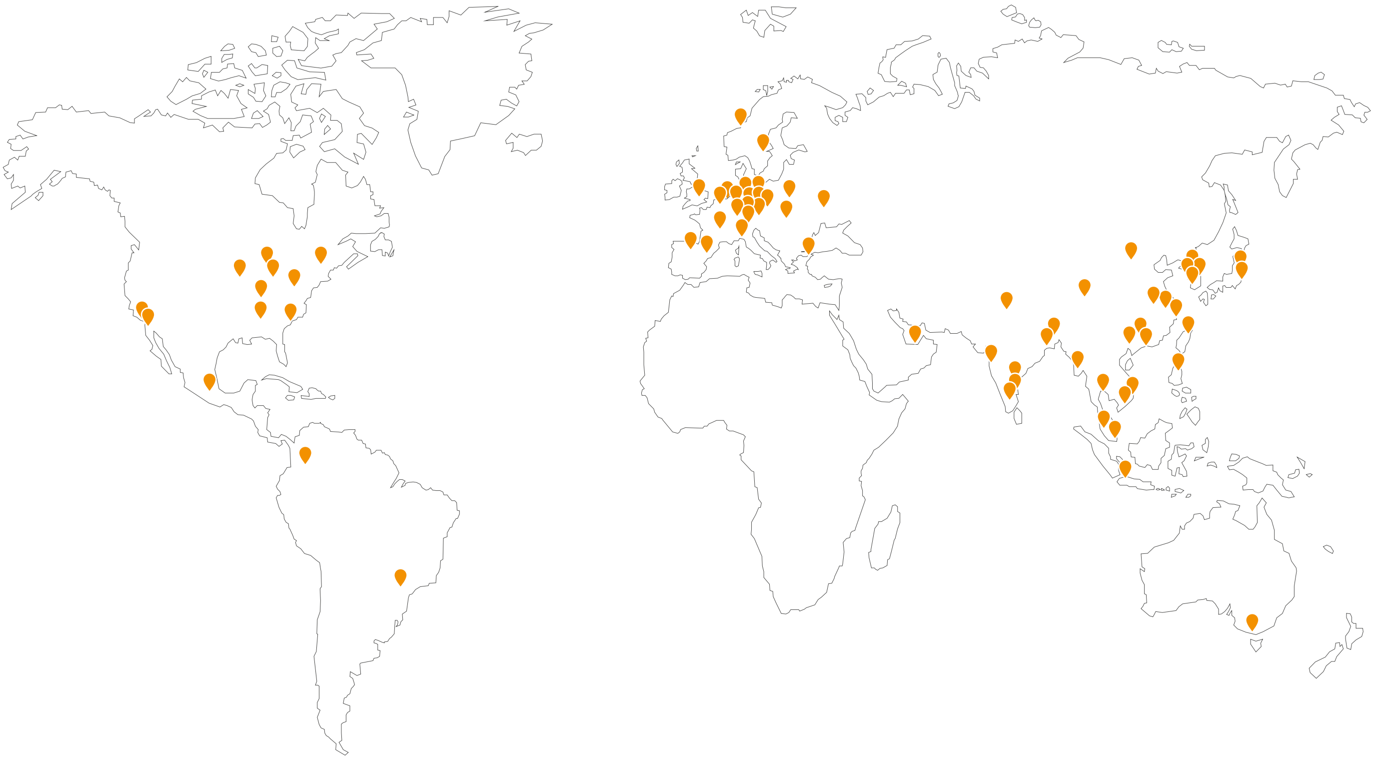
Water and Steam Resistance

- Excellent resistance to boiling water.
- Volume decrease in boiling water below 1 %, even after prolonged action.
- Steam sterilization (as per ISO 17665, DIN EN 868-8 at 500 cycles at 134 °C, 5 min.) may slightly change mechanical properties.
- Water (gaseous) absorption of < 0.5 % with virtually no effect on mechanical or electrical properties.

Weathering and UV Resistance

- Silicone rubber items are generally insensitive to UV radiation.
- Properties only change slightly even in long-term tests (several years of weathering).
- Unlike with organic elastomers, weathering resistance can be achieved without additives (e.g. organic antioxidants, UV stabilizers, etc.).

EXPERTISE AND SERVICE NETWORK ON FIVE CONTINENTS



Sales offices, production sites and technical competence centers around the world.

WACKER is one of the world's leading and most research-intensive chemical companies, with total sales of €6.4bn. Products range from silicones, binders and polymer additives for diverse industrial sectors to bioengineered pharmaceutical actives and hyperpure silicon for semiconductor and solar applications. As a technology leader focusing on sustainability, WACKER promotes products and ideas that offer a high value-added potential to ensure that current and future generations enjoy a better quality of life, based on energy efficiency and protection of the climate and environment. Spanning the globe with 4 business divisions, we offer our customers highly-specialized products and comprehensive service via 27 production sites, 22 technical competence centers, 14 WACKER ACADEMY training centers and 48 sales offices in Europe, North and South America, and Asia – including a presence in China.

WACKER

CREATING TOMORROW'S SOLUTIONS

ELASTOSIL®

SEMICOSIL®

PRODUCT OVERVIEW

INDUSTRIAL SEALING & BONDING APPLICATIONS

Non-slump RTV silicone grades (self-adhesive)

Main characteristics Brand / Product	Product type / curing system	Shrink-free curing	By-product of curing	Additional features	Food compli-ance	Viscosity [mPa·s]	Potlife or skin forming time	Hardness [Shore A]	Tensile strength [MPa]	Elongation at break [%]	Tear strength [N/mm]	Density, cured [g/cm³]	Recom-mended max. service tempera-ture [°C]	CIPG	FIPG	Aspect / color
Self-adhesive after curing at room temperature																
General purpose																
ELASTOSIL® E 4	RTV-1 / condensation cure		Acetic acid			Non-slump	20 min	15	2.0	750	7.3	1.02	180	X	X	Translucent
ELASTOSIL® E 43 N	RTV-1 / condensation cure		Acetic acid	Titanium catalyzed	X	300,000	5 min	30	7.8	450	12.5	1.12	180		X	Translucent / white / black
ELASTOSIL® E 900	RTV-1 / condensation cure		Acetic acid			Non-slump	10 min	20	0.6	300	4.2	1.02	230		X	Anthracite
ELASTOSIL® N 2199	RTV-1 / condensation cure		Alcohol			Non-slump	15 min	30	2.5	350	4.0	1.06	180		X	Translucent
ELASTOSIL® N 9111	RTV-1 / condensation cure		Alcohol	Titanium catalyzed		Non-slump	25 min	30	2.2	500	10.0	1.33	180		X	White / gray / black
ELASTOSIL® RT 771	RTV-2 / condensation cure (Base + Catalyst 10:1)*		Alcohol			150,000	5 min / 10 min *	45	1.0	180		1.54	180			Black
Improved mechanical properties																
ELASTOSIL® E 47	RTV-1 / condensation cure		Acetic acid			Non-slump	5 min	35	4.5	450	10.0	1.07	180		X	Translucent
Heat resistance																
ELASTOSIL®A 33	RTV-1 / condensation cure		Amine			Non-slump	10 min	28	2.5	300	7.8	1.17	200		X	Ivory
ELASTOSIL® E 14	RTV-1 / condensation cure		Acetic acid			Non-slump	15 min	38	3.0	450	7.0	1.18	250		X	Red
ELASTOSIL® E 43 N BLACK	RTV-1 / condensation cure		Acetic acid	Titanium catalyzed		300,000	5 min	30	7.5	500	12.5	1.12	250		X	Black
ELASTOSIL® RT 778	RTV-2 / condensation cure (Base + Catalyst 10:1)*		Alcohol	Fast cure		Non-slump	5 min / 10 min *	42	3.5	180	7.0	1.32	250		X	Black
Media resistance																
ELASTOSIL® N 2189	RTV-1 / condensation cure		Alcohol	Oil resistant		Non-slump	15 min	45	2.5	250	4.0	1.23	180		X	Black
ELASTOSIL® RT 779	RTV-2 / condensation cure (Base + Catalyst 10:1)**		Alcohol	Coolant resistant, oil resistant		Non-slump	5 min	50	2.8	250	9.5	1.32	180		X	Anthracite
Compressible																
ELASTOSIL® RT 773	RTV-2 / condensation cure (Base + Catalyst 10:1)*		Alcohol	Low density		Non-slump	5 min / 15 min *	35	0.7	75		0.70	140	X		Black
ELASTOSIL® SC 833	RTV-2 / platinum cure (A/B 1:1)		Hydrogen gas	Silicone foam, flame retardant		17,000	4 min	27	1.2	80		0.50	200	X		Black
ELASTOSIL® SC 835	RTV-2 / platinum cure (A/B 1:1)		Hydrogen gas	Silicone foam		15,000	240 s	20	0.45	80		0.45	200	X		Reddish brown
ELASTOSIL® SC 870	RTV-2 / platinum cure (A/B 1:1)		Hydrogen gas	Silicone foam, thixotropic		40,000	150 s	10	0.35	100		0.40	200	X		Gray
Self-adhesive after curing at elevated temperature																
General purpose																
ELASTOSIL® RT 703	1-component heat-curing / platinum cure	X		Screen printable		Non-slump	6 months	35	4.0	300		1.08	200	X	X	Translucent
ELASTOSIL® RT 724	RTV-2 / platinum cure (Base + Catalyst 10:1)***	X				100,000	12 h	45	4.0	180	10.0	1.25	180		X	Blue
SEMICOSIL® 986/1K	1-component heat-curing / platinum cure	X		UV fluorescent		Non-slump	6 months	51	5.0	200	8.0	1.07	180		X	Translucent
SEMICOSIL® 987 GR	1-component heat-curing / platinum cure	X		Sealing adhesive		Non-slump	6 months	50	5.0	200		1.10	180		X	Gray
SEMICOSIL® 988/1K gray	1-component heat-curing / platinum cure	X		Sealing adhesive		Non-slump	6 months	35	4.5	350	24.0	1.10	180	X	X	Gray
SEMICOSIL® 989/1K	1-component heat-curing / platinum cure	X		Sealing adhesive		Non-slump	6 months	55	5.0	200	10.0	1.10	180		X	Translucent
SEMICOSIL® 970 TC	RTV-2 / platinum cure (A/B 1:1)	X		Thermally conductive		94,000	16 h	65	4.0	90		2.26	160		X	White-gray
High tear resistance																
ELASTOSIL® RT 722	RTV-2 / platinum cure (A/B 1:1)	X		High tensile strength		Non-slump	6 h	45	6.0	300		1.10	180		X	Gray
Heat resistance																
ELASTOSIL® RT 702	1-component heat-curing / platinum cure	X				Non-slump	6 months	40	6.1	500	10.1	1.22	250		X	Black
Media resistance																
ELASTOSIL® RT 728	RTV-2 / platinum cure (A/B 1:1)	X		Coolant resistant		Non-slump	24 h	45	5.8	400	17.3	1.13	180	X		Anthracite
Compressible																
ELASTOSIL® RT 713	1-component heat-curing / platinum cure	X		Low density		Non-slump	6 months	23	1.5	350	7.0	0.75	140	X		Gray

* base component to be combined with WACKER® Catalyst T 77 or WACKER® Catalyst T 77 PLUS (please see the corresponding technical data sheet for details)
** base component to be combined with WACKER® Catalyst T 79 (please see the corresponding technical data sheet for details)
*** base component to be combined with ELASTOSIL® CAT PT, ELASTOSIL® CAT PT-F or ELASTOSIL® CAT UV to allow curing at room temperature, under heat or by UV light (please see the corresponding technical data sheet for details)

Note: these figures are intended as a guide and should not be used in preparing specifications.

WACKER

CREATING TOMORROW'S SOLUTIONS

ELASTOSIL®

PRODUCT OVERVIEW

INDUSTRIAL COATING OR SEALING APPLICATIONS

Flowable RTV silicone grades (self-adhesive)

Main characteristics Brand/ Product	Product type / curing system	Shrink-free curing	By-product of curing	Additional features	Food compli-ance	Viscosity [mPa·s]	Potlife or skin forming time	Hardness [Shore A]	Tensile strength [MPa]	Elongation at break [%]	Tear strength [N/mm]	Density, cured [g/cm^3]	Recommended max. service temperature [°C]	Aspect / color	Main characteristics Brand/ Product
Self-adhesive after curing at room temperature															**Self-adhesive after curing at room temperature**
General purpose															**General purpose**
ELASTOSIL® A 07	RTV-1 / condensation cure		Amine	Solvent based		8,000	3 min	20	1.5	300	4.0	1.02	200	Translucent	ELASTOSIL® A 07
ELASTOSIL® E 41	RTV-1 / condensation cure		Acetic acid	Solvent based		65,000	15 min	40	6.0	350	11.5	1.12	180	Translucent	ELASTOSIL® E 41
ELASTOSIL® E 50 N	RTV-1 / condensation cure		Acetic acid	Titanium catalyzed	X	50,000	10 min	35	1.5	150	5.0	1.07	180	Transparent	ELASTOSIL® E 50 N
ELASTOSIL® E 303	RTV-1 / condensation cure		Acetic acid	Solvent based		500	5 min	30	5.0	400		0.90	180	Translucent	ELASTOSIL® E 303
ELASTOSIL® N 2010	RTV-1 / condensation cure		Alcohol			15,000	20 min	25	1.0	200		1.01	180	Translucent	ELASTOSIL® N 2010
ELASTOSIL® RT 745 T	RTV-2 / platinum cure (A/B 1:1)	X				1,000	4 h	5	1.0	100		0.97	160	Brownish	ELASTOSIL® RT 745 T
Heat resistance															**Heat resistance**
ELASTOSIL® A 234	RTV-1 / condensation cure		Amine			35,000	15 min	36	2.5	200	3.7	1.19	230	White	ELASTOSIL® A 234
ELASTOSIL® A 316	RTV-1 / condensation cure		Amine	Solvent based		500	5 min	15	0.8	200		1.02	180	Translucent	ELASTOSIL® A 316
ELASTOSIL® A 59	RTV-1 / condensation cure		Amine	Oil resistant		60,000	45 min	20	1.2	300	3.0	1.43	210	Gray	ELASTOSIL® A 59
ELASTOSIL® E 10	RTV-1 / condensation cure		Acetic acid			8,000	10 min	25	2.5	300	7.3	1.10	250	Red	ELASTOSIL® E 10
ELASTOSIL® E 60 N	RTV-1 / condensation cure		Acetic acid	Titanium catalyzed	X	80,000	5 min	35	2.5	250		1.07	230	Black / gray / red	ELASTOSIL® E 60 N
ELASTOSIL® RT 772	RTV-2 / condensation cure (Base + Catalyst 10:1)*		Alcohol			35,000	5 min / 10 min *	35	2.2	200		1.26	230	Black	ELASTOSIL® RT 772
Flame Retardant															**Flame Retardant**
ELASTOSIL® N 2034	RTV-1 / condensation cure		Alcohol			25,000	20 min	35	2.0	200		1.16	180	Black	ELASTOSIL® N 2034
ELASTOSIL® N 2076	RTV-1 / condensation cure		Alcohol	EN 45545 compliant		150,000	15 min	36	1.6	150		1.30	180	Anthracite	ELASTOSIL® N 2076
Self-adhesive after curing at elevated temperature															**Self-adhesive after curing at elevated temperature**
General purpose															**General purpose**
ELASTOSIL® RT 720	RTV-2 / platinum cure (A/B 10:1)	X				30,000	6 h	35	5.0	200		1.13	180	Gray	ELASTOSIL® RT 720
Heat resistance															**Heat resistance**
ELASTOSIL® RT 705	1-component heat-curing / platinum cure	X				72,500	6 months	42	3.5	200	3.5	1.24	230	Black	ELASTOSIL® RT 705
ELASTOSIL® RT 706	1-component heat-curing / platinum cure	X				15,000	6 months	30	2.5	200		1.23	210	Red	ELASTOSIL® RT 706
ELASTOSIL® RT 707 W	1-component heat-curing / platinum cure	X				60,000	6 months	42	3.3	270		1.18	230	White	ELASTOSIL® RT 707 W
ELASTOSIL® RT 708	1-component heat-curing / platinum cure	X		UV fluorescent		75,000	6 months	42	3.5	300		1.36	230	Dark gray	ELASTOSIL® RT 708

* base component to be combined with WACKER® Catalyst T 77 or WACKER® Catalyst T 77 PLUS (please see the corresponding technical data sheet for details)

Note: these figures are intended as a guide and should not be used in preparing specifications.

WACKER

CREATING TOMORROW'S SOLUTIONS

ELASTOSIL®

SEMICOSIL®

WACKER SilGel®

PRODUCT OVERVIEW

INDUSTRIAL POTTING, ENCAPSULATION OR CASTING APPLICATIONS

Flowable RTV silicone grades

Main characteristics Brand/ Product	Product type / curing system	Shrink-free curing	By-product of curing	Additional features	Self-adhesive after curing at room temperature	Food compliance	Viscosity [mPa·s]	Potlife	Hardness [Shore A]	Tensile strength [MPa]	Elongation at break [%]	Tear strength [N/mm]	Density, cured [g/cm³]	Recommended max. service temperature [°C]	Aspect / color	Main characteristics Brand/ Product
General purpose																**General purpose**
ELASTOSIL® RT 402	RTV-2 / condensation cure (Base + Catalyst 100:3)*		Alcohol	Antistatic			13,000	75 min	11	2.0	350	3	1.28	160	Light gray	ELASTOSIL® RT 402
ELASTOSIL® RT 563	RTV-2 / condensation cure (Base + Catalyst 100:4)*		Alcohol	Excellent flowability			5,000	35 min	55	4.5	120	3	1.27	180	Beige	ELASTOSIL® RT 563
ELASTOSIL® RT K	RTV-2 / condensation cure (Base + Catalyst 100:4)*		Alcohol	Excellent flowability			7,000	30 min	45	2.0	130	3	1.22	180	Light gray	ELASTOSIL® RT K
ELASTOSIL® RT 601	RTV-2 / platinum cure (A/B 9:1)	X		Crystal clear		X	3,500	90 min	45	6.0	100		1.02	150	Transparent	ELASTOSIL® RT 601
ELASTOSIL® RT 604	RTV-2 / platinum cure (A/B 9:1)	X		Crystal clear		X	800	90 min	25	1.0	100	3	0.97	150	Transparent	ELASTOSIL® RT 604
ELASTOSIL® RT 628	RTV-2 / platinum cure (A/B 9:1)	X		High tear strength			50,000	60 min	50	3.5	230	11	1.23	180	Gray	ELASTOSIL® RT 628
ELASTOSIL® RT 743 LV-K	RTV-2 / platinum cure (A/B 1:1)	X		Thermally conductive			1,100	2 h	20	3.0	150		1.45	180	Gray	ELASTOSIL® RT 743 LV-K
ELASTOSIL® RT 745	RTV-2 / platinum cure (A/B 1:1)	X			X		1,000	4 h	15	1.0	150		0.97	160	Brownish translucent	ELASTOSIL® RT 745
ELASTOSIL® RT 745 T	RTV-2 / platinum cure (A/B 1:1)	X		Soft elastomer	O		1,000	4 h	5	1.0	100		0.97	160	Brownish translucent	ELASTOSIL® RT 745 T
SEMICOSIL® 911	RTV-2 / platinum cure (A/B 1:1)	X		Soft gel, thixotropic	X		8,000	1 h	-	-	-	-	0.99	160	Translucent	SEMICOSIL® 911
SEMICOSIL® 912	RTV-2 / platinum cure (Base + Catalyst 10:1)**	X		Soft gel	X		1,000	Depending on catalyst used	-	-	-	-	0.97	160	Transparent	SEMICOSIL® 912
WACKER SilGel® 612	RTV-2 / platinum cure (A/B 1:1)	X		Soft gel, crystal clear	X		1,000	150 min	-	-	-	-	0.97	160	Transparent	WACKER SilGel® 612
WACKER SilGel® 613	RTV-2 / platinum cure (Base + Catalyst 10:1)**	X		Soft gel, crystal clear	X		200	Depending on catalyst used	-	-	-	-	0.97	160	Transparent	WACKER SilGel® 613
High tear resistance																**High tear resistance**
ELASTOSIL® RT 620	RTV-2 / platinum cure (A/B 10:1)	X		Excellent mechanical properties		X	6,000	35 min	17	5.0	900	12	1.05	200	Translucent	ELASTOSIL® RT 620
ELASTOSIL® RT 622	RTV-2 / platinum cure (A/B 9:1)	X		Excellent mechanical properties		X	12,000	60 min	27	6.5	550	30	1.13	200	Reddish brown / gray	ELASTOSIL® RT 622
ELASTOSIL® RT 623	RTV-2 / platinum cure (A/B 9:1)	X		Excellent mechanical properties		X	10,000	30 min	31	7.5	700	30	1.12	200	Reddish brown	ELASTOSIL® RT 623
ELASTOSIL® RT 625	RTV-2 / platinum cure (A/B 9:1)	X		Excellent mechanical properties		X	12,000	60 min	25	6.5	600	30	1.10	180	Translucent	ELASTOSIL® RT 625
ELASTOSIL® RT 629	RTV-2 / platinum cure (A/B 10:1)			Antistatic			8,000	40 min	31	6.0	500	25	1.13	180	Turquoise	ELASTOSIL® RT 629
ELASTOSIL® RT 646	RTV-2 / platinum cure (A/B 10:1)	X		Good chemical resistance		X	70,000	80 min	53	5.0	280	12	1.28	180	Beige	ELASTOSIL® RT 646
ELASTOSIL® RT 720	RTV-2 / platinum cure (A/B 10:1)	X			O		30,000	6 h	35	5.0	200		1.13	180	Gray	ELASTOSIL® RT 720
Heat resistance																**Heat resistance**
ELASTOSIL® RT 426	RTV-2 / condensation cure (Base + Catalyst 100:3)*		Alcohol	Thermally conductive			10,000	90 min	60	4.5	120	4	1.44	200	Reddish brown	ELASTOSIL® RT 426
ELASTOSIL® RT 602	RTV-2 / platinum cure (A/B 9:1)	X				X	3,500	80 min	30	1.5	130		1.17	200	Light gray	ELASTOSIL® RT 602
ELASTOSIL® RT 607	RTV-2 / platinum cure (A/B 9:1)	X				X	12,000	80 min	55	3.0	100		1.43	210	Reddish brown	ELASTOSIL® RT 607
ELASTOSIL® RT 619	RTV-2 / platinum cure (A/B 9:1)	X		Flame retardant			9,500	60 min	50	3.9	120		1.42	230	Reddish brown	ELASTOSIL® RT 619
ELASTOSIL® RT 675	RTV-2 / platinum cure (A/B 1:1)	X		Thermally conductive		X	50,000	150 min	80	2.0	20		2.30	180	Reddish brown	ELASTOSIL® RT 675
ELASTOSIL® RT 685	RTV-2 / platinum cure (A/B 9:1)	X				X	40,000	48 h	40	4.0	250	5	1.10	200	Cream white	ELASTOSIL® RT 685
ELASTOSIL® RT 772	RTV-2 / condensation cure (Base + Catalyst 10:1)***		Alcohol		X		37,000	5 min / 10 min ***	35	2.2	200		1.26	230	Black	ELASTOSIL® RT 772
ELASTOSIL® RT 706	1-component heat-curing / platinum cure	X			O		12,000	6 months	30	2.5	200		1.23	210	Red	ELASTOSIL® RT 706
ELASTOSIL® RT 707 W	1-component heat-curing / platinum cure	X			O		60,000	6 months	42	3.3	270		1.18	230	White	ELASTOSIL® RT 707 W
Low-temperature flexibility																**Low-temperature flexibility**
WACKER® RTV-S 691	RTV-2 / platinum cure (A/B 9:1)	X		Flexible at very low temperature			20,000	100 min	55	4.5	130	5	1.42	200	Red	WACKER® RTV-S 691
ELASTOSIL® S 692	RTV-2 / platinum cure (A/B 9:1)	X		Flexible at very low temperature			40,000	4 h	35	1.5	200	3	1.05	200	Black	ELASTOSIL® S 692

* grade can be transformed into a self-adhesive silicone elastomer when cured with WACKER® Catalyst T 77 or WACKER® Catalyst T 77 PLUS in a mixing ratio of 10:1 (for details, please see the technical data sheets for WACKER Catalyst T 77 and T 77 PLUS)
** base component to be combined with ELASTOSIL® CAT PT, ELASTOSIL® CAT PT-F or ELASTOSIL® CAT UV to allow curing at room temperature, under heat or by UV light (please see the corresponding technical data sheet for details)
*** base component to be combined with WACKER® Catalyst T 77 or WACKER® Catalyst T 77 PLUS (please see the corresponding technical data sheet for details)
O self-adhesive when cured at elevated temperature

Note: these figures are intended as a guide and should not be used in preparing specifications.

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