The data presented in this medium are in accordance with the present state of our knowledge but do not absolve the user from carefully checking all supplies immediately on receipt. We reserve the right to alter product constants within the scope of technical progress or new developments. The recommendations made in this medium should be directed by project teams because of conditions during processing over which we have no control, especially when other components/ raw materials are also being used. The information provided by us does not absolve the user from the obligation of investigating the possibility of infringement of third parties’ rights and, if necessary, clarifying the position. Wacker’s regulations for use do not constitute a warranty, either express or implied, of the fitness or suitability of the product for a particular purpose.

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WELCOME TO THE WORLD OF SILICONE RUBBER
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WACKER is one of the world’s three biggest silicone manufacturers. For over 50 years, we have been developing, refining and producing silicones for a huge variety of applications.

Global Production – Local Customer Support
The silicones that WACKER makes at its various production sites worldwide meet identical quality standards. What’s more, we have set up technical centers across the globe to offer all manner of support for product selection, manufacturing, and end-product specification.

Close on 100 Years of Experience – Close on 100 Years of Innovation
WACKER is one of the most research-intensive companies in the industry. We maintain our own basic-research institute as well as industry-oriented innovation teams in close contact with universities. This enables us to offer you ever more refined solutions.

Silicone Rubber – 1,000 and More Grades
Silicones can be tailored to practically any application. Accordingly, we have a very wide and deep product range. Your choice of product depends on processing parameters and the properties required for the cured rubber product. Our experts will gladly assist you in choosing the right silicone grade.

WACKER Production Sites for Silicone Rubber
Burghausen (Germany): Production and technical center
Nünchritz (Germany): Production
Pilsen (Czech Republic): Production
Adrian, USA: Production and technical center
Chino (USA): Production
North Canton (USA): Production
Zhangjiagang (China): Production and technical center
Akeno-Tsukuba (Japan): Production and technical center
Jandira (Brazil): Technical center
Mumbai, India: Technical center
Amtala, India: Production
SECTION 1:
SILICONE RUBBER – BASIC PRINCIPLES
General characteristics of silicones and why WACKER silicones are so successful

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   How solid and liquid silicone rubber grades differ, and what characterizes them

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   Fillers, additives and catalysts, and their role in formulation

1.4 Curing 12
   Peroxide curing and platinum-catalyzed addition curing: Two different processes and their specific advantages
Uncured silicone rubber contains polymers of different chain lengths. It always comprises a principal silicon-oxygen chain (the siloxane backbone) and an organic moiety bound to the silicon. A silicon atom has four valence electrons, which is why silicone rubber is often abbreviated with a Q for “quaternary group”. 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. Depending on which organic groups are present, silicone polymers in common use 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 small number of methyl groups have been replaced by vinyl groups.

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

- FVMQ
  FVMQ stands for a VMQ in which a small number of methyl groups have been replaced by trifluoropropyl substituents.
1.2 MAJOR CLASSES

Aside from polymer structure, the viscosity frequently serves as a classification feature. A distinction is accordingly made between liquid and solid silicone rubber.

Solid Silicone Rubber
Solid silicone rubber contains polymers with a high molecular weight and relatively long polymer chains. It is referred to as HTV (= high-temperature-vulcanizing). WACKER offers two product ranges based on solid silicone rubber: a range of peroxide-curing grades marketed as ELASTOSIL® R (R = Rubber) and a range of addition-curing (platinum-catalyzed) grades marketed as ELASTOSIL® R plus.

The standard delivery form is as bars measuring 90 x 100 mm (cross-section), which are wrapped in PE film and shipped in cartons. For special requirements, we also offer our ready-to-use blends in the form of strips, round-cords, pellets and profile strips.

Liquid Silicone Rubber
Liquid silicone rubber contains polymers of lower molecular weight and hence shorter chains. It has better flow properties. Liquid silicone rubber is always addition-curing (platinum-catalyzed), and is marketed by WACKER as ELASTOSIL® LR (LR = Liquid Rubber). The A¹ and B² components are supplied in 20-kg or 200-kg containers:
- 20-kg pails with a PE inliner (ø inside 280 mm)
- 200-kg drums with a PE inliner (ø inside 571.5 mm)

¹ Contains platinum catalyst.
² Contains crosslinker.
Aside from the “pure polymer”, uncured silicone rubber generally contains only three additional substances: crosslinker, fillers and additives.

1.3 COMPONENTS

Uncured, Filled Polymer Compared with Cured Rubber

Crosslinkers
A crosslinker is required to convert the raw rubber into a mechanically stable cured product. Use is made of peroxides or platinum catalyst systems (see section 4.3, pages 36 and 37).

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 raw and cured rubber.

- Reinforcing fillers:
  Pyrogenic silica with very high BET surface areas (more than 100 m²/g) is the most frequently used reinforcing filler. WACKER HDK® has proven to be especially effective here, although precipitated silica and carbon black can also be used.

- Non-reinforcing fillers:
  These have merely a fill-up function. Quartz, for example, increases 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 siloxane polymer used. Thus, a finished polymer compound may consist only of polymer and filler. Particularly notable is the fact that silicone rubber is free of curing accelerators or retarders, organic plasticizers and organic antioxidants. Additives include stabilizers, masticating aids and colorants.

Stabilizers
Stabilizers are available for special applications in order to optimize properties such as heat and media resistance.

Colorants
Silicone rubber is generally transparent and can be colored as desired: from transparent through translucent to opaque. WACKER will supply you with suitable pigment pastes, both for liquid silicone rubber and solid silicone rubber. These pigment pastes are tailored specifically to the rubber grade in question and are easily blended into the compound while on the roll mill or via metering equipment during injection molding. It should be remembered that some additives are themselves inherently colored.

You will find additional information on fillers, additives, stabilizers and colorants in section 4.3, as from page 31.
To become an elastomeric material, raw silicone rubber has always to be cured. This can be done either by peroxide or addition curing.

Peroxide curing involves the use of organic peroxides. At elevated temperatures, they decompose to form highly reactive radicals which chemically crosslink the polymer chains. The result is a highly elastic, three-dimensional network. WACKER offers peroxide crosslinkers in paste or powder form.

**Advantages**
Peroxide curing is a time-tested and technically mature process. Peroxide-curing silicone rubber from WACKER has been in use for more than 50 years and is refined continuously in close cooperation with our customers. The same applies to the production processes, which ensure consistently high quality.
The rubber compounds are characterized by low sensitivity to catalyst poisons and have a particularly long shelf life.

**Processing Information**
Some peroxide crosslinkers (ELASTOSIL® AUX Crosslinker C1 and ELASTOSIL® AUX Crosslinker C6) are inhibited by atmospheric oxygen. Any surface coming into contact with air during curing will cure incompletely and remain sticky.

You will find additional information on the various crosslinkers in section 4.3, page 36.
1.4 CURING
PLATINUM-CATALYZED ADDITION CURING

During platinum-catalyzed addition curing, the crosslinker’s Si-H groups react with the vinyl groups of the polymer to form a three-dimensional network. WACKER offers silicone rubber grades which already contain the platinum catalyst as well as grades to which the catalyst must be added prior to use.

Advantages
Unlike peroxide-curing, platinum-catalyzed addition reactions do not produce odor- or flavor-impairing by-products. This is a major advantage for food-contact applications. A further benefit is that colors are not affected by thermal post-curing. Curing is fast, and the curing speed can be controlled via the temperature. The cured rubber demolds very easily and has a dry surface, thus facilitating further processing and reducing production cycle times.

Processing Information
Even small amounts of catalyst poisons in the ambient air can inhibit the catalyst, especially amine- and sulfur-containing compounds of the kind encountered during processing of organic rubber grades. For this reason, platinum-catalyzed systems must be stored and processed in a separate room, well away from organic rubber. Roll mills and processing machinery must always be scrupulously cleaned in order to prevent cross-contamination.

You will find additional processing information in section 5, page 39.
SECTION 2:
SILICONE RUBBER – MATERIAL AND PROCESSING ADVANTAGES
Contents

Why and when ELASTOSIL® silicone rubber is the material of choice

2.1 Material Advantages 16
   Why the property range is unique, and how it differs from other elastomers

2.2 Processing Advantages 19
   Where ELASTOSIL® solid and liquid rubber grades are particularly efficient
Silicone rubber differs from other elastomers in its unparalleled property range. Of particular interest are the characteristics resulting not from additives or surface treatment but from the polymer and filler structure. These are inherent properties of the rubber.

**2.1 MATERIAL ADVANTAGES**

**INHERENT PROPERTIES**

**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. C-C links, by comparison, 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 surface energy is low.

- **ELASTOSIL®** silicone rubber is flame resistant and flame retardant. Clothing made of silicone-coated fabric provides vital protection for rescue personnel in action.
- **SILPURAN®** silicone rubber is highly transparent, chemically inert, does not contain organic plasticizers and therefore complies with medical standards.
- **ELASTOSIL®** silicone rubber is extremely heat resistant, odorless, tasteless and permanently elastic, making it predestined for seals and gaskets.

This results in the following properties:

- Excellent high-temperature resistance combined with low-temperature flexibility
- High resistance to chemicals and environmental influences
- Water repellent surface
2.1 MATERIAL ADVANTAGES

GENERAL PROPERTIES

ELASTOSIL® silicone rubber withstands continuous high temperatures and dynamic stress, and thus represents the perfect solution for turbocharger hoses.

All ELASTOSIL® silicone rubber grades have good mechanical properties. Specialty grades have very high tear resistance, making them ideal for bottle nipples and pacifiers.

ELASTOSIL® silicone rubber has good release properties. Since it is odorless and tasteless, it is suitable for the manufacture of baking liners or molds.

Material Benefits Resulting from the Polymer/Filler Structure

Silicone rubber usually contains pyrogenic silica as filler, e.g. HDK® from WACKER. Pyrogenic silica is structurally very similar to the polymer. They both consist predominantly of Si and O which leads to very interesting properties:

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

General Properties of Silicone Rubber

- Broad operating-temperature range from –50 °C to +250 °C, (specialty grades: –110 °C to +300 °C)
- Only slight changes in physical properties between –50 and +180 °C
- Excellent compression set
- Odorless and tasteless (many grades are BfR and FDA compliant)
- Can be pigmented as desired
- Can be easily processed
- Can be adjusted electrically from insulating to semiconducting
- High radiation resistance

Typical Range of Mechanical Properties

- Density 1.05 – 1.60 g/cm³
- Shore A hardness 3 – 90
- Tensile strength 5 – 11 N/mm²
- Elongation at break 100 – 1,100%
- Tear strength (ASTM D 624) 5 – 55 N/mm
- Compression set (22 h /175 °C) 5 – 25%
- Rebound resilience 30 – 70%
2.1 MATERIAL ADVANTAGES

Exceptional Property Profile
Elastomers are generally expected to be heat resistant, oil resistant and flexible at low temperatures. Outstanding performance in any of these properties is likely to come at the expense of the other ones. Silicone rubber is an exception here: it shows excellent mechanical properties over a very wide temperature range and exhibits satisfactory resistance to oil. Silicones also have an outstanding low compression set.

High Purity
Compared to other elastomers, silicone rubber is exceptionally pure and is therefore also suitable for use in the food and medical sectors.

Ready-to-use Compounds
Silicone rubber is available as ready-to-use compounds or as compounds to which the crosslinker and, if required, pigment, must be added.
2.2 PROCESSING ADVANTAGES

Besides curing properties, the processing properties also represent a major criterion for the choice of a suitable elastomer. Liquid and solid silicones each have a large number of processing advantages:

**Advantages of Liquid Silicone Rubber**
- Short cycle times (low viscosity, high curing speed)
- Process can be fully automated
- Molds with up to 256 cavities
- Suitable for complex part geometry
- 2K injection molding
- No secondary finishing

**Advantages of Solid Silicone Rubber**
- Processing is highly variable, so that, e.g., a wide range of different parts can be made with a few basic silicone grades
- High flexibility for small-to-medium series

Processes:
- Press curing, injection molding
- Extrusion
- Calendering

ELASTOSIL® liquid silicone rubber permits mass production of parts without secondary finishing

Self-adhesive ELASTOSIL® silicone rubber grades permit the production of composite materials in a single operation
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WACKER SILICONE RUBBER GRADES
Contents

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3.1 Overview of Important Applications 22

3.2 Overview of Typical Properties 24
3.1 IMPORTANT APPLICATIONS OF SILICONE RUBBER

- Water management/irrigation
- Sanitary
- Coffee machine tubing
- Oven door profiles
- Food tubing
- Bakeware & accessories
- Ignition technologies, e.g. spark plug boots, pencil coils, ignition cables
- Switches & buttons
- Connector seals/weather packs
- Exhaust pipe hangers
- Vibration dampers, e.g. engine mounts
- Turbocharger hoses
- Other hoses, e.g. radiator hoses
- Gaskets and bellows
- Profiles
- Sound-insulation panels
- Bellows, e.g. trains, buses
- Wall transitions
- Floor profiles
- Insulators
- Insulator coatings
- Cable accessories
- Insulating fluids

Please also see our applications-specific brochures on medical technology, SILPURAN®, automotive, cables and textile coatings.
Looking for a Specific Product?  
The most important products are listed in the product overviews.

Your Application is not Listed?  
Why not give us a call? Our specialists will quickly tell you whether a particular silicone rubber is the right material for you.

### Technical Textile Coatings
- Airbags
- Industrial textiles, e.g. conveyor belts
- Architectural textiles
- Safety textiles, e.g. insulation, door panels, protective clothing, gloves
- Lifestyle textiles, e.g. sails, paragliders, tents

### Baby
- Pacifiers
- Baby-bottle nipples
- Others, e.g. breast feeding articles

### Wire/Cable
- General purpose cable
- Ignition cable
- High performance cable
- Fire safety cable
- Electrical sleeving

### Medical
- Catheters
- Tubing, drainage
- Seals, gaskets, O-rings, valves, membranes
- Respiratory care, anesthetics, e.g. masks
- Medical instruments
- Medical cables
- Medical textile coating

### Baby
- Pacifiers
- Baby-bottle nipples
- Others, e.g. breast feeding articles

### Sports & fashion, e.g. diving masks
- Key pad
- Window profiles
- Extruded and molded parts
- Conveyor belts
- Roll coatings

### Lighting
- Lens molding
- Reflectors
- Diffusors
- Gaskets / sealings

### Lifestyle
- Key pad
- Window profiles
- Extruded and molded parts
- Conveyor belts
- Roll coatings

### Industry
- Lens molding
- Reflectors
- Diffusors
- Gaskets / sealings

### Medical
- Catheters
- Tubing, drainage
- Seals, gaskets, O-rings, valves, membranes
- Respiratory care, anesthetics, e.g. masks
- Medical instruments
- Medical cables
- Medical textile coating

### SILPURAN®
- Lens molding
- Reflectors
- Diffusors
- Gaskets / sealings

### LUMISIL®
- Lens molding
- Reflectors
- Diffusors
- Gaskets / sealings
3.2 PROPERTIES OF SILICONE RUBBER

- High tear and fast curing
- Self-adhesive to PA and PBT
- Self-adhesive to PC and PBT
- Self-adhesive and oil-exuding
- Self-adhesive and coolant resistant
- Self-adhesive, oil resistant and non-abrasive
- Self-adhesive and flame resistant

- Standard
- Fast-curing
- Low compression set

- High tear
- High tear and fast curing

- Flame resistant
- Ceramifying

- Flame resistant
- Heat Conducting

- Highly Transparent
- Ceramifying

- Multi-Purpose
- Tear Resistant
- Self-Adhesive

- Low Surface Friction/Haptic Effects
- Extremely heat resistant
- Heat and oil resistant
- Heat and solvent resistant
- Extremely heat resistant and low compression set
- Low-temperature resistant

Electrically Conductive

Media Resistance
- Oil and fuel resistant
- Oil and abrasion resistant
- Coolant resistant

Oil-Exuding
- Oil-exuding, with varying oil content (1 – 6% oil)
- Oil-exuding and high tear strength
- Oil-exuding and high cut resistance
- Oil-exuding and media resistant (fluorine)

Compliance with Industrial Standards
- Food contact
  FDA, BfR
- Drinking water contact
  WRAS, KTW, ACS
- Medical/pharmaceutical
  ISO 10993, USP Class VI, E.P. 3.1.9.
- Fire safety
  UL 94, NFF 16101, BS 6853, DIN 5510

Low Compression Set

Your Application is not Listed?
Why not give us a call? Our specialists will quickly tell you whether a particular silicone rubber is the right material for you.

Looking for a Specific Product?
The most important products are listed in the product overviews.
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4.3 Compounding ELASTOSIL® Solid Silicone Rubber 30
  Additives, colorants and stabilizers: important information on roll-mill compounding. When the method of choice is peroxide curing and when it is addition curing
4.1

STORAGE OF SOLID SILICONE RUBBER

Properly stored, ELASTOSIL® solid silicone rubber has a shelf life of up to 12 months depending on the grade. Products which have been stored longer may also still be usable. For quality assurance reasons, however, you should check that the rubber still has the properties required for the intended use.

Storage-Induced Increase in Mooney Viscosity

Long-term storage of silicone rubber may cause a rise of its Mooney viscosity. This is due to polymer/filler orientation that causes stronger mutual interaction. However, this phenomenon is reversible, and the rubber can be processed in the normal way within the given storage period. The viscosity is reduced when additives are blended in on a roll mill or when the rubber is extruded or compression molded. Rubber which has been stored too long can usually be made suitable for processing by replasticating it on a roll mill. If this doesn’t work, a mastication aid may be used in addition.

General Information on Storing ELASTOSIL® Solid Silicone Rubber

- Store in closed containers in cool rooms at 0 – 30 °C
- Do not expose to direct sunlight
- Keep separate from organic rubber and crosslinker chemicals

Caution:

- If stored above 30 °C, platinum-catalyzed grades and compounds containing Crosslinker E are particularly susceptible to scorching
- Contact with organic rubber may inhibit the curing system and also cause discoloration
4.2
STORAGE OF LIQUID SILICONE RUBBER

If kept in closed containers at 0 to 30 °C, ELASTOSIL® liquid silicone rubber has a shelf life of up to 12 months from the delivery date depending on the grade. Even if the product is stored for longer than the recommended time, you can usually still use it. For quality assurance reasons, however, please check that the rubber still has the properties required for the intended use.

Viscosity Increase
As with solid silicone rubber, the viscosity of liquid silicone rubber may increase during storage. This is due to a particular polymer/filler orientation that can be reversed at any time. Despite its higher viscosity, the rubber can be processed in the normal way within the given storage period. When the rubber is injected into the injection molding machine, the screw generally causes its viscosity to decrease, enabling the rubber to flow better and fill the mold.

General Information on Storing ELASTOSIL® Liquid Silicone Rubber
• Store in closed containers in cool rooms at 0 – 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.
4.3 COMPOUNDING

ELASTOSIL® solid silicone rubber is characterized by its ease of processing. Most applications involve the use of additives. Typically, the compounding components are blended in the following order: rubber, stabilizers, colorant, crosslinker. In the case of non-ready-to-process solid silicone rubber grades, crosslinker and any other necessary additives, stabilizers or pigment pastes are blended in on the roll mill. At WACKER, compounds which do not contain additives have the affix oH or S (standard). We offer many solid silicone rubber grades in a ready-to-process form (having the affix mH) or as a customized, ready-to-use SILMIX® grade.

Recommendations*

• The roll mills should be temperature-controlled (water cooling)
• Friction should be about 1:1.2. If your roll mills have rough surfaces, soft formulations may stick to them
• The roll nip should be always adjusted in such a way to allow the formation of a sufficient rubber bead (= mixing zone) in the nip
• First feed the harder grade onto the roll mill, then the softer one, and homogenize them thoroughly
• Homogenize the silicone rubber for 2 to 10 minutes before incorporating paste additive
• To speed up and optimize homogenization, make frequent incisions at the edges of the sheet, or roll it up into “dollies” and fold it back into the center of the nip

*All recommendations are intended only as suggestions and not as instructions for any particular application. It is essential that you check for yourself in how far these recommendations are suitable for your application, your compound and your machine.
4.3 COMPOUNDING STABILIZERS AND ADDITIVES

For particularly demanding applications, special properties of solid silicone rubber can be further enhanced by the addition of stabilizers and other additives.

Improving Hot-Air Resistance
Parts exposed to extremely high temperatures, such as turbocharger hoses, need to be heat-stabilized. Special oxides of transition metals (e.g. iron) and special carbon blacks are particularly suitable for this purpose. WACKER supplies hot-air stabilizers ELASTOSIL® AUX H0-H6 in the form of pastes that are readily incorporated via the roll mills. The correct choice of stabilizer depends on the crosslinker, color and operating temperature. Please note that crosslinker ELASTOSIL® AUX E is incompatible with stabilizer ELASTOSIL® AUX H3. All other heat stabilizer grades can be used without restriction. Crosslinkers ELASTOSIL® AUX C1 and ELASTOSIL® AUX C6 can be used safely with all stabilizers. Although stabilizer ELASTOSIL® AUX H0 is milky white, it causes a slight brown discoloration of the cured rubber product under the influence of thermal aging. It should therefore be preferably used for colored compounds. The tables show our recommendations for choosing a suitable heat stabilizer.

Reversion Stabilizers
Stabilizer ELASTOSIL® AUX R is used as an anti-reversion agent (reversion = breakdown of the network). It also prevents a blooming effect on the surface of non-post-cured rubber products by binding by-products of crosslinker ELASTOSIL® AUX E (2,4-dichlorobenzoyl peroxide). Stabilizer ELASTOSIL® AUX R simultaneously improves the rubber’s oil resistance. We recommend adding 0.8 – 1% paste via the roll mill.

### Recommendations for the Right Choice of Heat Stabilizer are Depicted in the Following Table

<table>
<thead>
<tr>
<th>ELASTOSIL® AUX stabilizer</th>
<th>Peroxide curing rubber</th>
<th>Addition curing rubber</th>
</tr>
</thead>
<tbody>
<tr>
<td>H0</td>
<td>225 °C</td>
<td>225 °C</td>
</tr>
<tr>
<td>H1</td>
<td>250 °C</td>
<td>225 °C</td>
</tr>
<tr>
<td>H2</td>
<td>250 °C</td>
<td>250 °C</td>
</tr>
<tr>
<td>H3</td>
<td>275 °C</td>
<td>275 °C</td>
</tr>
<tr>
<td>H4</td>
<td>275 °C</td>
<td>225 °C</td>
</tr>
<tr>
<td>H6</td>
<td>300 °C</td>
<td>225 °C</td>
</tr>
<tr>
<td>H6 F</td>
<td>300 °C</td>
<td>225 °C</td>
</tr>
</tbody>
</table>

### The Hot-Air Resistance of ELASTOSIL® LR Grades can be Improved by Adding ELASTOSIL® Color Pastes FL

<table>
<thead>
<tr>
<th>ELASTOSIL® Color Pastes FL</th>
<th>Recommended maximum service temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ivory RAL 1014</td>
<td>225 °C</td>
</tr>
<tr>
<td>Reddish-brown RAL 2001</td>
<td>225 °C</td>
</tr>
<tr>
<td>Iron oxide red RAL 3013</td>
<td>225 °C</td>
</tr>
<tr>
<td>Deep black RAL 9005</td>
<td>250 °C</td>
</tr>
</tbody>
</table>
Improving Flame Resistance
If the flame resistance has to be improved, we recommend adding 2.2% ELASTOSIL® AUX Batch SB 2.

Using a Mold-Release Aid
In the production of press-vulcanized rubber parts, the metal molds are often treated with external release agents, e.g. with ELASTOSIL® AUX Mold Release Agent 32. The internal mold release agent ELASTOSIL® AUX Mold Release Agent A can serve as a feasible alternative. The paste is incorporated into the rubber in a concentration between 0.3 and 1.0%. However, consider the following: ELASTOSIL® AUX Mold Release Agent A slightly impairs the rubber’s compression set. We therefore strongly advise you to conduct thorough tests before using it!

Adding Fillers on Roll Mills
Never add quartz powder on an open roll mill because of the silicosis risk. It is better to use products already containing quartz powder, such as ELASTOSIL® R 701 or R 780/80 from WACKER. Small amounts of amorphous fillers, such as diatomaceous earth or pyrogenic silica, can be added on a roll mill fitted with a good ventilation hood.

Fillers and Additives

<table>
<thead>
<tr>
<th>Additive group</th>
<th>Additive</th>
<th>Description /effect</th>
<th>%</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stabilizer R</td>
<td>ELASTOSIL® AUX</td>
<td>Improves oil resistance and reversion stability</td>
<td>0.8 – 1 Lowers reversion tendency (thermal network breakdown)</td>
<td>BfR* FDA**</td>
</tr>
<tr>
<td></td>
<td>Stabilizer R</td>
<td>Binds by-products of crosslinker E, thus preventing surface blooming</td>
<td></td>
<td>Easy to add on the roll mill</td>
</tr>
<tr>
<td>Heat stabilizers</td>
<td>ELASTOSIL® AUX</td>
<td>Milky white</td>
<td>0.5 – 2 May cause slight brown discoloration of the cured rubber</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Stabilizer H0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ELASTOSIL® AUX</td>
<td>Reddish brown</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Stabilizer H1</td>
<td>Beige</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ELASTOSIL® AUX</td>
<td>Jet black</td>
<td>1.5</td>
<td>Incompatible with ELASTOSIL® AUX Crosslinker E</td>
</tr>
<tr>
<td></td>
<td>Stabilizer H3</td>
<td></td>
<td></td>
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</tr>
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<td>ELASTOSIL® AUX</td>
<td>Reddish brown</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Stabilizer H4</td>
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<td></td>
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</tr>
<tr>
<td></td>
<td>ELASTOSIL® AUX</td>
<td>Beige</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Stabilizer H6 F</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mastication aids</td>
<td>ELASTOSIL® AUX</td>
<td>Enhances ease of adding and soft-rolling properties on the roll mill, and stabilizes the viscosity</td>
<td>1 – 3</td>
<td></td>
</tr>
<tr>
<td>Mold release agents</td>
<td>ELASTOSIL® AUX</td>
<td>Improves mold-release properties; a detergent which is sprayed onto the mold</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mold Release Agent 32</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ELASTOSIL® AUX</td>
<td>Improves mold-release properties; paste for adding to the solid rubber</td>
<td>0.3 – 1 Has a negative effect in the compression set test and should only be used after thorough testing</td>
<td></td>
</tr>
<tr>
<td>Flame resistance</td>
<td>ELASTOSIL® AUX</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Batch SB 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Foam batches</td>
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# Additives

<table>
<thead>
<tr>
<th>Description/effect</th>
<th>%</th>
<th>Comments</th>
<th>BfR*</th>
<th>FDA**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improves oil resistance and reversion stability</td>
<td>0.8 – 1</td>
<td>Lowers reversion tendency (thermal network breakdown) Binds by-products of crosslinker E, thus preventing surface blooming Easy to add on the roll mill</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Milky white</td>
<td>0.5 – 2</td>
<td>May cause slight brown discoloration of the cured rubber</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reddish brown</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beige</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jet black</td>
<td>1.5</td>
<td>Incompatible with ELASTOSIL® AUX Crosslinker E</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reddish brown</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beige</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beige</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enhances ease of adding and soft-rolling properties on the roll mill, and stabilizes the viscosity</td>
<td>1 – 3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improves mold-release properties; a detergent which is sprayed onto the mold</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improves mold-release properties; paste for adding to the solid rubber</td>
<td>0.3 – 1</td>
<td>Has a negative effect in the compression set test and should only be used after thorough testing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improves flame resistance</td>
<td>2.2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


---

WACKER supplies almost 1,000 different ready-to-use rubber grades. We also supply additional, customized grades whenever required. Just ask us about our SILMIX® system!
4.3 COMPOUNDING COLORS

WACKER is a “one-stop supplier”. We can supply you with suitable pigment pastes for both solid silicone rubber grades (ELASTOSIL® PT pigment pastes) and liquid silicone rubber grades (ELASTOSIL® FL pigment pastes). To ensure optimal processing, the viscosity of these pastes is adjusted to match that of our silicone rubber grades.

Choosing your Color
Choose the color you would like from our range of standard and special colors (see table on page 35). As our pigment additives can be mixed together in any ratio, almost any desired color can be obtained. Our technical support specialists will gladly assist you in mixing a specific color in their lab. For special regulatory requirements we offer a broad range of FDA- and BfR-compliant pigments. We will gladly advise you on existing dosage limits prescribed by these standards. Please also contact us if you require pigments compliant with USP Class VI und ISO 10993.

Adjusting Colors with PT Pastes on the Roll Mill
We recommend adding the PT pigment pastes together with the crosslinker because a homogeneously colored material will then indicate uniform crosslinker distribution.

Processing Tip
We recommend to homogenize PT color pastes on the mill and FL color pastes through stirring before use. In general, PT color pastes are dosed with 1%, FL pastes with 2%. Please note the specific exceptions like e.g. for color paste 9005.

Looking for a Special Color?
Should you require a particular color not included in our standard pigment paste range, we will formulate a customized paste on request. Just contact us!

The conformity values quoted in the table alongside are not guaranteed because the relevant regulations can change. Please consult our Technical Service for the latest data.

1 The RAL values in the table are only a guide.
2 BfR and FDA compliance necessitates adhering to existing dosage limits. We will be glad to assist you.
3 Not suitable for use with crosslinker E.
4 For questions regarding the biocompatibility of our FL pigment pastes, please contact our technical service department.
5 Please consider the defined time-temperature use conditions (B-H) acc. to table 2 under 21 CFR §176.170.
6 Please consider the defined time-temperature use conditions (C-H) acc. to table 2 under 21 CFR §176.170.
7 Only analogous certificates possible.
Our ELASTOSIL® AUX PT bzw. FL show a minimum temperature resistance of 42d/175°C or 21d/200°C or a UV-resistance of 21d (exposure in UV weathering chamber). For higher requirements please contact our technical service.

### ELASTOSIL® PT Color Pastes

<table>
<thead>
<tr>
<th>Color name</th>
<th>Similar to RAL¹</th>
<th>BfR²</th>
<th>FDA²</th>
<th>USP Class VI / ISO 10933⁷</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Standard colors</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yellow</td>
<td>RAL 1016⁸</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>Yellow</td>
</tr>
<tr>
<td>Reddish-brown</td>
<td>RAL 3013</td>
<td>●</td>
<td>●</td>
<td></td>
<td>Reddish-brown</td>
</tr>
<tr>
<td>Blue</td>
<td>RAL 5022</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>Blue</td>
</tr>
<tr>
<td>White</td>
<td>RAL 9010</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>White</td>
</tr>
<tr>
<td>Black standard</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Black</td>
</tr>
<tr>
<td><strong>Other colors</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yellow</td>
<td>RAL 1021⁶</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>Yellow</td>
</tr>
<tr>
<td>Yellow</td>
<td>RAL 1026 F⁸</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>Yellow</td>
</tr>
<tr>
<td>Yellow</td>
<td>RAL 1033⁶</td>
<td>●</td>
<td>●</td>
<td></td>
<td>Yellow</td>
</tr>
<tr>
<td>Orange</td>
<td>RAL 2004</td>
<td>●</td>
<td>●</td>
<td></td>
<td>Orange</td>
</tr>
<tr>
<td>Orange</td>
<td>RAL 2004 F⁸</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>Orange</td>
</tr>
<tr>
<td>Red</td>
<td>RAL 3000</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>Red</td>
</tr>
<tr>
<td>Red</td>
<td>RAL 3000 F</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>Red</td>
</tr>
<tr>
<td>Reddish-purple</td>
<td>RAL 4002</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>Reddish-purple</td>
</tr>
<tr>
<td>Ultramarine blue</td>
<td>RAL 5002</td>
<td>●</td>
<td>●</td>
<td></td>
<td>Ultramarine blue</td>
</tr>
<tr>
<td>Dark blue</td>
<td>RAL 5010</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>Dark blue</td>
</tr>
<tr>
<td>Light blue</td>
<td>RAL 5015</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>Light blue</td>
</tr>
<tr>
<td>Helio green</td>
<td>RAL 6004</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>Helio green</td>
</tr>
<tr>
<td>Green</td>
<td>RAL 6017</td>
<td>●</td>
<td>●</td>
<td></td>
<td>Green</td>
</tr>
<tr>
<td>Gray</td>
<td>RAL 7040</td>
<td>●</td>
<td>●</td>
<td></td>
<td>Gray</td>
</tr>
<tr>
<td>Pale brown</td>
<td>RAL 8003</td>
<td>●</td>
<td>●</td>
<td></td>
<td>Pale brown</td>
</tr>
<tr>
<td>Dark brown</td>
<td>RAL 8015</td>
<td>●</td>
<td>●</td>
<td></td>
<td>Dark brown</td>
</tr>
<tr>
<td>Deep black</td>
<td>RAL 9005³</td>
<td>●</td>
<td>●</td>
<td></td>
<td>Deep black</td>
</tr>
<tr>
<td>Black</td>
<td>RAL 9017</td>
<td>●</td>
<td>●</td>
<td></td>
<td>Black</td>
</tr>
</tbody>
</table>

### ELASTOSIL® FL Color Pastes

<table>
<thead>
<tr>
<th>Color name</th>
<th>Similar to RAL¹</th>
<th>BfR²</th>
<th>FDA²</th>
<th>USP Class VI / ISO 10933⁷</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Standard colors</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yellow</td>
<td>RAL 1016⁸</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>Yellow</td>
</tr>
<tr>
<td>Iron oxide red</td>
<td>RAL 3013</td>
<td>●</td>
<td>●</td>
<td></td>
<td>Iron oxide red</td>
</tr>
<tr>
<td>Blue</td>
<td>RAL 5022</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>Blue</td>
</tr>
<tr>
<td>White</td>
<td>RAL 9010</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>White</td>
</tr>
<tr>
<td>Deep black</td>
<td>RAL 9011</td>
<td>●</td>
<td>●</td>
<td></td>
<td>Deep black</td>
</tr>
<tr>
<td><strong>Other colors</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yellow</td>
<td>RAL 1021⁶</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>Yellow</td>
</tr>
<tr>
<td>Yellow</td>
<td>RAL 1026 F⁸</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>Yellow</td>
</tr>
<tr>
<td>Yellow</td>
<td>RAL 1033⁶</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>Yellow</td>
</tr>
<tr>
<td>Orange</td>
<td>RAL 2004</td>
<td>●</td>
<td>●</td>
<td></td>
<td>Orange</td>
</tr>
<tr>
<td>Orange</td>
<td>RAL 2004 F⁸</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>Orange</td>
</tr>
<tr>
<td>Red</td>
<td>RAL 3000</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>Red</td>
</tr>
<tr>
<td>Red</td>
<td>RAL 3000 F</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>Red</td>
</tr>
<tr>
<td>Reddish-purple</td>
<td>RAL 4002</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>Reddish-purple</td>
</tr>
<tr>
<td>Ultramarine blue</td>
<td>RAL 5002</td>
<td>●</td>
<td>●</td>
<td></td>
<td>Ultramarine blue</td>
</tr>
<tr>
<td>Dark blue</td>
<td>RAL 5010</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>Dark blue</td>
</tr>
<tr>
<td>Light blue</td>
<td>RAL 5015 F</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>Light blue</td>
</tr>
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<td>Helio green</td>
<td>RAL 6004</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>Helio green</td>
</tr>
<tr>
<td>Green</td>
<td>RAL 6010</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>Green</td>
</tr>
<tr>
<td>Gray</td>
<td>RAL 7000</td>
<td>●</td>
<td>●</td>
<td></td>
<td>Gray</td>
</tr>
<tr>
<td>Deep black</td>
<td>RAL 9005³</td>
<td>●</td>
<td>●</td>
<td></td>
<td>Deep black</td>
</tr>
<tr>
<td>Black</td>
<td>RAL 9005 F³</td>
<td>●</td>
<td>●</td>
<td></td>
<td>Black</td>
</tr>
</tbody>
</table>
4.3 COMPOUNDING
PEROXIDE CURING

WACKER offers three different peroxide crosslinkers for peroxide curing.

For Pressureless Vulcanization: ELASTOSIL® AUX Crosslinker E
We recommend ELASTOSIL® AUX Crosslinker E for pressureless vulcanization, e.g. for the extrusion of hoses, profiles and the like.

Processing tips:
It is important to remember that ELASTOSIL® AUX Crosslinker E begins to react at approx. 100 °C:
• Always cool the rolls (< 60 °C)
• Never roll up the rubber sheet into thick “dollies”. Lay it out to cool for approx. 30 minutes in strips not thicker than 15 mm, either open to the air or covered loosely with a PE film
• Store catalyzed rubber compounds at a temperature below 30 °C to prevent premature curing

For Vulcanization under Pressure or in Steam:
ELASTOSIL® AUX Crosslinker C1
ELASTOSIL® AUX Crosslinker C1 is used for producing compression molded articles. ELASTOSIL® AUX Crosslinker C1 is hardly affected by temperature and can be handled safely under typical processing conditions. It decomposes at 155 °C.

Processing tips:
• Add the crystalline crosslinker at about 45 °C. At this temperature, the crystals melt and the liquified crosslinker is distributed homogeneously
• Intensive cooling of the roll mill is unnecessary
• The sheeted out rubber may be thicker than 15 mm in this case, and it can be folded into a zig-zag when laid out
• Avoid contact with atmospheric oxygen: all surfaces that come into contact with oxygen during crosslinking remain sticky

For Vulcanization under Pressure or in Steam:
ELASTOSIL® AUX Crosslinker C6
ELASTOSIL® AUX Crosslinker C6 is only used for processing rubber in compression molds and is easily incorporated on the roll mill. Like ELASTOSIL® AUX Crosslinker C1, Crosslinker C6 is largely unaffected by temperature. It is stable up to 160 °C, making processing particularly unproblematic.

Processing tips:
Avoid contact with atmospheric oxygen: all surfaces that come into contact with oxygen during crosslinking remain sticky.

<table>
<thead>
<tr>
<th>Peroxide Crosslinkers</th>
<th>Peroxide</th>
<th>%</th>
<th>Vulcanization [°C]</th>
<th>Processing</th>
</tr>
</thead>
<tbody>
<tr>
<td>ELASTOSIL® AUX Crosslinker E</td>
<td>(50% paste in silicone fluid) bis-(2,4-dichlorobenzoyl)-peroxide</td>
<td>1.5 – 1.8</td>
<td>&gt; 100</td>
<td>Especially suitable for rubber that is vulcanized under low-pressure conditions, especially for the extrusion of hoses and profiles</td>
</tr>
<tr>
<td>ELASTOSIL® AUX Crosslinker C1</td>
<td>Dicumyl peroxide (98%), crystalline powder</td>
<td>0.6 – 0.9</td>
<td>165 – 190</td>
<td>For manufacturing molded parts</td>
</tr>
<tr>
<td>ELASTOSIL® AUX Crosslinker C6</td>
<td>2,5-bis-(tert.-butylperoxy)-2,5 dimethyhexane</td>
<td>0.6 – 1.5</td>
<td>170 – 190</td>
<td>For manufacturing compression molded parts, easy to add on the roll mill</td>
</tr>
</tbody>
</table>
4.3 COMPOUNDING
PLATINUM-CATALYZED CURING

We recommend platinum-catalyzed addition curing for all applications in which it is important that:

- No odor or flavor is produced (e.g. for food-contact applications)
- No volatile peroxide by-products are released
- Transparent articles do not discolor during post-curing
- Curing is fast and cycle times therefore short
- The cured product is readily demoldable and has a dry surface

WACKER Offers Two Types of Solid Silicone Rubber for these Applications:

- Ready-to-process compound: The platinum-catalyst is already contained in the rubber formulation (1-part compound), as typified by the grade ELASTOSIL® R plus 4001.
- 2-part system: The catalyst is added later. WACKER offers the catalysts ELASTOSIL® AUX Batch PT 1 (for extrusion) and PT 2 (for molded articles). For example, the catalyst PT 1 is used with the grade ELASTOSIL® R plus 4305.

Processing tips:
Platinum-catalyzed grades may start crosslinking even at room temperature; therefore it is important to avoid exceeding the shelf life. We recommend carrying out preliminary tests to ensure that the rubber still has the required processing properties. It is important that all batches are stored for the same length of time between compounding and processing. Catalyst poisons in the ambient air inhibit curing. This is particularly true of amines and sulfur containing compounds, which are common components of organic rubber systems. So always keep platinum-catalyzed silicone rubber well separated from organic rubber during storage and processing, and always clean roll mills and processing machinery meticulously to avoid cross-contamination.

Storing and Adding Crosslinker

- Always store peroxides in cool rooms
- Shelf life approx. 12 months
- To ensure homogeneous distribution, spread pasty crosslinkers onto the sheeted-out rubber during roll milling
- Add powdered crosslinkers portion-wise, and avoid inhaling any dust

Tip
Any special requests? Further crosslinkers are available for special requirements

Platinum Catalysts

<table>
<thead>
<tr>
<th>Crosslinkers</th>
<th>%</th>
<th>Vulcanization [°C]</th>
<th>Recommended for rubber grades</th>
<th>Recommended for processing</th>
</tr>
</thead>
<tbody>
<tr>
<td>ELASTOSIL® AUX Batch PT 1</td>
<td>Paste 1.5 – 2</td>
<td>165</td>
<td>ELASTOSIL® R plus</td>
<td>Extrusion</td>
</tr>
<tr>
<td>ELASTOSIL® AUX Batch PT 2</td>
<td>Paste 1.5 – 2</td>
<td>165</td>
<td>ELASTOSIL® R plus</td>
<td>Molded articles</td>
</tr>
<tr>
<td>SILPURAN® Curing Agent X</td>
<td>Paste 1.5 – 2</td>
<td>165 – 180</td>
<td>SILPURAN®</td>
<td>Extrusion of medical articles</td>
</tr>
<tr>
<td>SILPURAN® Curing Agent M</td>
<td>Paste 1.5 – 2</td>
<td>165 – 180</td>
<td>SILPURAN®</td>
<td>Molded medical articles</td>
</tr>
</tbody>
</table>

We offer additional catalysts for textile coating formulations and will gladly advise you on your specific application.
SECTION 5: PROCESSING THE MATERIAL
Contents

Everything you need to know about processing ELASTOSIL® silicone rubber

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  Metering, conveying, extrusion die, vulcanization, troubleshooting

5.3 Press Molding 48
  Compression molding, transfer molding and what to consider

5.4 Injection Molding 50
  Metering and mixing, injection and vulcanization, demolding, 2K injection molding, troubleshooting

5.5 Textile Coating 60
  Which properties can be achieved, which silicones are suitable and which processes are most important
ELASTOSIL® silicone rubber can be processed in a variety of ways. The main processes include extrusion, coextrusion, compression molding, transfer molding, injection molding and knife coating (on textiles). Calendering and low-pressure filling are also possible.

Selecting the Best Process
Since the choice of process always depends on a number of factors, the following questions should be clarified:

• How are the properties specified for the application?
• Which chemical and physical properties is the vulcanized rubber required to have?
• How large is the required production series?
• Is liquid or solid silicone rubber the right choice?
• Which sort of geometry does the part have? Complex or simple?
• Which equipment is available and how much investment is required, if any?
• What experience/expertise is available for the particular processes?

A rapid decision can then be made about which processing technique to choose. For complex part geometries in large quantities, for example, injection molding is recommended, while extrusion is to be preferred for producing continuous articles.

5.1 INTRODUCTION

<table>
<thead>
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<td>Low-pressure filling</td>
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Extrusion of ELASTOSIL® solid silicone rubber into tubing
EXTRUSION

Extrusion is a continuous manufacturing process in which silicone rubber is squeezed through a die and then vulcanized. The die gives the extrudate its shape. The required pressure is produced via a conveying screw, in which the material is homogenized, compressed and deventilated.

Typical Application
Extrusion is mainly used for the following products:
- Tubing
- Profiles
- Cables
- Flat tape
- Round cord

Selection and Preparation of the Material
Peroxide and addition-curing ELASTOSIL® solid silicone rubber grades are suitable for extrusion. The materials are either available as ready-to-process compounds or have to be compounded in advance.

For this purpose, the rubber is compounded with the required additives and crosslinkers on the roll mill. To eliminate contaminants from the rubber compound, it should be subsequently passed through a strainer.

Screens of approx. 100 µm mesh remove foreign particles, homogenize the material, and eliminate any trapped air.
The extruder should be fed as uniformly as possible. This can be done manually, semi-automatically or automatically.

**Manual Feeding**
For manual feeding, a sheet is produced on the roll mill, cut into strips and fed into the feed hopper manually.

**Semi-Automatic Feeding**
We offer special delivery forms for semi-automatic feeding. The rubber strips have already been wound into coils in the plant. They can be placed on a rotating disk coiler. Operation can be integrated directly into the extruder’s machine control. Alternatively, the coil strips can be introduced directly from the cardboard box via a take-off unit.

**Automatic Feeding**
Feeding and metering can be performed automatically using appropriate auxiliary equipment (e.g. PolyLoad® from Krauss Maffei, RotoFeeder® from Engel or CTM®-System from Colmec). The material is transferred to a reserve container containing one or more screws. The screw feeds the extruder continuously via the outlet opening. For this purpose, ELASTOSIL®/SILPURAN®/SILMIX® solid silicone rubber can be used in all delivery forms.

RotoFeeder® is a registered trademark of Engel.
PolyLoad® is a registered trademark of Krauss Maffei.
CTM® is a registered trademark of Colmec.
The screw performs several functions during the process, it conveys and compresses the rubber while at the same time building up the pressure for deaeration of the material. Homogenization, back venting and output rate can be controlled by varying the screw geometry and machine parameters.

Screw Design
- Feeding is facilitated by maximum flight clearance in the screw feed zone. Slots in the flights have also proved successful.
- One or two-flight screws with compression ratios from \(1:1.5\) to \(1:2\) can be used. Twin-flight screws increase output.
- A progressive core or flight pitch is an advantage. With progressive cores, the core diameter increases gradually from the feed zone towards the screw tip. With a progressive pitch, the flight pitches decrease towards the screw tip.

- Typical screw dimensions are length: diameter = \(10:1\) to \(12:1\)
- The screw and cylinder jacket must be cooled to prevent scorching of the material.
5.2 EXTRUSION

EXTRUSION DIE

The extrusion die determines the profile of the cured rubber. Die design does not require any specific measures for silicone rubber; the customary guidelines apply.

- The wall should have the same thickness in all areas of the die
- Avoid sharp edges or corners: they can cause rough surfaces on the extrudate
- Avoid dead corners and sudden changes in direction of flow; material can accumulate in the dead corners and vulcanize
- It is important to have a uniform flow rate across the cross section. Material more distant from the die center has a slower flow rate. For the production of straight edges a concave design of the die edges is required

Compensating the Die Swell

The extrudate swells as it leaves the die. This phenomenon is affected by:
- Viscosity: the lower the viscosity, the greater the die swell
- The material temperature: the higher the temperature, the greater the die swell
- The extrusion velocity: the faster the extrusion, the greater the die swell
- The die diameter: the smaller the die, the greater the die swell

If the take-off belt of the heating tunnel runs faster than the extrudate leaves the die, stretching occurs. This can be used to adjust the desired diameter of the extrudate. As a result, die swell can be compensated and cured products manufactured with diameters smaller than the die orifice.
5.2 EXTRUSION VULCANIZATION

Extrudates are usually vulcanized via vertical or horizontal heating zones, with or without pressure. Silicone rubber is usually not vulcanized in a salt bath, though this option is possible in principle for peroxide-curing compounds.

Vulcanization in Heating Zones without Pressure
Tubing and profiles are usually vulcanized in a heating zone (at 200 – 500 °C) without the application of external pressure. Horizontal or vertical heating tunnels are heated by means of resistance heaters, infrared heating bars with reflectors, hot-air systems or ceramic dark radiators. The extrudates are conveyed on sheet-steel or mesh conveyor belts. The conveyor belts run on movable deflector rolls to compensate for the thermal expansion of the belt. Their velocity can be regulated. The conveyor belt return should be located in the heating tunnel to prevent excessive cooling. If this is not possible, use covers to prevent rapid heat loss.

To avoid pressure marks resulting from the conveyor belt, a shock tunnel can be fitted upstream in horizontal heating zones to prevulcanize the parts at about 600 °C. In many instances, it is preferable to extrude vertically using an extruder head deflected through 90°. This prevents belt pressure marks, so that even very soft materials can be easily processed.

Cable production: extrusion with subsequent vulcanization in the infrared tunnel
Vulcanization in Heating Zones with Pressure

Continuous vulcanization (CV) lines are primarily used to manufacture cables. Heating is usually by means of pressurized steam. The line is usually fed with steam at a pressure of 4 to 20 bar. At least 6 bar is necessary to achieve the required vulcanization temperature. Different steam temperatures are reached, depending on the supply pressure. With this process, the extruder head is continually supplied with saturated steam. To prevent scorching, the extruder head must be intensively cooled. The vulcanization time depends on the length of the zone, the temperature, and the wall thickness of the insulation. It is usually between 30 seconds and 2 minutes.

General Information on Extrusion

Cooling:
During extrusion, high shearing rates occur, which generate heat.
- To avoid scorching, the extruder, screw and extruder head should be cooled to ensure that the rubber temperature lies safely below the decomposition temperature of the peroxide.
- In addition, the highest output rates are obtained when the cylinder is cooled.

Extruder Size:
- Extruders with 45 to 90 mm screw diameter and an L/D ratio of 10:1 to 16:1 (typically 10:1 to 12:1) are most commonly used.
- The bigger the extruder, and therefore the screw, the lower is the speed, and therefore the heat of friction for the same output.

Coextrusion

Coextrusion allows extrudates to be produced from different materials. For example, it allows the manufacture of striped tubes, pigmented extrudates, or sheets with an extruded-on profile. WACKER offers self-adhesive ELASTOSIL® R plus grades for this purpose.
5.2 EXTRUSION TROUBLESHOOTING

The following table shows the most common faults and possible causes. If you still have any questions, please ask your WACKER contact or call the WACKER info line.

In General, to Avoid Problems:
- The material has to be mixed homogeneously and has to be free of impurities
- The extruder should be thoroughly cleaned between two production runs
- Fluctuations in the material temperature and pressure should be avoided
- Material feed into the extruder should be uniform
- Strainer screens should be used (for ventilation of the material and to avoid pressure fluctuations)
- All machines should be regularly maintained

<table>
<thead>
<tr>
<th>Overview</th>
<th>Possible cause</th>
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<tbody>
<tr>
<td>Fault</td>
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<tr>
<td>Bubbles</td>
<td>Atmospheric moisture on machines, air inclusions</td>
</tr>
<tr>
<td>Fisheyes</td>
<td>No strainer sieve, scorching of particles due to excessive material temperature, inhomogeneous mixing</td>
</tr>
<tr>
<td>Brittle extrudate/white stripes when the extrudate is stretched</td>
<td>Material damage due to high curing temperature</td>
</tr>
<tr>
<td>Round, soft region in the center of the extrudate</td>
<td>Insufficient curing, line speed too high or temperature too low</td>
</tr>
<tr>
<td>Sharp edges on the extrudate have a sawtooth structure</td>
<td>Poor die design</td>
</tr>
<tr>
<td>Fluctuation in the extrudate geometry</td>
<td>Fluctuations in the material pressure or temperature</td>
</tr>
<tr>
<td>Rough surface</td>
<td>Scratched/damaged die surface, material temperature too high</td>
</tr>
</tbody>
</table>
5.3 PRESS MOLDING PROCESSES
COMPRESSION AND TRANSFER MOLDING

Press molding processes are used for a wide range of applications. ELASTOSIL® solid silicone rubber is vulcanized in molds by heat and pressure. Compression and transfer molding are the preferred methods for solid silicone rubber.

Material Selection/Mold Filling
For compression molding, peroxide-curing and platinum-catalyzed ELASTOSIL® solid silicone rubber grades are preferred. Each cavity is individually filled with a precisely weighed amount of rubber.

Pressing/Vulcanization
The platen presses are usually hydraulically operated, they are heated, e.g. electrically or with steam. For vulcanization of peroxide mixtures with ELASTOSIL® AUX Crosslinker C1 or C6, and for platinum-catalyzed solid silicone rubber, a mold temperature of about 150 to 200 °C is usually chosen. The temperature plays an important role: it is required to be as high as possible to shorten the vulcanizing time, and therefore the cycle times. However it must not be too high, since scorching may otherwise occur. The vulcanizing time is determined by the temperature of the material, the mold temperature and the thickness of the part.

Demolding
External and internal mold-release agents can be used to assist demolding.

- External release agents:
  In this case, a 1 – 3% aqueous solution of the mold release agent ELASTOSIL® AUX Mold Release Agent 32 is sprayed into the hot mold. The process is repeated as required.

- Internal mold-release agents: Alternatively, ELASTOSIL® AUX Mold Release Agent A can be added to the silicone rubber. However, it should be correctly metered. Too much release agent can lead to mold contamination by forming deposits on the hot mold wall. It can also cause inhomogeneities in the end product. If the mold release agent is pushed forward by the flow front during mold filling, it can lead to (undesirable) weld lines as a result of incomplete welding of the merging flow fronts. In both cases, the end product is no longer usable.
Transfer molding is a development of compression molding. It is more economic for small-volume parts with complex geometries, which are produced in large quantities and with less manual work (no secondary finishing). It differs from compression molding in that the mold is charged via a chamber (the “pot”) with runner. Transfer molding is particularly suitable for producing moldings in which high dimensional accuracy is required (precision parts).

Material Selection/Mold Filling
The pot is charged with a defined amount of silicone rubber. A plunger then forces the rubber through a runner into the mold. For greater economy, several molds can be filled by using a sliding table unit or runner manifold.

Die Cutting/Slitting
Die cutting offers an economic alternative for very small quantities. In this process, parts such as O-rings are die cut from extruded, calendared or pressed sheet. Note that silicone rubber grades with high notch resistance are not easy to die cut. It is better to use blends of elastic grades and standard extrusion grades. Always carry out tests in advance.

For Safety’s Sake
• Please follow the instructions in our material safety data sheets
• We recommend using an extractor to purify the room air
Injection molding is currently the most popular and efficient method of processing large quantities of silicones where there are strict demands for consistently high product quality.

Advantages of Injection Molding
Injection molding is characterized by high dimensional accuracy. It produces high quality parts without secondary finishing, and allows much shorter production cycles than other processes. The disadvantages are higher mold and machine costs, though these can be offset by the high productivity.

Typical Applications
Injection molding is particularly suitable for the production of large numbers of small to medium-sized parts, such as:
- Nipples for baby bottles
- Gasket rings

Material Selection
ELASTOSIL® solid silicone rubber and ELASTOSIL® liquid silicone rubber are both suitable for injection molding.
5.4
INJECTION MOLDING
METERING AND MIXING

Due to their widely differing viscosities, liquid and solid silicone rubbers are metered and mixed differently.

ELASTOSIL® Liquid Silicone Rubber
Liquid silicone rubber grades require special metering and mixing systems.

Metering
The metering units pump the A and B components of liquid silicone rubber directly from the pails or drums in a ratio of 1:1 and feed it to a mixer, and then to the feed dosing cylinder of the injection-molding machine. If required, ELASTOSIL® Pigment Paste FL can be fed to the mixer via an additional pigment line.

Mixing
A static or dynamic mixer can be used. Static mixers do not have moving parts; the material is homogenized via fixed mixing elements in the interior. Dynamic mixers have moving parts supporting the homogenization. Static mixers are typically used for liquid silicone rubbers. After the two components A and B have been mixed, the material can be injected into the mold.

Injection
The mixed material is metered and injected into the mold with a screw in the injection cylinder. Modern injection molding machines offer precise control of the injection process.

Pot Life
At room temperature (about 20 °C), the A/B mixture has a pot life of at least three days. If the temperature is higher, the pot life may decrease correspondingly. To prevent premature vulcanization, it is advisable to thermostat the metering cylinder and mixer. The injection unit should be flushed with one of the components before relatively long production breaks of more than three days.
The A and B components of liquid silicone rubber should have the same batch number, since the curing systems are matched to one another within a batch. If the silicone rubber contains abrasive fillers, the cylinder, screw, non-return valve, needle valve, sprue and runners must be hard-faced.

Please Note
- The A and B components of liquid silicone rubber should have the same batch number, since the curing systems are matched to one another within a batch.
- If the silicone rubber contains abrasive fillers, the cylinder, screw, non-return valve, needle valve, sprue and runners must be hard-faced.

ELASTOSIL® Solid Silicone Rubber
ELASTOSIL® solid silicone rubber for injection molding is available in two supply forms:
- As ready-to-process material in different delivery forms. Preferably as bars, but also as strips or round cord, etc.
- As a silicone rubber base compound, to which the crosslinker and possibly other additives are added. This is usually performed via roll mills (see section 4, page 30).

Metering
Solid silicone rubber is generally metered to the injection molding machine via a stuffing box. It is generally performed either semi- or fully automatically in the case of profile strips. As an alternative to the stuffing box, RotoFeeder® (Engel) or PolyLoad® (KraussMaffe) systems can be used.

The cylinder and discharge from the stuffing box are usually maintained at 40 – 50 °C to facilitate material feed.

RotoFeeder® is a registered trademark of Engel.
PolyLoad® is a registered trademark of Krauss Maffe.

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ELASTOSIL® Liquid Silicone Rubber

There are two types of sprue system: indirect gating via a cold runner and hot sub-runner, or direct gating. The cold runner may have a hydraulic needle valve. Each gating method has its pros and cons.

Indirect Gating
The material is injected into the cavities through a cold runner, via a manifold. The vulcanized sprue waste must be removed from the mold together with the molding, and discarded after separation from the molded part.

- Advantages:
  - Less expensive mold making
  - Suitable for small and medium-sized series
- Disadvantages:
  - High material consumption (sprue waste)
  - Secondary finishing of the parts is required (to remove the sprue)
  - Not suitable for fast-curing systems (risk of premature curing in the runners)

Direct Gating
In this case the material in the cold runner is injected into the part. A cold runner with needle valve offers additional processing advantages, such as low shearing during injection.

- Advantages:
  - Articles do not require secondary finishing
  - High degree of automation possible
  - Low material consumption (no sprue waste)
  - Can also be used for rapid curing systems
- Disadvantages:
  - Expensive mold design/production
  - Higher costs for multicavity molds (a cold runner for each cavity) is required

Comparison: Indirect and Direct Gating via Cold Runner

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<td><strong>Indirect Gating</strong></td>
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<td>- Secondary finishing of the parts is required (to remove the sprue)</td>
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<tr>
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<table>
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<tr>
<th>Injection nozzle</th>
<th>Top mold half</th>
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<tr>
<td>Sprue</td>
<td>Silicone molded part</td>
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<tr>
<td>Bottom mold half</td>
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</tbody>
</table>

| Open cold runner | Water cooling | Top mold half |
|------------------|---------------|
| Sprue            | Silicone molded part |
| Bottom mold half |                |
Vulcanization
The curing temperatures and times depend on the quality of the heating system and on the material, volume and geometry of the rubber part. ELASTOSIL® liquid silicone rubber is usually processed at between 150 and 200 °C.

ELASTOSIL® Solid Silicone Rubber
In general, it offers the same advantages as liquid silicone rubber. However, due to the higher viscosity, the runner cross-sections are generally larger.

Curing
Solid silicone rubber is processed at between 150 and 200 °C.
5.4 INJECTION MOLDING DEMOLDING

Vulcanized silicone rubber tends to stick to the mold wall. This can be solved in various ways.

**Multiple Process Passes**
Demolding may be more difficult at the beginning of the process. After multiple cycles, a release layer resulting from the silicone rubber forms on the mold surface, and assists in demolding (cf. diagram).

**Mold Release Agents**
The use of mold release agents, e.g. ELASTOSIL® Mold Release Agent 32, aids demolding on process startup.

**Auxiliary Equipment**
The parts are generally demolded by means of ejector pins and brush or blower units.
5.4 INJECTION MOLDING

2K INJECTION MOLDING

Multicomponent parts can be manufactured by 2K injection molding.
- Soft-hard combinations (combinations of silicone rubber with thermoplastic or metal parts)
- Silicone rubber/silicone rubber combinations (e.g. color combinations or combinations of grades with different hardnesses)

Advantages of 2K Injection Molding
- Excellent adhesion of the components
- Greater scope for designers (color combinations, etc.)
- Soft or non-slip surfaces can be produced in one step
- Outstanding sealing, e.g. against dust or condensation

Material Selection
WACKER offers self-adhesive ELASTOSIL® silicone rubber. For more information, please see our product overview leaflets.

Process Options
Combination parts can be produced by different processes.
- Insert process: Prefabricated hard components (thermoplastics, glass or metal) are inserted in the cavity on a 1K injection molding machine and then overmolded with ELASTOSIL® liquid silicone rubber. Before insertion, metals should be degreased with a solvent such as ethanol or acetone. With thermoplastics, ensure that they have been properly dried, since adsorbed moisture leads to poor adhesion. With difficult material combinations, adhesion can be assisted by, e.g. flame, corona or plasma treatment.
- 2K injection molding on one injection molding machine: A 2K injection molding machine with rotary table produces combination parts in one step. In the first position, the parts are molded from thermoplastic. The moldings are then transferred to position 2 on the turntable, where they are overmolded with liquid silicone rubber.
- 2K injection molding on two injection molding machines: This is a two-stage process with two machines: the thermoplastic backing part is molded on the first machine in a thermoplastic mold. While the part is still hot, a gantry robot transfers it to a silicone mold on the second machine, where it is overmolded with liquid silicone rubber.
Diagram Comparing the Different 2K Injection Molding Methods

- **Insert process**
- **2K injection molding on one injection molding machine**
- **2K injection molding on two injection molding machines**
### 5.4 INJECTION MOLDING TROUBLESHOOTING

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<td>Mold temperature too low</td>
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<td>Mold temperature too high</td>
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<td>Mold has excessive undercuts</td>
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<td>Mold surface too smooth</td>
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<td>Inadequate mold balancing (cold runner/manifold)</td>
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<td>Mold defective</td>
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<td>Heating time too short</td>
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<td>Clamping force too low</td>
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<tr>
<td>Inhomogeneous temperature distribution in the mold</td>
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<td>Inadequate deaeration/vacuum</td>
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<tr>
<td>Injection too fast</td>
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<td>Injection too slow</td>
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<td>Nonreturn valve faulty</td>
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<td>Holding pressure too high/too long</td>
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<td>Too little material</td>
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<td>Switchover point to holding pressure incorrect</td>
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<td>Deviations in mixing ratio of the components</td>
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<tr>
<td>Poor material mixing</td>
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<tr>
<td>Faulty shut-off valve on material feed</td>
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<td>Air in the material feed</td>
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</table>
Troubleshooting

Symptoms

Moldings not fully crosslinked
Overpacking/flash
Mold adhesion/parts not demoldable
Air inclusions/bubbles
Burn marks/white spot
Weld seam
Part deformation/scorching
Defects in the molding
Irregular mold filling
Fluctuations from shot to shot
Underfilling
Sink marks

Possible Causes

Mold temperature too low
Mold temperature too high
Mold has excessive undercuts
Mold surface too smooth
Inadequate mold balancing (cold runner/manifold)
Mold defective
Heating time too short
Clamping force too low
Inhomogeneous temperature distribution in the mold
Inadequate deaeration/vacuum
Injection too fast
Injection too slow
Nonreturn valve faulty
Holding pressure too high/long
Too little material
Switchover point to holding pressure incorrect
Deviations in mixing ratio of the components
Poor material mixing
Faulty shut-off valve on material feed
Air in the material feed
5.5 TEXTILE COATING

Offering the right solution for virtually every coating job, silicones are suitable for all common coating techniques and any conceivable application – even ones that are not yet feasible.

Silicones are ideal for a wide variety of uses thanks to their special chemistry and, most of all, their extraordinary material properties. Manufacturers can also vary the properties of silicones virtually at will via a combination of different grades and additives.

Silicones can be used for coating nearly any type of fabric. The art of formulation requires a great deal of experience and creativity and a wealth of knowledge about relevant chemical and processing relationships. WACKER SILICONES’ technical service specializes in precisely that. We help you manage the often difficult balancing act between product, coating system and substrate in order to achieve the perfect end result.

Info

We will advise you on formulations and will conduct application-related testing for you. We will gladly show you the opportunities and advantages of innovative coating technologies that meet your individual needs. Upon request, we can also carry out pilot runs for you (product width up to 90 cm).
Hydrophobic, Waterproof Material
Silicone rubber is a water-repellent material. The contact angle of a drop of water on a smooth silicone surface is approx. 130°, which means that water does not wet textiles coated with silicone. In addition, even very low coating weights produce textiles capable of withstanding water columns of >10 m as described in EN 20811.

Flame Resistance
Silicones are inherently flame-resistant polymers. The autoignition temperature of silicone elastomers is approx. 430 °C. In the event of a fire, silicone reverts to silicon dioxide (which accumulates as white ash); the gases formed are non-corrosive and non-toxic. Special additives ensure that silicone-coated textiles also meet highly stringent fire-safety requirements.

UV and Weathering Resistance
Silicones are extraordinarily resistant to UV radiation. Combined with their hydrophobic properties and considerable chemical resistance, this makes them exceptionally resistant to weathering. The industrial climate test described in DIN 50018 – SFW 2.0 S (2 l sulfur dioxide) has shown that specialty blends withstand 1.5 million cycles with no change in their surface properties. Since silicones absorb short-wave UV light, silicone coatings can also protect textile fibers that would otherwise be more susceptible to UV damage.

Wash Resistance
Silicones can form chemical bonds with a large array of substrates, making silicone-coated textiles particularly durable – a characteristic demonstrated by their outstanding wash resistance, for example.

Food Contact
When processed properly, many silicones meet Recommendation XV of the German Federal Institute for Risk Assessment (BfR) and requirements of the Food and Drug Administration (FDA) 21 CFR § 175.300 Resinous and Polymeric Coatings. Please note: each individual silicone formulation must be approved for use in food industry applications.
5.5. TEXTILE COATING
SILICONE PRODUCT GROUPS

WACKER SILICONES offers you a number of silicone systems that differ substantially from each other in terms of processing parameters – regardless of the properties of the cured rubber. The differences lie primarily in the application method, in the curing rate and temperature, and in the number of components. Each product group offers specific processing advantages tailored to particular applications. Contact your technical representative to discuss the selection of system components most suitable for you.

<table>
<thead>
<tr>
<th>Product Group</th>
<th>Crosslinking mechanism</th>
<th>Components</th>
<th>Solvent</th>
<th>Viscosity</th>
<th>Curing</th>
<th>Processing</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ELASTOSIL® R</td>
<td>Peroxide curing</td>
<td>1- or 2-component systems</td>
<td>Solvent-free; can be dispersed with solvents</td>
<td>Stiff pastes</td>
<td>In a drying tunnel, 150 – 200 °C, 1 – 5 min</td>
<td>Knife coating, calendering, extrusion</td>
<td>High resistance to substances that disrupt the curing process, very good mechanical properties, high heat resistance, rapid curing</td>
</tr>
<tr>
<td>ELASTOSIL® R plus</td>
<td>Addition curing</td>
<td>1- or 2-component systems</td>
<td>Solvent-free; can be dispersed with solvents</td>
<td>Stiff pastes</td>
<td>In a drying tunnel, 130 – 200 °C, 1 – 3 min</td>
<td>Knife coating, calendering, extrusion</td>
<td>Rapid curing, excellent mechanical properties, dry surface</td>
</tr>
<tr>
<td>ELASTOSIL® LR</td>
<td>Addition curing</td>
<td>2-component systems</td>
<td>Solvent-free; can be dispersed with solvents</td>
<td>10,000 - 500,000 mPas·s</td>
<td>In a drying tunnel, 130 – 200 °C, 1 – 3 min</td>
<td>Knife coating, dip coating</td>
<td>Very rapid curing, good processability, considerable formulation flexibility</td>
</tr>
<tr>
<td>ELASTOSIL® RD</td>
<td>Addition curing</td>
<td>2-component systems</td>
<td>Xylene or petroleum ether</td>
<td>5,000 – 700,000 mPas·s</td>
<td>Evaporate solvent at no more than 100 °C and then cure for 1 – 3 min at 130 – 200 °C in a drying tunnel</td>
<td>Knife coating, dip coating</td>
<td>Excellent mechanical properties, good processability, considerable formulation flexibility, dry surface, low coating weights possible</td>
</tr>
<tr>
<td>ELASTOSIL® E</td>
<td>Condensation curing</td>
<td>1-component systems</td>
<td>Solvent-free or solvent-based</td>
<td>50,000 – 350,000 mPas·s</td>
<td>Skin forms at room temperature after approx. 15 min, fully cured after 1 – 3 days (dependent on atmospheric humidity)</td>
<td>Knife coating, dispensing, screen printing</td>
<td>High resistance to substances that disrupt the curing process, easy processing, good adhesion</td>
</tr>
</tbody>
</table>
Silicones can be applied by all common application methods for coating textiles. The most common methods are knife coating for liquid silicones and calendering for solid silicones. After careful cleaning, coating equipment used for silicones can even serve for processing other coating compounds, such as PVC or acrylates. We recommend aliphatic solvents such as white spirits or isoparaffins as cleaning agents. After cleaning, the heating tunnel should be held at a temperature of at least 150 °C for about an hour before switching over to other materials.

During the calendering process, solid rubber is rolled to the desired film thickness, applied to the textile under pressure and then subjected to thermal crosslinking. Film thicknesses are typically 1 – 2 mm.

Knife coating, by contrast, is ideal for applying thinner films. In this method, liquid silicone pastes are applied, either manually or automatically, in front of a doctor blade. The shear force applied under the blade distributes the silicone rubber evenly and allows it to permeate the fabric, resulting in a good adhesive bond. The distance between the blade and the textile defines the resulting coating thickness. If the coating weight is very low, the blade (air knife) is pressed directly onto the textile, allowing for coatings as thin as approx. 10 µm. Expertise and fine-tuning of the silicone paste’s rheology are key factors in obtaining excellent coating results by knife coating.
SECTION 6: SECONDARY FINISHING
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Secondary finishing of cured silicone rubber

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   Self-adhesive silicone rubber, priming, bonding: step by step

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   Optimizing properties and enhancing cured rubber
6.1. POST-CURING

Ideally, silicone rubber articles do not need secondary finishing. But in many cases the material must be post-cured. That involves heating at a high temperature for a defined time.

Why is Post-Curing Necessary?
Post-curing is performed to achieve an improvement in the mechanical properties (e.g. a particularly low compression set), and to remove volatiles (by-products from the crosslinker chemicals and low-molecular polymer components). For e.g. food-contact applications, post-curing is recommended or even essential in order to meet legal requirements.

- Peroxide-curing rubber:
  Post-curing serves principally to eliminate by-products from the peroxide curing reaction. When ELASTOSIL® AUX Crosslinker E is used, by-products migrate to the cured rubber surface over several hours, and can be seen as white crystal deposits on the surface (blooming). In the case of ELASTOSIL® AUX Crosslinker C1 or C6, the by-products impart a characteristic odor to the cured rubber, which can be removed by post-curing.

- Addition-curing platinum-catalyzed rubber:
  In this case, curing does not form odor containing by-products. But post-curing is still recommended if the silicone article is intended for use in sensitive areas, such as food-contact or medical applications. In such cases the relevant recommendations FDA¹ or BfR² or E.P. 3.1.9³ must be followed.

Removing Defects
Other work steps may be necessary in the following cases:
- Correcting flash or defects (cryogenic deflashing or sanding down)
- Removing sprue waste and talc

Our experts will be glad to help you set up your production plant to manufacture products that meet your demands, and eliminate unnecessary production steps, e.g. by means of test series in our pilot plant or on-the-spot advice.

¹ FDA Chapter 21 CFR § 177.2600 Rubber Articles Intended for Repeated Use.
² BfR recommendation XV. Silicones.
³ E.P. 3.1.9: European Pharmacopoeia 5.0, Chapter 3.1.9.
Ideally, cured ELASTOSIL® silicone rubbers are free of flash and ready to use with no further production steps.

The Right Way to Post-Cure

- Fresh-air supply:
  Carry out post-curing in a circulating-air oven with a fresh air supply. The volatile components consist predominantly of flammable low-molecular siloxanes and maybe peroxide by-products, which must be removed from the oven during post-curing. To ensure reliable operation, fresh air must be supplied at a rate of 100 – 120 l/min/kg of silicone to prevent a risk of deflagration (observe the explosion limits). Most of the volatile components escape in the first 2 hours. Ensure good ventilation during this time.

- Inserting the cured parts:
  Place the parts on a perforated plate or wire mesh, if possible without their touching each other, so that they are not deformed by their inherent weight. To avoid unrestricted air flow, do not place parts one inside the other. Coil up tubes or profiles. In the production of cables, the cable drums should be wound loosely. Single rods between the layers ensure that air can circulate through the cable drum.

- Temperature/time:
  Perform tests to assure the optimum conditions for your part. Check the volatiles content by measuring the weight loss. The required post-curing time increases with the layer thickness. Sheets 2 mm thick generally require 4 hours at 200 °C. The temperature profile, too, depends on the thickness of the parts: the thicker the part the lower the starting temperature and the slower the temperature is increased. Following the heating-up phase, post-curing should be conducted for at least 4 hours at 200 °C. Never exceed 225 °C or a post-curing time of 8h, since this can lead to undesirable thermal aging of the material and embrittlement. Besides thermal aging, an oxygen deficiency can also cause undesirable reversion (degradation of crosslinks) and the formation of unwanted formaldehyde. Check regularly that the oven is operating at constant conditions (e.g. constant temperature).

Important!

Never post-cure platinum-curing grades in contact with peroxides or their degradation products. The presence of such substances in the ventilation air can affect the basic properties of the rubber. Avoid contact with volatile components of organic rubber to prevent cross contamination. Clean the post cure ovens and exhaust system regularly, and replace the pipes in certain intervals.

1 BfR tests require drying over calcium chloride prior to weight loss determination.
Many HTV extrusion grades (e.g. for window profiles) do not need to be post-cured if Stabilizer R is added to the silicone rubber. The stabilizer prevents the blooming of by-products in ELASTOSIL® AUX Crosslinker E and improves the compression set.

Large-volume parts require post-curing and the addition of Stabilizer R. Here, incomplete migration of dichlorobenzoic acid, a primary by-product of ELASTOSIL® AUX Crosslinker E, chemically ages the rubber by acid attack from the rubber bulk (softening it). Stabilizer R binds the by-products and significantly restricts this reaction.

Post-Curing for Technical Applications
Post-curing can also be used to achieve particular technical properties. For example, the compression set of cured ELASTOSIL® silicone rubber depends very significantly on the post-curing time. In the case of ELASTOSIL® LR 3003/50, non-post-cured products have a compression set of 60 – 70%, which can be improved by post-curing. The non-post-curing grades ELASTOSIL® LR 3005, ELASTOSIL® LR 3015, ELASTOSIL® LR 3065 and ELASTOSIL® R 701 are designed for a particularly low compression set even without post-curing. However, they are generally restricted to use in technical applications.

Influence of Post-Curing Time on Compression Set of ELASTOSIL® LR 3003/50 at Various Wall Thickness

* Measurement of compression set at 22h/175 °C in compliance with DIN ISO 815-B
Silicone rubber can bond either mechanically or chemically to other substrates. The mechanical bond is produced by interlocking, for example by overmolding of openings or undercuts in the hard component. Chemical bonding generally offers several advantages: there are various ways of achieving this.

**Chemical Bonding Techniques**

Chemical bonding techniques include:
- Use of self-adhesive silicone rubber
- Vulcanizing onto a primer-treated substrate
- Bonding of premolded individual parts
- Chemical (e.g. priming), physical (e.g. plasma) or mechanical treatment of the substrate surface

**Advantages of Chemical Bonding**

Chemical bonding generally offers price and performance advantages:
- Lower mechanical loading
- Lower tendency of the bond to fatigue
- Lower weight
- Bonds and seals simultaneously
- Can be bonded to shock-sensitive substrates (e.g. glass)
- Can be bonded to electrochemically sensitive metals
- Usually relatively cost effective
6.2  MULTICOMPONENT TECHNIQUES
SELF-ADHESIVE SILICONE RUBBER

Self-adhesive silicone rubber grades such as ELASTOSIL® R plus 4070 or ELASTOSIL® LR 3070 adhere directly to a substrate during vulcanization.

Adhesion to metals such as steel, aluminum or brass is generally very good. The same applies to many thermoplastics and thermosets. Silane-based products are generally used in the rubber as internal adhesion promoters. They are compatible with the uncured rubber but incompatible with the cured rubber, and therefore diffuse to the surface during vulcanization, forming a chemical bond.

Injection Molding
The following processing methods can be used here (for details, see section 5, pages 56 – 57):
• Insertion process
• 2K process on an injection molding machine
  – Mold with rotary table
  – Transfer within the mold by a handling robot
• 2K injection molding process with two IM machines
  – Two different molds linked via a handling robot

Extrusion
For extrusion applications, coextrusion can be used to produce extrudates from different materials in one step (for details, see section 5, page 46).

Advantages
The advantages of self-adhesive silicone rubbers ELASTOSIL® R plus and LR are especially clear:
• Only one step (no application of primer, no cleaning of the substrate, no undercuts)
• Rapid curing and therefore short contact time with the mold
• Easily demoldable, even from uncoated steel
• Rapid build-up of adhesion strength to the substrate
• No adhesion to the mold

Please Note
• Always check that the silicone rubber is compatible with the substrate (metal, glass, PA, PBT, PET, etc.)
• The melting point of the substrate should be as high as possible
• Extensive information about tested material combinations and adhesion values is available from our technical service.
  We will be pleased to perform tests in house on your behalf

Injection molding machine for 2K materials
6.2 MULTICOMPONENT TECHNIQUES
PRIMER/ADHESIVE

ELASTOSIL® AUX PRIMERS G serve as adhesion promoters between silicone elastomers and other substrates like metals, glass and thermoplasts. ELASTOSIL® AUX PRIMERS G are solvent based and contain a mixture of reactive silanes and siloxanes.

Special Characteristics

- Provide excellent adhesion onto various substrates.
- Solvent based – Different viscosities available for various coating techniques like dipping, brushing or spraying.
- Further dilution in organic solvents possible.

Application

ELASTOSIL® AUX PRIMERS G are used to pretreat metallic, ceramic, glass or other polymeric substrate surfaces to enable excellent adhesion towards subsequent Vulcanized ELASTOSIL® R, R plus or LR silicone elastomers.

Step by Step

- The substrate to be primed must be dry and free of grease, oils or other contaminants. Very smooth surfaces must be roughened, for example thoroughly cleaned by sandblasting or with glass beads, and degreased with solvents such as white spirit or acetone.
- Apply primer by spraying, dipping or brushing (thin coat with no bubbles). For absorbent surfaces, repeat priming several times.
- Dry primed metal parts in air for at least 15 minutes.
- Store the pretreated surfaces in a clean and dust-free place for maximum 24 hours drying time.
- So that the primer film is not damaged by high shearing forces during vulcanization, in the case of large-area coatings and for the production of rollers or rubberized metal parts by injection molding, the primer should be baked in the press. For example: 20 to 40 minutes at 100 to 140 °C.

Please Note

Primers are based on moisture-sensitive compounds. Therefore, only open the containers briefly during processing and do not return residues to the vessel.

<table>
<thead>
<tr>
<th>Primers</th>
<th>Dynamic viscosity in mPa•s</th>
<th>Special Characteristics</th>
<th>Suitable for</th>
<th>Recommended coating technique</th>
</tr>
</thead>
<tbody>
<tr>
<td>WACKER® PRIMER G 790</td>
<td>1</td>
<td>General purpose</td>
<td>Platinum curing rubber</td>
<td>Spraying</td>
</tr>
<tr>
<td>WACKER® PRIMER G 790 Toluene Free</td>
<td>1</td>
<td>General purpose</td>
<td>Platinum curing rubber</td>
<td>Spraying</td>
</tr>
<tr>
<td>WACKER® PRIMER G 791 A+B</td>
<td>4000</td>
<td>Silicone-on-silicone curing</td>
<td>Platinum curing rubber</td>
<td>Brushing or dipping</td>
</tr>
<tr>
<td>ELASTOSIL® AUX G 3241</td>
<td>600</td>
<td>Electrically conductive</td>
<td>Peroxide curing rubber</td>
<td>Spraying or brushing</td>
</tr>
<tr>
<td>ELASTOSIL® AUX G 3242</td>
<td>5</td>
<td>General purpose</td>
<td>Peroxide curing rubber</td>
<td>Spraying</td>
</tr>
<tr>
<td>ELASTOSIL® AUX G 3243</td>
<td>550</td>
<td>General purpose</td>
<td>Peroxide curing rubber</td>
<td>Spraying or brushing</td>
</tr>
<tr>
<td>ELASTOSIL® AUX G 3244</td>
<td>300</td>
<td>Red color</td>
<td>Peroxide curing rubber</td>
<td>Spraying or brushing</td>
</tr>
<tr>
<td>ELASTOSIL® AUX G 3246</td>
<td>2600</td>
<td>General purpose</td>
<td>Peroxide curing rubber</td>
<td>Brushing or dipping</td>
</tr>
</tbody>
</table>
6.2 MULTICOMPONENT TECHNIQUES
BONDING OF PREMOLDED INDIVIDUAL PARTS

WACKER supplies one and two-component room-temperature-curing systems for bonding vulcanized silicone rubber parts or bonding silicone rubber to other substrates.

One-Component Adhesive
One-component room-temperature-vulcanizing (RTV-1) silicone rubber compounds are supplied ready to process in tubes, cartridges and pails. The compounds cure on exposure to atmospheric moisture. ELASTOSIL® E 43 N is a solvent-free, heat-resistant transparent adhesive that does not use tin-containing catalysts. ELASTOSIL® E 41 is a toluene-containing one-component dispersion that is easier to handle due to its improved flow properties. However, ELASTOSIL® E 43 N is better for large-area bonding of relatively thin silicone rubber parts. The warping caused by the swelling effect of toluene can be avoided in this case.

<table>
<thead>
<tr>
<th>Adhesive</th>
<th>Dynamic viscosity in mPa·s (Brookfield)</th>
<th>Special Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>ELASTOSIL® E43</td>
<td>350.000</td>
<td>General purpose</td>
</tr>
<tr>
<td>ELASTOSIL® E43 N</td>
<td>300.000</td>
<td>For food contact applications</td>
</tr>
<tr>
<td>ELASTOSIL® E47</td>
<td>Non-slump</td>
<td>Fast curing at elevated temperatures</td>
</tr>
<tr>
<td>ELASTOSIL® N10</td>
<td>10.000</td>
<td>General purpose</td>
</tr>
<tr>
<td>ELASTOSIL® N199</td>
<td>Non-slump</td>
<td>General purpose</td>
</tr>
<tr>
<td>SILPURAN® 4200</td>
<td>300.000</td>
<td>For medical applications</td>
</tr>
</tbody>
</table>

Two-Component Systems
Two-component systems are an economically attractive alternative for larger production runs and large-area bonds. They cure rapidly even under lower air exposure.

- Step by step:
  - Clean the rubber parts or substrate carefully and degrease if necessary
  - Apply the silicone rubber 1-component adhesive (RTV-1) to a thickness of at least 0.5 mm
  - Miter cut the ends of cords or profiles obliquely before bonding to give the biggest possible bonding area
  - Press together the parts to be bonded and fix them in position until the adhesive has cured
  - Depending on the air humidity, the optimum bond strength at room temperature is achieved within 12 to 15 hours. It is much faster at temperatures between 50 and 100 °C and high humidity

Bonding of Metal
- ELASTOSIL® E one-component silicone rubber compounds release acetic acid when they cure causing corrosion to some metals
- Therefore, pretreat metals with primer G 790; the primer also improves adhesion
- With very corrosion-sensitive metals, we recommend using amine-curing or neutral systems
Cured ELASTOSIL® silicone rubber can be refined in a number of different ways.

**There are Several Possibilities:**
For example, the following properties can be further influenced by secondary surface treatment:
- Abrasion resistance
- Dirt repellency
- Haptic properties and structure
- Chemical resistance
- Electrical conductivity
- Thermal conductivity
- Electrostatic charging,
and many others

**Processes and Products**
Typical coating processes include knife coating, spraying or printing. Suitable products include ELASTOSIL® RTV-1 silicone rubber, ELASTOSIL® RTV-2 silicone rubber and ELASTOSIL® and SILPURAN® liquid silicone rubber.

**Ask Us!**
If you have any questions on this topic, please ask your sales manager. He will be glad to show you the many possibilities and give you specific advice about the product.
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7.1.
TECHNICAL SUPPORT AND ADVICE

We offer you technical support at various levels to ensure the success of our products at every stage in your process chain.

Technical Centers
We maintain technical centers in all key regions to assist you in any technical matters. From adjusting formulations to individual requirements, to property testing of rubber compound and cured material. The technical centers are equipped to perform all relevant analytical techniques and lab tests for you according to international and local standards and regulations. You have access not only to our locally based experts but also to our globally networked knowledge from over 50 years of market experience.

For example, our pilot plant in Burghausen forms the interface between product and applications expertise. It is equipped with a lab and test facilities, as well as production systems (extrusion and injection molding) for HTV and LSR silicone rubber, and 2K combinations. At our pilot plant, we put our ELASTOSIL® product series through a range of practical tests as part of their development, testing, modification and optimization. At the same time, we offer extensive advice at every step in the supply chain, and put our pilot plant and all the necessary tools at your disposal. Or we work on your premises at your production plant.

What We Offer
• Preliminary material selection tests
• Production of two-component samples especially for adhesion testing and other test purposes
• Extruding profiles, tubing, round strands, cables of different geometries and silicone rubber materials for test purposes
• In-site production of prototypes and sample series using the client’s own tooling for screening tests, approval or subsequent use by the end customer
• Joint development of specific products
• Training and instruction
• System consulting, particularly process design and utilization of machines/tooling in new applications and projects
• In-site process optimization
• Analysis and simulation of problems occurring in processing and production
• Individual problem solving and ensuring process stability
Applications Labs
For technical support, our application chemists 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 supporting your product development from material selection through to industrial production – worldwide. Our laboratories deal with key issues from specific industrial sectors (such as medical and automotive applications and cables). They have thereby built up special expertise and know-how in these application fields.

Some of Our Services
- Technical consultancy for product selection to your specific requirements
- Joint development of specific products
- Testing the chemical resistance of materials
- Thermal storage tests
- Providing samples and sheet samples
- Color matches
- Advice on questions about material processing
7.2.
SILMIX®: CUSTOM SILICONE RUBBER COMPOUNDS

With SILMIX®, we offer you ready-to-use silicone rubber compounds tailored to your specifications.

Flexible and Globally Represented
At our SILMIX® plants at various sites around the world, we develop custom compounds to your specifications.

Direct and Versatile
Our ready-to-process SILMIX® products allow you to manufacture a wide variety of silicone rubber articles directly by various processes, such as pressing, transfer molding, injection molding and extrusion. Applications range from automotive gaskets, through cable insulation, to rubber-coated rolls for photocopiers.

Best Quality
SILMIX® compounds are manufactured to the same quality standards as all WACKER silicone rubber grades. Thanks to its integrated silic on production system, WACKER is highly backward-integrated and produces the necessary raw materials itself, from the polymer base upwards. This ensures highly consistent good quality.

Interested?
You can find further information on our website: www.wacker.com/silmix
7.3.
WACKER INFOLINE
E-BUSINESS

Infoline
To make it easier for you to get into rapid personal dialog, we have set up an info hotline for you. For all questions concerning silicone rubbers from WACKER, our products and services, just call us or send us an email: you will be redirected to a specialist who can answer your questions.

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  (+1 888-WACKER 4 U)
- Email: info.usa@wacker.com

E-Business
WACKER e-solutions simplify communication with customers and suppliers, and offer many new possibilities: from global searches to expedited order processing via the web platform or Hub2Hub, to vendor managed inventory – just as you wish. We compile a tailored service package for you. Exactly tailored to the size of your company, your profile and the wishes of each contact.

You can gain considerably greater efficiency through:
- “Clean orders”
- Fewer order changes
- Faster processing with a greatly reduced proportion of errors
- Maximum planning reliability and
- Full transparency

WACKER e-solutions support you exactly where human error is most common. However, they supplement rather than replace human interactions, by bringing the right people together. Our partners value the direct line to our experts in R&D, supply chain management, sales support and technical customer service.

And you can
- Call up any industry and product information you want
- Order easily, quickly and reliably – 24/7
- Carry out paperless invoicing
- Automatically process all orders
- Automatically check and complete your inventories
To ensure product safety, we – of course – offer you regulatory support. Our experts will deal with your enquiries about environmental, health and regulatory matters.

This includes, for example, 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)
- Requirements of specific industries (e.g. GADSL, IMDS, automotive industry)
- Specific customer requirements (e.g. banned-substance and substance-avoidance lists)
- Toxicology and ecotoxicology
- Risk assessment
- Organizational assistance

Call us if you have any questions about food approvals, REACH or other regulatory issues. Please ask our sales managers first, who are your direct contacts. They will pass your questions on to our experts and send you our reply to your specific question!

Just Ask Us!
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
• General seminars, e.g. on intercultural communication or innovation management

You can find the current program at: www.wacker.com/wacker-academy. The WACKER ACADEMY is headquartered at our largest production plant, which is in Burghausen, Germany. Further WACKER ACADEMY centers located in different regions exemplify our policy of making global expertise available right on your doorstep. As a result, we can offer you a seminar program that is tailored to you 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.
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Tracking Resistance 87
Volume resistivity 87
Water and steam resistance 87
Weathering and UV resistance 87
8. RUBBER SOLUTIONS A–Z
FACTS AND FIGURES ABOUT SILICONE

Coefficient of Expansion
• Linear thermal coefficient of expansion of tool steel is approx. 1.5 \(10^{-6}\) K\(^{-1}\), and leads to shrinkage of the final parts.
• Typical values: approx. 2 - 4 \(10^{-4}\) K\(^{-1}\).

Compression Set
• Determination of the compression set as per ISO 815-B (ASTM D395 B-2) by storage for 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 silicone rubber: 5 – 25%.

Density
• Determination as per ISO 1183-1 A (buoyancy method).
• Typical range for specific density 1.05 – 1.60 g/cm\(^3\).
• When using additional inactive fillers (e.g. quartz), values up to 1.75g/cm\(^3\) can be achieved, e.g. to improve swelling resistance.

Dielectric Constant \(\varepsilon\)
• Determination of dielectric constant \(\varepsilon\) as per DIN 53 482 or VDE 0303.
• Typical values for silicone rubber: \(\varepsilon = 2.7 - 3.3\) (at 25 °C and 50 Hz).
• This property can be increased up to 150 by the use of suitable fillers.

Dielectric Strength
• Determination of dielectric strength per IEC 60243-1.
• Typical value for ELASTOSIL® silicone rubber > 20 kV/mm (measured on a 1 mm sheet).

Dissipation Factor Tan \(\delta\)
• Determination of the dissipation factor as per VDE 0303.
• Typical values for loss angle tan \(\delta \sim 10^{-3}\) tan \(\delta\) is raised by increasing the filler content/density.

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 for high-safety cables form a ceramic layer in the case of fire.

Flame Resistance
• Determination of the flame resistance acc. to test standard ASTM D 2863 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*).
• In the case of solid silicone rubber, the addition of 2.2% ELASTOSIL® AUX Batch SB-2 improves the flame resistance considerably.

* dep. on grade
Gas Permeability
- Determination 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 cm³ ∙ mm ∙ m⁻² ∙ h⁻¹ ∙ bar⁻¹ (volume of air measured in cm³, that penetrates a membrane of 1 m² area per hour at a pressure difference of 1 bar and 1 mm thickness)
- Technical advantage, e.g. for contact lenses, textile coatings and for some medical applications
- At high temperatures, silicone has similar values to organic elastomers

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<td>Ethylene</td>
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</table>

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® R 490/55, has higher resistance.
- Properties not severely affected by gamma and beta radiation (25 – 75 kGy), as widely used for sterilization of medical equipment.
- Very good resistance to microwaves, since silicone parts are not microwave-active and therefore not heated.

Rebound Resilience
- Determination of rebound resilience 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%.

Hot-Air Resistance
- The mechanical properties of WACKER silicone rubber are retained even at high temperature loading (hot air).
- The hot-air resistance is thereby clearly superior to that of most organic elastomers (cf. ASTM Charta D2000)

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

For selected products of the ELASTOSIL® R 401 and ELASTOSIL® LR 3003 series, a cracking level of 0 was obtained after 96h at an ozone concentration of 200 pphm (temperature: 40 °C, r.h. 55%, elongation 80%)

Just Ask Us!

Gas Permeability

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Hardness
- Determination of the hardness of silicone rubber in Shore A (DIN 53 505) or in IRHD units (DIN 53 519).
- Typical bandwidth 3 – 90 Shore A.

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

Reversion
- By reversion is meant in general degradation of the crosslinking network in the cured rubber as a result of chemical or thermal effects, which 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
- In the case of thick parts, where oxygen diffusion is difficult, this process is inhibited by the use of Stabilizer R.
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, swelling tendency decreases and resistance is therefore improved.
• High swelling tendency to non-polar liquids such as hydrocarbons, mineral oils and greases.
• Low swelling tendency to polar liquids, such as polyhydric 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
• Linear shrinkage of approx. 2 – 4% falls with increasing Shore hardness and lower vulcanization temperature.
• The higher the filler content or density, the less is the shrinkage of the cured parts.
• Very strong dependency on processing parameters and material grades.
• For precision parts, fine tuning is necessary by means of preliminary tests.

Surface Resistence
• Determination of the surface resistivity per VDE 0303.
• Typical values for insulating ELASTOSIL® LR compounds: approx. $10^{12} - 10^{13} \Omega$.

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 – 55 N/mm.
• Values are up to 30% lower when measured by ISO 34-1, method B-b (Graves).
• ISO 34-1 method A (trouser) yields values about 50% lower.

Tear Strength and Elongation at Break
• Determination as per DIN 53 504.
• Standard test on S1 bar. In exceptional cases also measurements on small S2 and S3 test specimens, though the values deviate correspondingly.
• Typical values for tensile strength: approx. 5 – 12 N/mm² (or MPa).
• Typical values for elongation at break: approx. 100 – 1,100%.
Temperature Behavior

- Mechanical properties of silicone elastomers determined at 23 °C (RT) as per DIN 53503 or DIN 53505 respectively.
- The change in the mechanical properties is only small compared to organic elastomers.
- Typical service temperature range: −50 to +250 °C.
- The material hardens at very low temperatures (−40 °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 cause post-curing of the polymer chains, with an increase in hardness together with a decrease of tensile strength and elongation at break (embrittlement).
- The simultaneous weight decrease of the vulcanizate leads to shrinkage.
- The lifetime of the vulcanizate can be increased by the use of heat stabilizers H1 – H6 (usually oxides of multi-valent elements).
- 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 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 at 100 °C: approx. 0.2 – 0.3 W · m⁻¹ · K⁻¹.
- Special thermally conductive compounds achieve values of about 0.1 – 1.2 W · m⁻¹ · K⁻¹.
- Typical values for specific heat capacity: approx. 1.25 kJ · kg⁻¹ · K⁻¹.

Tracking Resistance

- Silicone rubber generally features high tracking resistance (CTI: 600 - <1 as per IEC 60112).

Volume Resistivity

- Determination as per VDE 0303
- Typical values for insulating silicone rubber grades approx. $10^{15}$ Ω · cm.
- Typical values for conductive grades approx. 2 - 150 Ω · cm.
- Lower temperature dependency in the case of platinum-catalyzed grades compared to peroxide-cured systems.

Water and Steam Resistance

- Excellent resistance to boiling water.
- Volume decrease in boiling water below 1%, even after prolonged action.
- Resistance to superheated steam is higher for elastic grades than for notch-resistant grades.
- Steam sterilization (as per ISO 17665, DIN EN 868-8 at 500 cycles at 134 °C, 5min.) leads to only a slight worsening of mechanical properties.

Weathering and UV Resistance

- Silicone rubber articles 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. sorganic antioxidants, UV stabilizers, etc.).
WACKER is one of the world’s leading and most research-intensive chemical companies, with total sales of €5.3 billion. 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 5 business divisions, we offer our customers highly-specialized products and comprehensive service via 25 production sites, 22 technical competence centers, 12 WACKER ACADEMY training centers and 50 sales offices in Europe, North and South America, and Asia – including a presence in China. With a workforce of some 17,000, we see ourselves as a reliable innovation partner that develops trailblazing solutions for, and in collaboration with, our customers. We also help them boost their own success. Our technical centers employ local specialists who assist customers worldwide in the development of products tailored to regional demands, supporting them during every stage of their complex production processes, if required.

WACKER e-solutions are online services provided via our customer portal and as integrated process solutions. Our customers and business partners thus benefit from comprehensive information and reliable service to enable projects and orders to be handled fast, reliably and highly efficiently. Visit us anywhere, anytime around the world at: www.wacker.com

All figures are based on fiscal 2015.
PEROXIDE-CURING
SOLID SILICONE RUBBER

Multi-purpose · High green strength · High tear resistance · Low compression set

This information is the property of the company and the present state of our knowledge but does not release the user from carefully checking all supplies immediately on receipt. We reserve the right to alter product constants within the scope of technical progress or new developments. The recommendations made in this medium should be checked by preliminary trials because of conditions during processing over which we have no control, especially where other companies’ raw materials are also being used.

The information provided by us does not absolve the user from the obligation of investigating the possibility of infringement of third parties’ rights and, if necessary, clarifying the position. Recommendations for use do not constitute a warranty, either expressed or implied, of the fitness or suitability of the product for a particular purpose.
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1 UL94 classification V-0, when tested according to UL STD 581 standard
2 FDA = Food and Drug Administration
3 BfR = Bundesinstitut für Risikobewertung
4 KTW = contact – Drinking water
5 WRAS = contact – Drinking water
6 UL = Underwriters Laboratories

Please contact us if you are interested in products with specific characteristics or if you need products from our basic portfolio in other hardnesses.

Please contact us for in-depth technical consulting to select the right product for your individual demands.

4 Non-postcured

3 Categories on request.

2 FDA CFR 21 § 177.2600 “Rubber articles intended for repeated use” (FDA = Food and Drug Administration).

1 BfR recommendation XV (silicones); (BfR = Bundesinstitut für Risikobewertung).

These figures are only intended as a guide and should not be used in preparing specifications.
CREATING TOMORROW’S SOLUTIONS

PRODUC T OVERVIEW

PEROXIDE-CURING
SOLID SILICONE RUBBER

Media resistant · High rebound resilience · Low temperature resistance ·
High heat resistance · Ceramifying · Electrically conductive · Flame retardant · Low rebound resilience · Superheated steam resistance · Magnetisable

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info@wacker.com
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</table>

These figures are only intended as a guide and should not be used in preparing specifications.

1 Determination of mechanical properties at 23°C/175°C.
2 Determination of mechanical properties at 100°C.
3 Determination of mechanical properties at 23°C.

Please contact us if you are interested in products with specific characteristics or if you need products from our basic portfolio in other hardnesses.

Please contact us for in-depth technical consulting to select the right product for your individual demands.

4 Non-postcured

3 Categories on request.

2 FDA CFR 21 § 177.2600 “Rubber articles intended for repeated use” (FDA = Food and Drug Administration).

1 BfR recommendation XV (silicones); (BfR = Bundesinstitut für Risikobewertung).

These figures are only intended as a guide and should not be used in preparing specifications.
LIQUID SILICONE RUBBER

Multi-purpose · High tear resistance · Media resistance · Heat resistance · Low coefficient of friction
<table>
<thead>
<tr>
<th>Material</th>
<th>Brand</th>
<th>Product</th>
<th>Tension</th>
<th>Tear</th>
<th>Hardness</th>
<th>Viscosity</th>
<th>Crosslinking</th>
<th>Molded parts</th>
<th>Typical applications</th>
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LIQUID SILICONE RUBBER

Self-adhesion · Oil-bleeding · Low viscosity · Electrically conductive · High transparency · Flame retardant
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<th>Main characteristics</th>
<th>Brand</th>
<th>Product</th>
<th>Further characteristics</th>
<th>Hardness</th>
<th>Shore A</th>
<th>Density</th>
<th>Tensile strength</th>
<th>Elongation at</th>
<th>Tear resistance</th>
<th>Compression set</th>
<th>Food – Water contact</th>
<th>FDA contact</th>
<th>– KTW</th>
<th>– WRAS</th>
<th>Typical applications</th>
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</table>

ISO 7619-1  
Shore A  
ISO 1183-1  
[g/cm³]  
Tensile strength  
Elongation at  
ASTM D 624 B  
Tear resistance  
Compression set  
Food – Water contact –  
FDA contact –  
– KTW  
– WRAS  
Drinking water  
Drinking water –  
Kath. BfR  
Kath. BfR –  
BfR recommendation XV (silicones); (BfR = Bundesinstitut für Risikobewertung).

Please contact us for in-depth technical consulting to select the right product for your individual demands.
CREATING TOMORROW’S SOLUTIONS

PRODUCT OVERVIEW

ADDITION CURING SOLID SILICONE RUBBER

- Multi-purpose
- High tear resistance
- Low compression set
- High elasticity
- Low coefficient of friction
- Self-adhesion
- High heat resistance
- Oil bleeding
- Electrically conductive

The data presented in this medium are in accordance with the present state of our knowledge but do not absolve the user from carefully checking all supplies immediately on receipt. We reserve the right to alter product constants within the scope of technical progress or new developments. The recommendations made in this medium should be checked by preliminary trials because of conditions during processing over which we have no control, especially where other companies' raw materials are also being used. The information provided by us does not absolve the user from the obligation of investigating the possibility of infringement of third parties' rights and, if necessary, clarifying the position. Recommendations for use do not constitute a warranty, either express or implied, of the fitness or suitability of the product for a particular purpose.

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<table>
<thead>
<tr>
<th>Multi-purpose</th>
<th>ELASTOSIL® R</th>
<th>Relative density TYP ISO 37 Typ 1</th>
<th>Specific gravity [g/cm³]</th>
<th>ISO 7619-1</th>
<th>Tensile strength [N/mm²]</th>
<th>Normal elongation at break [%]</th>
<th>TYP ISO 37</th>
<th>Molding Extrusion</th>
<th>Food contact materials</th>
<th>Appearance</th>
<th>Typical applications</th>
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<td>Production of electrically conductive cable components and profiles (volume resistivity 1.8 Ω cm)</td>
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<td>573/50 50 1.11 5.5 370 16 32 X Platinum (A/B component) Black</td>
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<td>4070/30 31 1.11 10.8 1096 47 30 3 X Platinum (1 component, ready to use) Translucent Hard-soft composite molded parts, primerless adhesion to various plastic substrates (e.g. PA, PBT) and metals</td>
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<td>4060/60 60 1.15 8.5 380 20 8 X X X Platinum (1 component, ready to use) Transparent Molded parts, e.g. spark plug boots</td>
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<td>4305/80 80 1.19 7.8 360 21 10 X X X Platinum (100:1.5 base + catalyst) Transparent Extruded parts, e.g. tubes or profiles</td>
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<td>4305/50 50 1,14 9.2 800 38 15 X X X Platinum (1 component, ready to use) Transparent Molded parts, e.g. baby-bottle nipples or pacifiers</td>
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<td>4000/40 40 1.12 8.8 1000 46 35 X X X Platinum (100:1.5 base + catalyst) Transparent Molded parts, e.g. baby-bottle nipples or pacifiers</td>
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<tr>
<td>4001/80 80 1.20 8.5 580 29 32 X X X Platinum (1 component, ready to use) Transparent Molded parts, e.g. seals, membranes, baking molds</td>
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<td>4001/60 60 1.14 11.0 608 30 16 X X X Platinum (1 component, ready to use) Transparent Molded parts, e.g. seals, membranes, baking molds or spark plug boots</td>
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These figures are only intended as a guide and should not be used in preparing specifications.
**PRODUCT OVERVIEW**

**SILICONE RUBBER FOR MEDICAL APPLICATIONS**

- **Liquid Silicone Rubber** - Multi-purpose · High tear resistance · Low coefficient of friction · Non-healing · Self-adhesion
- **Solid Silicone Rubber** - Multi-purpose · High tear resistance · Low coefficient of friction

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Liquid silicone rubber

<table>
<thead>
<tr>
<th>Product Code</th>
<th>Brand</th>
<th>Product type / cure system</th>
<th>Hardness</th>
<th>Specific gravity</th>
<th>ISO 1183-1A</th>
<th>ISO 37 Typ 1</th>
<th>Tensile strength</th>
<th>Elongation at break</th>
<th>Tear resistance</th>
<th>FDA CFR 21 § 177.2600</th>
<th>Medical pharma., Class VI</th>
<th>BfR 1</th>
<th>FDA 2</th>
<th>Food contact – Class VI</th>
<th>Biotech – Medical pharma.</th>
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<td>570</td>
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<tr>
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Solid silicone rubber

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<th>Brand</th>
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<th>Hardness</th>
<th>Specific gravity</th>
<th>ISO 1183-1A</th>
<th>ISO 37 Typ 1</th>
<th>Tensile strength</th>
<th>Elongation at break</th>
<th>Tear resistance</th>
<th>FDA CFR 21 § 177.2600</th>
<th>Medical pharma., Class VI</th>
<th>BfR 1</th>
<th>FDA 2</th>
<th>Food contact – Class VI</th>
<th>Biotech – Medical pharma.</th>
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<tbody>
<tr>
<td>6800/60</td>
<td>SILPURAN®</td>
<td>HTV, peroxide (70:1.5 base + catalyst)</td>
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<td>1.15</td>
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<td>57</td>
<td>570</td>
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<td>91</td>
<td>46</td>
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<tr>
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<tr>
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<tr>
<td>6800/10</td>
<td>SILPURAN®</td>
<td>HTV, peroxide (70:1.5 base + catalyst)</td>
<td>10</td>
<td>1.07</td>
<td>520</td>
<td>70</td>
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**Notes:**
- **SILPURAN®** is a trademark of Wacker Chemicals GmbH.
- **HTV** stands for High Temperature Vulcanization.
- **TENSIL®** and **TENSIL®-FX** are trademarks of Wacker-Chemie GmbH.
- This list is not exhaustive and is provided for illustrative purposes only. Always consult the manufacturer for the most accurate information. 

**Contact:**
Please contact us for more information or to order samples. You can reach us at +1 (123) 456-7890 or via email at info@wacker.com. Visit our website at www.wacker.com to explore our full product line and learn more about our applications.
SILICONE RUBBER FOR TEXTILE COATING

Rubber Dispersions · High Temperature Curing Silicone Rubber · Room Temperature Curing Silicone Rubber · Top Coats
<table>
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<td>Top Coats</td>
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<tr>
<td>ELASTOSIL® RD 3151 F</td>
<td>addition</td>
<td>Acrylic varnish, easy to clean, solid content 63 % in white spirit</td>
<td>transparent</td>
<td>83.000</td>
<td>11.030</td>
<td>1.800</td>
<td>15.000</td>
<td>12.000</td>
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<tr>
<td>ELASTOSIL® RD 6620 F</td>
<td>addition</td>
<td>Matt varnish, solid content 50 % in xylene</td>
<td>colorless, opaque</td>
<td>165.000</td>
<td>11.000</td>
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| Room Temperature Curing Silicone Rubber |                 |                 |       |                                 |                                 |                 |                 |                 |                 |                 |
| ELASTOSIL® E43 N | condensation | General purpose, excellent adhesion, tin-free | transparent | 380.000 | 260.000 | 35 | 4.5 | 350 | 12.0 | Ready to use system |
| ELASTOSIL® E50 N | condensation | General purpose, anti-slip, tin-free | transparent | 63.000 | 53.000 | 35 | 1.5 | 150 | 5.0 | Ready to use system |
| ELASTOSIL® E91 | condensation | Anti-slip surface, fast skin formation at room temperature, tin-free | transparent | 100.000 | 60.000 | 20 | 1.5 | 350 | - | Ready to use system |
| ELASTOSIL® E92 N | condensation | Anti-slip surface, fast skin formation at room temperature, tin-free | transparent | 120.000 | 80.000 | 20 | 1.5 | 350 | - | Ready to use system |
| ELASTOSIL® E93 N | condensation | Anti-slip surface, fast skin formation at room temperature, tin-free | transparent | 80.000 | 60.000 | 20 | 1.5 | 350 | - | Ready to use system |

| High Temperature Curing Silicone Rubber |                 |                 |       |                                 |                                 |                 |                 |                 |                 |                 |
| ELASTOSIL® LR 3001/55 FR A/B | addition | Flame retardant (UL 94: V-0) | grey | 150.000 | 90.000 | 51 | 3.5 | 300 | 11.0 | Addition of 3 % ELASTOSIL® CROSSLINKER 525 or 1 % WACKER® CROSSLINKER W required |
| ELASTOSIL® LR 6200 A/B | addition | Low viscosity | white | 15.000 | 9.000 | 45 | 4.3 | 190 | 4.0 | A/B-System, mixing ratio A:B = 1:1 |
| ELASTOSIL® LR 6220 A/B | addition | General purpose | transparent | 353,000 | 248,000 | 20 | 8.5 | 880 | 25.0 | A/B-System, mixing ratio A:B = 1:1 |
| ELASTOSIL® LR 6240 A/B | addition | General purpose | transparent | 30,000 | 20,000 | 36 | 3.0 | 290 | 7.0 | A/B-System, mixing ratio A:B = 1:1 |
| ELASTOSIL® LR 6250 F | addition | General purpose | transparent | 53,000 | 32,000 | 40 | 5.0 | 350 | 6.0 | Addition of 3 % ELASTOSIL® CROSSLINKER 525 or 1 % WACKER® CROSSLINKER W required |
| ELASTOSIL® LR 6260 A/B | addition | High dielectric strength | ivory | 57,000 | 31,000 | 44 | 5.7 | 430 | 7.0 | Addition of 3 % ELASTOSIL® CROSSLINKER 525 or 1 % WACKER® CROSSLINKER W required |
| ELASTOSIL® RD 6680 F | addition | General purpose | transparent | 75.000 | 45.000 | 51 | 3.5 | 300 | 11.0 | Addition of 3 % ELASTOSIL® CROSSLINKER 525 or 1 % WACKER® CROSSLINKER W required |
| ELASTOSIL® RD 6600 F | addition | General purpose | black | 18.000 | 4.000 | 35 | 3.5 | 420 | 10.0 | Addition of 3 % ELASTOSIL® CROSSLINKER 525 or 1 % WACKER® CROSSLINKER W required |

**Noteworthy**: The above properties may vary depending on the specific formulation and curing conditions. Always consult the manufacturer's datasheets for the most accurate information.
The data presented in this medium are in accordance with the present state of our knowledge but do not absolve the user from carefully checking all supplies immediately on receipt. We reserve the right to alter product constants within the scope of technical progress or new developments. The recommendations made in this medium should be checked by testing after receipt because of conditions during processing over which we have no control, especially when other components/raw materials are also being used.

The information provided by us does not absolve the user from the obligation of investigating the possibility of infringement of third parties’ rights and, if necessary, clarifying the position. Wacker cannot be held liable for the correctness, either express or implied, of the content or usability of the product for specialized branches.