WACKER SILICONES

ELASTOSIL®

THE GRADES AND PROPERTIES OF ELASTOSIL® R SOLID SILICONE RUBBER

CREATING TOMORROW'S SOLUTIONS

Contents

THE DIFFERENCE BETWEEN STANDARD RUBBER GRADES AND ELASTOSIL® R SOLID SILICONE RUBBER IS THE WORD “SILICONE.”

LUCKILY, SILICONE EXISTS AS RUBBER, TOO

ELASTOSIL® R solid silicone rubbers are synthetic rubbers which differ in structure from conventional elastomers. ELASTOSIL® R grades are based on the chemistry of silicone – and share the same outstanding properties. These materials offer a wealth of remarkable features which meet the rubber industry's strict requirements in every respect.

On the following pages, you will find detailed information about what makes ELASTOSIL® R solid silicone rubbers[1] what they are: we explain their chemical structure and the resulting properties, as well as how to test and describe these properties.

For those who just want a quick overview, we have listed the individual ELASTOSIL® R grades in a table. This will help you to find precisely the information you are looking for.

[1] The abbreviation >HTV (for high-temperature vulcanizing) is misleading, since liquid silicone rubbers are also high-temperature-vulcanizing systems. At Wacker Chemie AG, the difference between solid and liquid silicone rubbers is reflected in the trademarks ELASTOSIL® R (R = Rubber) und ELASTOSIL® LR (LR = Liquid Rubber). We refer to platinum-catalyzed solid silicone rubbers as ELASTOSIL® R *plus*.

THE RIGHT CHEMISTRY

Both solid and liquid silicone rubbers are made of three components: polymers, fillers and additives. Nothing more.

Polymers
Whether straight or branched – a polymer is a chain of small repeating units with the end group X:

X - A - A - A - A - A - A - A - X =
X - [A] n - X

With polyethylene (PE), for example, X is a methyl group (CH_3):

X - CH_2 - CH_2 - CH_2 - X = X - [CH_2] n - X

With silicones, the polymer chains, >siloxanes are formed with Si-O bonds. The so-called polysiloxane backbone is a chain consisting of silicon and oxygen:

- Si - O - Si - O- Si - O-

This differs from the carbon backbone of polyethylene (PE):

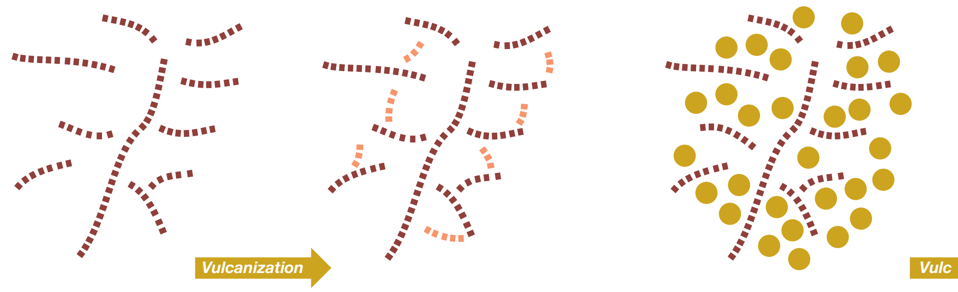
- C - C - C - C - C - C - C -

Silicone is part inorganic, part organic. It shares the same Si-O backbone with inorganic materials such as quartz or glass. But, silicones also contain organic groups which are attached to the silicon.

- SiR_2 - O - SiR_2 - O - SiR_2 - R = Me, Phenyl, Vinyl

The organic groups on the polysiloxane backbone may be methyl (Me), vinyl or phenyl groups. The term >polydiorganosiloxanes is then used.

The role of fillers in crosslinking



Polymer chains before and after crosslinking – without fillers

Polymer chains before and with fillers

Named after the side groups

The polymers are named after the organic side groups attached to the silicon atom. Each silicon atom has four chemical bonds, which is why silicone rubbers are often abbreviated with a Q for quaternary groups. The polymers present in rubber can vary in structure, e.g. with different chain lengths, with or without branching or with a high or low vinyl content. This, in turn, affects the ultimate properties of the rubber.

>MQ

In polydimethylsiloxanes, the organic groups are methyl groups. They have relatively little importance as they have no double bonds and do not react easily with >crosslinkers (peroxides). They can, however, be used as additives, e.g. as plasticizers. For further details, see page 7.

>VMQ

This compound is similar to polydimethylsiloxane (MQ), but some of the methyl groups have been replaced with vinyl groups. The double bond is a reactive group which is needed for crosslinking. For further details, see page 8.

>PVMQ

If a small proportion of the methyl groups in a VMQ is now replaced with phenyl groups, the polymer chain has less tendency to pack closely with adjacent chains at low temperatures than is the case with MQ or VMQ. In the latter cases, such packing causes >embrittlement of the rubber. The chemical structure of >phenylmethyl silicone rubbers helps them to retain their flexibility at temperatures as low as -80 °C.

after crosslinking –

Fillers interact with the polymer backbone and stabilize crosslinking.

OUR FORMULATORS NEED JUST A FEW SELECT INGREDIENTS

Silicone rubbers in fact consist of just a few ingredients. A simple mixture of polymers and fillers suffice for a final product. This final product needs just a few additives to obtain endless variations.

Fillers

A polymer compound crosslinked without the addition of >fillers would not produce a viable elastomer, and would be useless. This is because the polymer chains do not interact at normal temperatures, since they are chemically inert. Fillers are needed to fill the gaps between the polymers and support the network from within.

The type, quantity and composition of the filler can vary and this determines to a large extent the properties exhibited by the rubber or elastomer. A distinction is made between two types of fillers:

Reinforcing fillers

These primarily include fumed silicas with very large BET surface areas (larger than 100 m^2 per gram), >WACKER HDK®, for example. Precipitated silicas are also sometimes added. Even >carbon blacks can provide reinforcement.

Nonreinforcing fillers

Nonreinforcing fillers are needed for bulking up silicone rubbers, e.g. when compounding. They are also added to attain specific properties. Examples of nonreinforcing fillers are:

- >Diatomaceous earth: for reducing the price of compounds
- >Quartz: for reducing the price and providing resistance to certain chemicals
- >Carbon blacks

Additives

The composition of an organic rubber is far more complex than that of a silicone rubber primarily due to the additives used. An end formulation for a silicone rubber is uncomplicated: it can consist of just polymers and fillers.

And the few remaining >additives can be counted on one hand:

Crosslinking chemicals

>Peroxides as well as platinum catalyst systems can be used as crosslinking chemicals[1] for solid silicone rubbers.

[1] The common generic term >crosslinker is misleading here since it is also used to describe short-chain, highly reactive polymers, which are vital for curing. This is why we also refer to >catalysts, although this solely applies to platinum catalysts and not peroxides. The latter are altered by the curing process.

Vulcanization accelerators or retarders, often found in organic rubbers, are not used in silicones.

Plasticizers

Only >plasticizers with a silicone-polymer base are used. Problems inherent in organic plasticizers such as phthalates are thus avoided.

Pigments

Silicone rubbers are inherently transparent and can be made transparent to opaque in nearly all >colors. For more details, see pages 30/31.

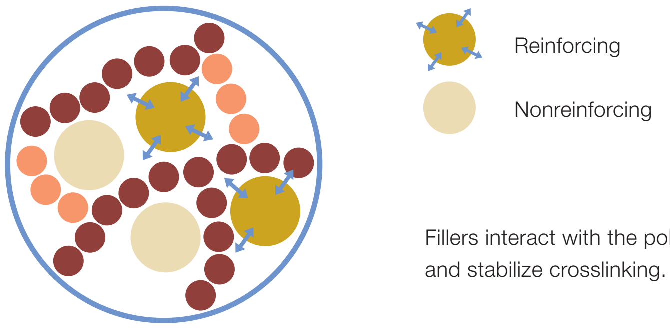
Stabilizers

Unlike organic elastomers, silicones do not require >stabilizers against UV radiation or the like. They are inherently very resistant to extremes of weathering and aging. WACKER offers a range of special stabilizers for stabilizing against hot air, improving chemical and solvent resistance and for avoiding depolymerization processes. For more details, see pages 28/29.

Special additives

Special additives are incorporated into silicone rubbers to optimize the properties required. These can include additives for increasing flame retardancy or for improving the green strength of extruded grades. >Special-purpose grades can also be regarded as additives, when they are mixed with standard grades to attain specific properties. For more details, see pages 28/29.

The role of fillers



Fillers interact with the polymer backbone and stabilize crosslinking.

ENOUGH TO STRENGTHEN THE SOFTEST COMPOUNDS

The uncured rubber compound is viscous and soft. A solid, elastomeric material is obtained by curing, i.e. crosslinking the rubber compound. For the rubbers to cure, polysiloxane chains need to bond together with the help of crosslinking chemicals.

Crosslinking is initiated by crosslinking chemicals, which react with the vinyl groups present in the VMQ and PVMQ polymer chains. The nature of this reaction depends to a large extent on the chemicals' properties: it can be fast or slow, complete or incomplete, more sensitive to temperatures or more resilient to external influences. The filler is not affected by curing. It serves merely to stabilize the backbone formed during curing.

There are two different >curing processes employed: peroxide curing and platinum-catalyzed addition curing. A brief explanation of both is given below.

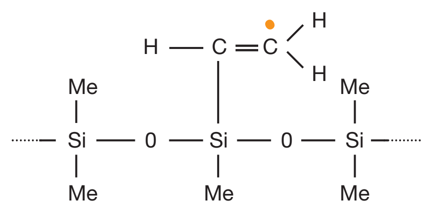
Liquid silicone rubbers[1] are always platinum catalyzed. For solid silicone rubbers, however, either curing system can be employed. WACKER provides suitable crosslinking chemicals for both processes.

We have published a separate brochure containing all the platinum-catalyzed ELASTOSIL® R *plus* grades.

[1] More on this subject can be found in our brochure "The Grades and Properties of ELASTOSIL® LR Liquid Silicone Rubber."

Peroxide curing

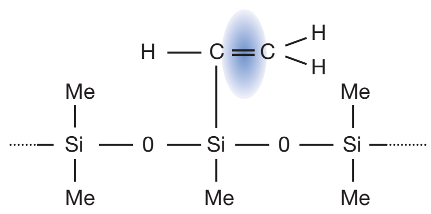
Reactive group on the polymer



The vinyl double bond is reactive.

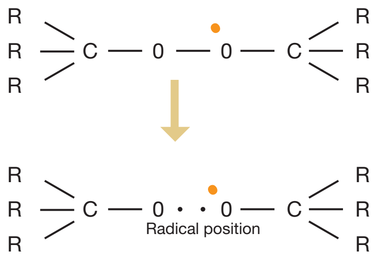
Platinum-catalyzed addition curing

Reactive group on the polymer



The vinyl double bond is reactive.

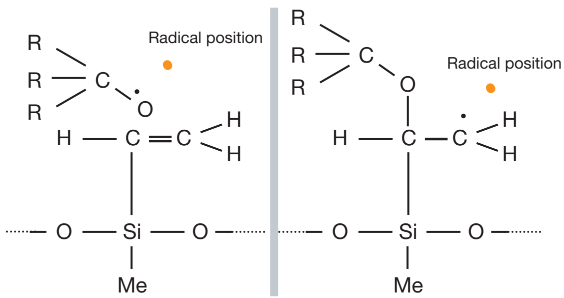
Reactive group



The peroxide group produces an oxygen free radical.

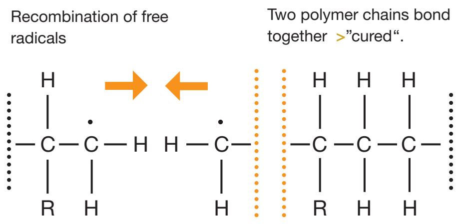
= Radical position

1st stage of the reaction



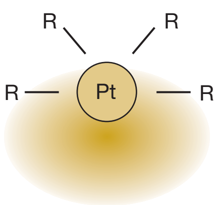
A reactive free radical is formed on the vinyl.

Crosslinking



The free radical attaches itself to another polymer chain and forms a bridge. The free radical chain reaction then continues.

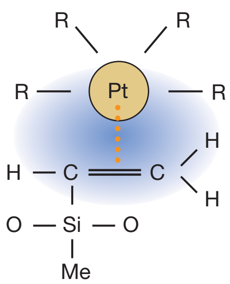
Reactive group



The platinum center has one free coordination site.

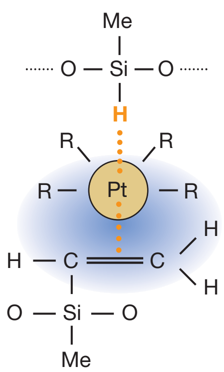
= Low charge density

1st stage of the reaction

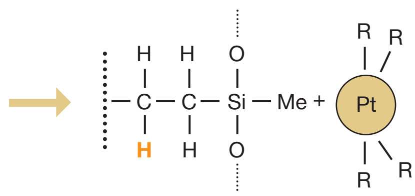


Interaction with the platinum center activates the double bond.

= High charge density



Crosslinking



The vinyl group crosslinks by transforming the double bond, creating a single bond to a polymer chain; in this case, to a crosslinker molecule containing Si-H groups. The catalyst becomes free and is again available for further crosslinking.

THE ALL-ROUNDERS FROM THE 400 RANGE

Peroxide-curing grades and their properties			
			ELASTOSIL® R 401/10
			ELASTOSIL® R 401/20
			ELASTOSIL® R 401/30
			ELASTOSIL® R 401/40
			ELASTOSIL® R 401/50
			ELASTOSIL® R 401/60
			ELASTOSIL® R 401/70
			ELASTOSIL® R 401/80
			ELASTOSIL® R 401/90
Basic characteristics			– Multipurpose grades – Transparent – Shore 20 and 30: opaque – For extrusion and molded articles
Special features			– R 401/20 with 0.8 % Crosslinker E is only recommended for extrusion – Postcured rubbers are suitable for application in pharmaceutical and food-contact sectors
Crosslinker			E, C1, C6
Appearance			Transparent
Density	DIN 53 479 A	[g/cm³]	1.10–1.19
Hardness, Shore A	DIN 53 505		10–90
Tensile strength	DIN 53 504-S1	[N/mm²]	6.5–11.8
Elongation at break	DIN 53 504-S1	[%]	300–1.100
Tear strength	ASTM D 624 B	[N/mm]	14–26
Rebound resilience	DIN 53 512	[%]	40–60
Compression set (22 h/175 °C)	DIN 53 517	[%]	12–60

These are the advantages of the 400 range:

- They are all-round products.
- They are well known and respected.
- They have been continually developed and are fully optimized.
- Postcured rubbers are suitable for application in the pharmaceutical and medical sectors.
- They can be easily mixed to produce intermediate Shore hardnesses.
- Individual grades are also available in our standard product range[1]: ELASTOSIL® R 401/30–80 S, ELASTOSIL® R 402/60 S, ELASTOSIL® R 402/75 S and ELASTOSIL® R 420/40–70 S.
- See the special-purpose grades on page 20.

[1] Standard grades can be recognized by the suffix “S” e.g. ELASTOSIL® R 401/30 S.

ELASTOSIL® R 402/60	ELASTOSIL® R 411/50	ELASTOSIL® R 420/30
ELASTOSIL® R 402/65	ELASTOSIL® R 411/55	ELASTOSIL® R 420/40
ELASTOSIL® R 402/75	ELASTOSIL® R 411/60	ELASTOSIL® R 420/50
	ELASTOSIL® R 411/70	ELASTOSIL® R 420/60
		ELASTOSIL® R 420/70
– High-green-strength grades – For extrusion – Especially for precision profiles and dimensionally accurate hoses	– Grades with good mechanical properties between R 401 and R 420 – Transparent – For extrusion and molded articles	– High-strength grades with high elongation at break – Highly transparent – For extrusion and molded articles
– R 402/60: high strength (e.g. for medical tubing) – Postcured rubbers are suitable for application in pharmaceutical and food-contact sectors	– Postcured rubbers are suitable for application in pharmaceutical and food-contact sectors	
E	E, C1, C6	E, C1, C6
Transparent	Transparent	Transparent
1.17–1.19	1.13–1.17	1.09–1.19
60–75	50–70	30–70
10.5–11.0	9.0–11.0	8.0
450–530	450–700	550–1,000
22–27	31–40	25–40
51–55	50–55	45–55
30–40	15–35	15–40

This table shows only the minimum and maximum values for each group of grades comprising more than two products. For more precise information, please ask for the individual product data sheets.

THE CABLE SPECIALISTS FROM THE 500 RANGE

Peroxide-curing grades and their properties			
			ELASTOSIL® R 501/65
			ELASTOSIL® R 501/75
Basic characteristics			– Multipurpose cable grades – High strength – Good mechanical properties – Insulators
Special features			– High radiation resistance (use in nuclear power stations) – R 501/75 is flame retardant
Crosslinker			E
Appearance			Translucent
Density	DIN 53 479 A	[g/cm³]	1.20/1.23
Hardness, Shore A	DIN 53 505		62/70
Tensile strength	DIN 53 504-S1	[N/mm²]	10.0/8.0
Elongation at break	DIN 53 504-S1	[%]	450/450
Tear strength	ASTM D 624 B	[N/mm]	19/30
Rebound resilience	DIN 53 512	[%]	
Compression set (22 h/175 °C)	DIN 53 517	[%]	
Limiting oxygen index (LOI)	ASTM D 2863		–/30
Volume resistivity	VDE 0303	[Ω · cm]	$10^{16}/10^{16}$
Dielectric strength	VDE 0303	[kV/mm]	20
Dielectric constant (50 Hz, 25 °C)	VDE 0303		2.7/2.9
Dissipation factor tan δ (50 Hz, 25 °C)	VDE 0303		$30 \cdot 10^{-4}/60 \cdot 10^{-4}$
Low calorific value	VDE 0303	[kJ/g]	16.9/16.2

These are the advantages of the 500 range:

- They are ideal for >cables, hoses and electrical applications.
- This range offers everything - from standard to highly-specialized grades.
- They comply with various fire protection and safety standards (Integrity Safety).
- They have very good electrical and mechanical/thermal properties.
- They permit high processing speeds.
- Individual grades are also available in our standard product range[1]: ELASTOSIL® R 501/65 S, ELASTOSIL® R 502/70, ELASTOSIL® R 502/80 S, ELASTOSIL® R 509/65 S and ELASTOSIL® R 510/70 S.
- Platinum-catalyzed grades are also available. These can be found on page 23 ff.

[1] Standard grades can be recognized by the suffix "S."

ELASTOSIL® R 502/70	ELASTOSIL® R 502/75	ELASTOSIL® R 502/80	ELASTOSIL® R 503/75
– Solvent-resistant and heat-resistant grade – Insulators	– Ceramifying, ash-resistant grade – Good mechanical properties – Insulators	– High-strength grade with increased resistance to oil and fuel – Very good dielectric properties – Insulators	– Ceramifying, ash-resistant grade – Good mechanical properties – Insulators
– Conform to UL 1581, class 22	– Form a ceramic layer in a fire – Suitable for safety cables according to DIN 4 102, Part 12, UL 2 196		– Circuit integrity up to 1,100 °C – DIN 4 102, UL 2196, BS 6387-CW
E	E	E	E
Translucent	White	Translucent	Translucent
1.20	1.27	1.21	1.27
70	75	80	75
10.0	8.0	9.0	9.0
450	300	250	430
22	15	19	14
50		50	
10^{16}	10^{15}	10^{15}	10^{15}
20	20	20	20
2.8	3.1	2.8	3.1
$40 \cdot 10^{-4}$	$80 \cdot 10^{-4}$	$40 \cdot 10^{-4}$	$80 \cdot 10^{-4}$
16.3	14.4	16.0	14.2

ELASTOSIL® R 509/65	ELASTOSIL® R 510/70	ELASTOSIL® R 562/80	ELASTOSIL® R 570/50
			ELASTOSIL® R 570/60
			ELASTOSIL® R 570/70
– Heat- and oil-resistant grade – Insulators	– Inexpensive cable grade – Insulators	– High-strength grade for high-voltage applications – Insulators	– Electrically conductive grades – For molded articles – Conductive core for ignition cables (CV tube vulcanization) – Conductors
– Conform to UL 1581, class 22			– For ignition and measuring cables etc. – 2.2 % Batch SB-2 can be added for flame retardancy with an LOI from 23 to over 32!
E, C1	E, C1	C1, C6	C1, C6
Beige	Translucent	Black	Black
1.31	1.22	1.20	1.10–1.18
68	70	78	45–75
8.0	10.0	8.0	6.0–9.0
300	350	300	200–400
15	20	15	12–14
	40–60		40–60
			25–50
10^{15}	$> 10^{15}$	$> 10^{16}$	
20		30	
3.1	2.9	2.8	
$80 \cdot 10^{-4}$	$50 \cdot 10^{-4}$	$30 \cdot 10^{-4}$	
		14.4	

This table shows only the minimum and maximum values for each group of grades comprising more than two products. For more precise information, please ask for the individual product data sheets.

The perfect coordination between the extruder and the heating tunnel permits high extrusion rates without compromising from the high quality of the articles.

THE APPLICATION-OPTIMIZED GRADES

Peroxide-curing grades and their properties

			ELASTOSIL® R 101/25 ELASTOSIL® R 101/35 ELASTOSIL® R 101/45 ELASTOSIL® R 101/50
Basic characteristics			– Grades with low Shore hardness – For compression-molded articles
Special features			– Inert fillers can be added to produce a low-cost product
Crosslinker			C1, C6
Appearance			Transparent
Density	DIN 53 479 A	[g/cm³]	1.05–1.14
Hardness, Shore A	DIN 53 505		20–55
Tensile strength	DIN 53 504-S1	[N/mm²]	6.0–12.0
Elongation at break	DIN 53 504-S1	[%]	500–1,300
Tear strength	ASTM D 624 B	[N/mm]	15–30
Rebound resilience	DIN 53 512	[%]	50–70
Compression set, 22 h/175 °C	DIN 53 517	[%]	10–30

These are the advantages of the application-optimized grades:

- They are adapted to a wide range of applications.
- They can be blended and filled with standard grades in almost any proportion.
- Individual grades are also available in our standard product range[1]: R 701/40 S, R 701/80 S, R 861/60 S, R 861/70 S.

[1] Standard grades can be recognized by the suffix "S."

ELASTOSIL® R 701/40	ELASTOSIL® R 750/40	ELASTOSIL® R 755/40
ELASTOSIL® R 701/50	ELASTOSIL® R 750/50	ELASTOSIL® R 755/60
ELASTOSIL® R 701/60	ELASTOSIL® R 750/60	
ELASTOSIL® R 701/70		
ELASTOSIL® R 701/80		
– Non-postcuring (n.p.c.) grades – Oil-resistant – Reversion stability – For compression-molded articles – R 701/80 also suitable for extrusion	– Grades resistant to high temperatures – Resistant to dry heat and oxygen – For extrusion and molded articles	– Reversion stable grades – For molded articles
– For applications involving oil or high temperatures – E.g. for seals and rollers	– Can be made heat resistant using stabilizers: Up to 300 °C for 7 days	– R 755/40 for spin casting plates – R 755/60 for applications in contact with steam
C1, C6	E, C1, C6	C1
Opaque, beige	Transparent	White
1.08–1.42	1.11–1.18	1.09–1.21
37–85	35–65	38–62
6.0–10.0	8.0–12.0	3,5–8,0
200–700	400–900	250–400
10–20	15–35	7–18
45–70	40–55	45–70
10–20	10–20	10–30

ELASTOSIL® R 760/60	ELASTOSIL® R 780/80	ELASTOSIL® R 861/60*
ELASTOSIL® R 760/70		ELASTOSIL® R 861/70*
		ELASTOSIL® R 861/80*
		* Values determined on non-postcured test specimens
– High-green-strength grades – For extrusion and calendering	– Masterbatch for compounding inert fillers	– Highly flexible, chemical-resistant and solvent-resistant non-postcuring grades – Opaque – For extrusion and molded articles
– For vertical extrusion, complete profiles and calendered parts – Comply to the FDA requirements for food-contact applications	– Can be easily blended	– Postcured rubbers are suitable for application in food-contact sectors
E	E, C1	E, C1
Translucent	Beige	Translucent
1.14–1.10	1.74	1.13–1.21
55–75	80	55–80
9.0–11.0	4.0	6.0–10.0
400–500	60	300–500
18–25	7	15–17
50–55	55	45–65
25–45	15	10–35

This table shows only the minimum and maximum values for each group of grades comprising more than two products. For more precise information, please ask for the individual product data sheets.

WACKER's applications laboratories are ideally equipped for the fine tuning of ELASTOSIL® R solid silicone rubber.

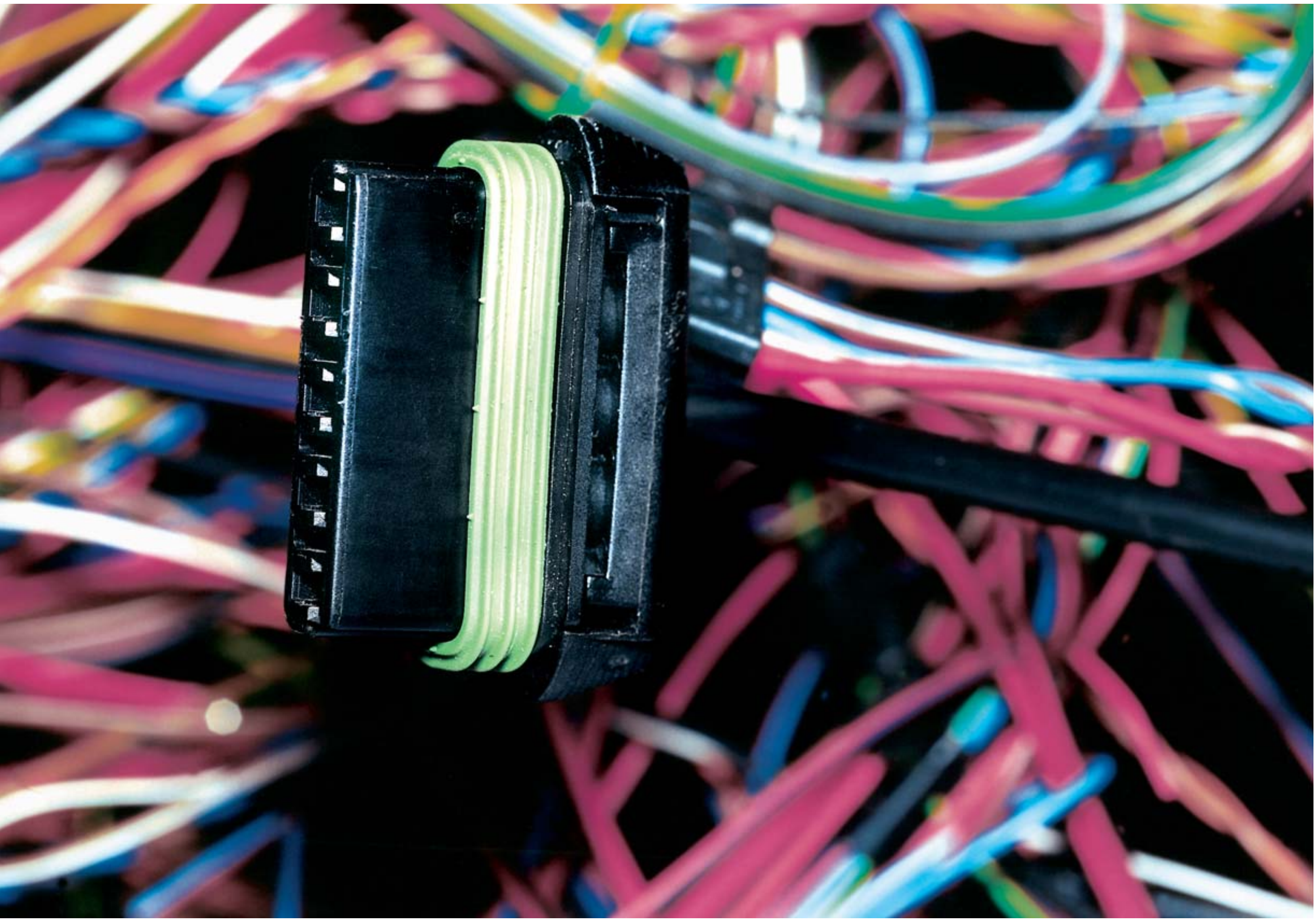
THE SPECIAL-PURPOSE GRADES FOR SPECIFIC APPLICATIONS

Peroxide-curing special-purpose grades

Designation	Grade	Application	Special features
Radio-opaque grade	ELASTOSIL® R 440/60	Contains barium sulfate in accordance with DAB 10	
Low-temperature grade	ELASTOSIL® R 490/55	For extrusion and molded articles	Consists of >phenylmethyl silicone rubber, resistant to X-rays and gamma radiation See ELASTOSIL® R 501 on page 12 ff.
Special grade	ELASTOSIL® R 710/50	For manufacturing self-welding tapes	
Low-modulus grade	ELASTOSIL® R 752/50	For damping elements	With excellent damping properties
Oil-resistant grade	ELASTOSIL® R 805/75	For shaft seals etc.	Very resistant to oil, very good compression set
Roller grade	ELASTOSIL® R 830	For photocopier and transport rollers	Low compression set Excellent reversion stability
Heat-conductive grade	ELASTOSIL® R 840	For roll coverings and compression-molded articles, also used for extrusion articles	

These are the advantages of the special-purpose grades:

– The ELASTOSIL® R >special-purpose grades have been blended for strictly defined special applications, whereas application-optimized grades are intended as optimum formulations for common applications.



ELASTOSIL® R solid silicone rubbers can be ideally compounded to suit almost any application. If your demands are tougher, our special-purpose grades are on hand.

PLATINUM-CATALYZED GRADES FOR ALL NEEDS: ELASTOSIL® R *plus*

When compared to peroxide-curing silicone rubbers, platinum-catalyzed addition-curing grades offer a wealth of advantages.

These are the advantages of the platinum-catalyzed grades:

- They do not liberate any crosslinker by-products and therefore produce no toxic residue.
- They offer excellent reversion stability, which has a positive effect on the compression set, transparency etc.
- They cure up to 50 % faster than conventional rubbers making them specially suitable for thick-walled products.
- They have good to very good mechanical properties.
- Their dry surfaces ensure excellent processing qualities.
- They are not inhibited by oxygen.

Please note:

- Avoid contaminating the grades with amines, sulfur etc. during processing, as these inhibit the platinum catalyst
- Try to avoid contact with peroxides or peroxide by-products while processing and especially while postcuring

THE PLATINUM-CATALYZED GRADES

Platinum-catalyzed addition-curing grades and their properties			for extrusion
			ELASTOSIL® R *plus* 4110/40
			ELASTOSIL® R *plus* 4110/50
			ELASTOSIL® R *plus* 4110/60
			ELASTOSIL® R *plus* 4110/70
			ELASTOSIL® R *plus* 4110/80
Basic characteristics			– 1-part, extrusion grades – Transparent – 1-part system for extrusion
Special features			– BfR/FDA-compliant
Appearance			Transparent
Density	DIN 53 479 A	[g/cm^3]	1.10–1.22
Hardness, Shore A	DIN 53 505		47–85
Tensile strength	DIN 53 504-S1	[N/mm^2]	7.0–11.0
Elongation at break	DIN 53 504-S1	[%]	300–900
Tear strength	ASTM D 624 B	[N/mm]	18–45
Rebound resilience	DIN 53 512	[%]	45–65
Compression set, 22 h/175 °C	DIN 53 517	[%]	
Volume resistivity	VDE 0303	[Ω · cm]	
Dielectric strength	VDE 0303	[kV/mm]	
Dielectric constant (50 Hz, 25 °C)	VDE 0303		
Dissipation factor tan δ (50 Hz, 25 °C)	VDE 0303		

		for molded articles	
ELASTOSIL® R *plus* 4305/30 ELASTOSIL® R *plus* 4305/40 ELASTOSIL® R *plus* 4305/50 ELASTOSIL® R *plus* 4305/60 ELASTOSIL® R *plus* 4305/70 ELASTOSIL® R *plus* 4305/80 ELASTOSIL® R *plus* 4305/90	ELASTOSIL® R *plus* 4360/60	ELASTOSIL® R *plus* 4000/40 ELASTOSIL® R *plus* 4000/50 ELASTOSIL® R *plus* 4000/60 ELASTOSIL® R *plus* 4000/70	ELASTOSIL® R *plus* 4001/30 ELASTOSIL® R *plus* 4001/40 ELASTOSIL® R *plus* 4001/50 ELASTOSIL® R *plus* 4001/60 ELASTOSIL® R *plus* 4001/80 ELASTOSIL® R *plus* 4001/90
– High-strenght extrusion grades in batch technology – Highly transparent – Pseudo-1-part system “A+PT 1” for extrusion	– Flexible extrusion grade in batch technology – Translucent – Pseudo-1-part system “A+PT 1” for extrusion	– Grades with very good mechanical properties – Highly transparent – 100 : 1.5-system “A+PT 2” for molding applications	– 1-part grades – Transparent – 1-part system for molded articles
– As with peroxide-curing grades, the amount of Crosslinker Batch PT 1 can be varied – This makes it a very flexible system – BfR/FDA-compliant	– As with peroxide-curing grade, the amount of Crosslinker Batch PT 1 can be varied – This makes it a very flexible system – BfR/FDA-compliant	– Postcured rubbers are suitable for application in pharmaceutical and food-contact sectors	– Platinum-catalyzed alternatives to ELASTOSIL® R 401 – Postcured rubbers are suitable for application in pharmaceutical and food-contact sectors
Transparent	Translucent	Transparent	Transparent
1.07–1.24	1.13	1.09–1.18	1.11–1.18
30–90	60	35–75	30–90
7.0–12.0	8.0	8.0–13.0	7.0–10.0
250–1,300	450	450–1,300	300–1.100
15–45	27	45–60	17–34
50–70	60	50–60	32–62
	15		19–35

This table shows only the minimum and maximum values for each group of grades comprising more than two products. For more precise information, please ask for the individual product data sheets.

ELASTOSIL® R *plus* 4020/60	ELASTOSIL® R *plus* 4070/60*	ELASTOSIL® R *plus* 4806/20	ELASTOSIL® R *plus* 4846/30
	* Values determined on non-postcured		
	test specimens		
– Notch-resistant, 1-part grade – Transparent – 1-part system for molded articles	– Self-adhesive, 1-part grade – Transparent – 1-part system for molded articles	– Translucent – Oil bleeding – For auto-lubricating molded parts	– Translucent – High tear, self bleeding – For auto-lubricating molded parts
– Platinum-catalyzed alternative to ELASTOSIL® R 420 – BfR/FDA-compliant			
Transparent	Transparent	Translucent	Translucent
1.15	1.16–1.20	1.04	1.11
60	60	20	30
11.4	10.0	6.0	10.0
850	850	900	1.000
45	45	9.0	28
50	42	65	50
37	65	15	15

for cable and electronical applications[1]			
ELASTOSIL® R *plus* 533/60 A+B	ELASTOSIL® R *plus* 543/70 A+B	ELASTOSIL® R *plus* 573/50 A+B ELASTOSIL® R *plus* 573/70 A+B	
– High-strength grade – For highly flexible and rigid cable insulations – Insulators – 50 : 50 system for cable and hose applications	– Ceramifying, ash-resistant grade – For safety cables – Insulators – In case of fire, self-ceramifying 50 : 50 system for cable applications	– Conductive grades – Pressureless curing – Conductors – 50 : 50 system for extrusion	**Basic characteristics**
– LOI = 26 – LOI = up to 32 with 2.2 % Batch SB-2	– Platinum-catalyzed alternative to ELASTOSIL® R 502/75 with even better mechanical properties – See pages 12/13 ff.	– For shielding electrical fields – Note that the conductivity shows longitudinal/transversal anisotropic characteristics	**Special features**
Translucent	White	Black	**Appearance**
1.14–1.18	1.27–1.31	1.11–1.19	**Density**
63–73	68–78	45–75	**Hardness, Shore A**
9.0	8.0	6.0	**Tensile strength**
600	500	200–350	**Elongation at break**
45	20–40	12–16	**Tear strength**
62	45–65	45–55	**Rebound resilience**
25–30	–	25–35	**Compression set, 22 h/175 °C**
$> 10^{16}$	10^{15}	8–12/1.5–2.5	**Volume resistivity**
20	20		**Dielectric strength**
3.1	3.1		**Dielectric constant (50 Hz, 25 °C)**
$25–10^{-4}$	$80 \cdot 10^{-4}$		**Dissipation factor tan δ (50 Hz, 25 °C)**

This table shows only the minimum and maximum values for each group of grades comprising more than two products. For more precise information, please ask for the individual product data sheets.

[1] Also for extruding hoses and profiles

Because platinum-catalyzed ELASTOSIL® R *plus* solid silicone rubbers cure rapidly, metering must be fast: ideally with WACKER pellets.

ANYTHING ELSE?

The right additives and auxiliaries enable you to blend ELASTOSIL® R solid silicone rubbers exactly to your requirements and wishes. A selection of examples is given below, but if you would like to find out more about WACKER's product range, contact our Technical Service team or visit us on the internet.

Crosslinkers

Please note: the >crosslinkers listed below must not come into contact with platinum-catalyzed systems.

- Organic >peroxides
- ELASTOSIL® AUX Crosslinker E: 50% paste of bis-(2.4-dichlorobenzoyl-)peroxide
- ELASTOSIL® AUX Crosslinker C1: dicumyl peroxide (95 %), crystalline powder
- ELASTOSIL® AUX Crosslinker C6: 45 % paste of 2.5-bis-(t-butylperoxy-) 2.5-dimethylhexane in silicone rubber
- ELASTOSIL® AUX Crosslinker Combinations G1-G9: for special applications. Please ask us for more details.

Fillers

- Reinforcing >fillers with very high BET surface areas
- Fumed silicas: >WACKER HDK®.
- Hydrophobic silicas: >WACKER HDK® H15, >WACKER HDK® H20, >WACKER HDK® H30

Stabilizers

ELASTOSIL® AUX Crosslinker R: for improving >oil resistance, >compression set and >reversion stability. The stabilizer prevents by-products from bleeding, which could occur with the addition of Crosslinker E.

Heat Stabilizers or Hot-Air Stabilizers ELASTOSIL® AUX H0–H6[1]: usually oxides of polyvalent elements, e.g. iron oxide or special carbon black. They are used for stabilizing against dry heat in the presence of oxygen.

Mastication aids

ELASTOSIL® AUX >Mastication Aid 4 improves the compounding and plasticizing properties on the roll mill and helps to prevent the rubber from crepe-hardening.

Mold release agents

Both >mold release agents improve mold release properties during compression and injection molding etc.

- ELASTOSIL® AUX Mold Release Agent 32: detergent to spray on the mold
- ELASTOSIL® AUX Mold Release Agent A: a paste for compounding

ELASTOSIL® AUX Batch SB-2

To improve flame retardancy, we recommend adding 2.2 % Batch SB-2.

ELASTOSIL® AUX Blowing Agent MTB

Nontoxic >blowing agent batch for manufacturing extruded, open-cell foam articles. Important: the batch is not suitable for platinum-catalyzed addition-curing solid silicone rubbers.

[1] For extrusion with Crosslinker E, use Pigment Paste PT RAL 9017 instead of Stabilizer H3.

ELASTOSIL® AUX Blowing Agent XTB
Nontoxic blowing agent batch for manufacturing closed-cell foam articles. Suitable for extrusion and can also be used for compression-molded articles.

ELASTOSIL® BTB Systems
Nontoxic blowing systems for mixed-cell foams.

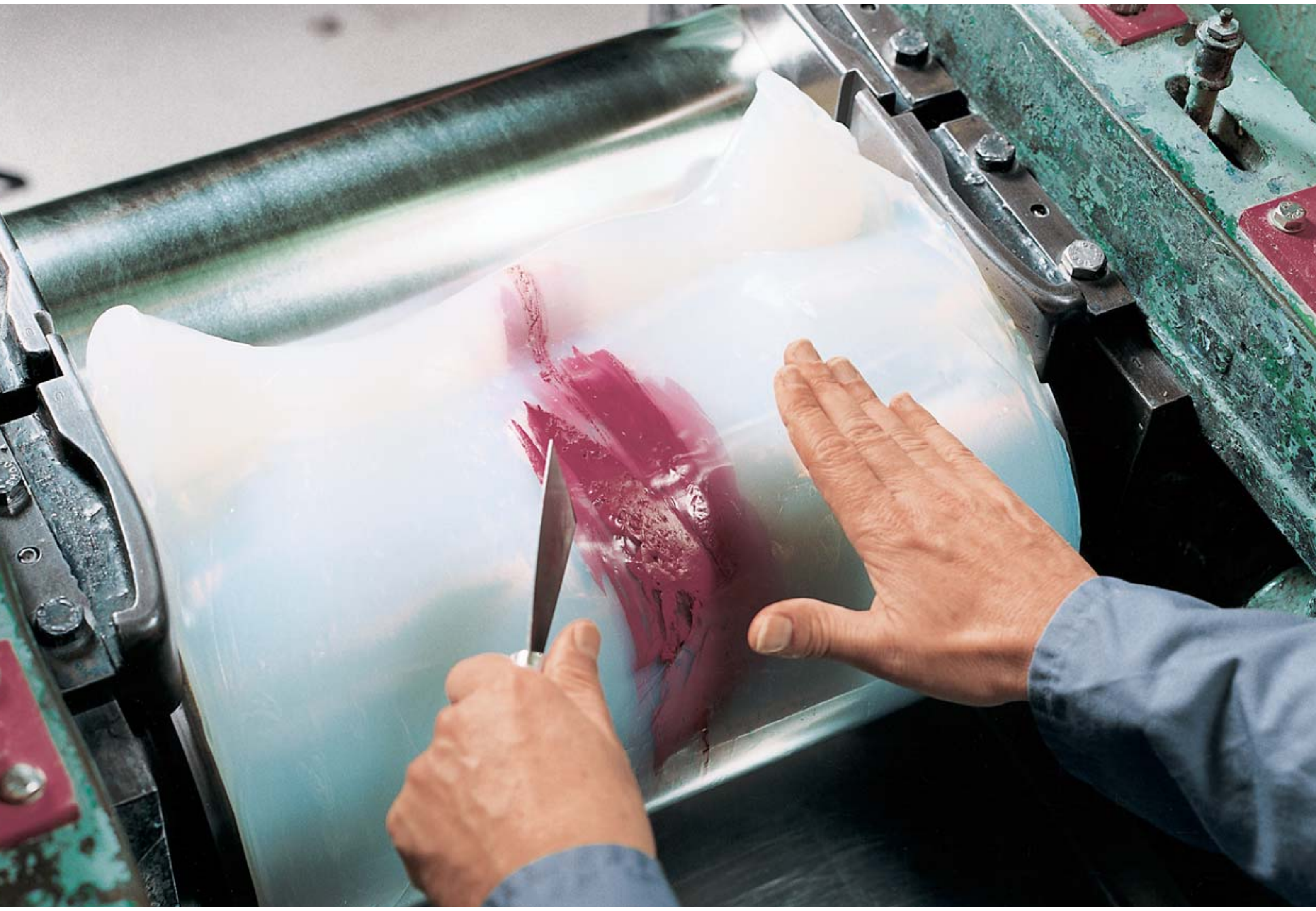
Microwave Batches
ELASTOSIL® R grades can also be made >microwave-active. Please contact us for more details.

Hot-air stabilizers

Stabilizer	Appearance	BfR	FDA	Percentage added
H0	Milky white	–	+	2
H1	Reddish brown	+	+	3
H2	Beige	–	–	2
H3	Jet black	–	+	1.5
H4	Reddish brown	+	+	3
H6	Beige	–	–	3
H6F	Beige	+	+	3

Black stabilizers are better suited for continuous high temperatures. White and red stabilizers are also used. For continuous high service temperatures, white stabilizers are more efficient than red ones. More information on this subject can be found in the “Processing ELASTOSIL® R Solid Silicone Rubber” brochure.

SET THE TONE



ELASTOSIL® Pigment Pastes PT are perfectly matched to WACKER's rubber bases and can be incorporated quickly and easily on the roll mill.

ELASTOSIL® Pigment Pastes PT can be mixed together in almost any combination you like. They can be either identical or similar to RAL colors and are nearly all suitable for food-contact applications.

All >colors are available as ELASTOSIL® Color Cords FS or as ELASTOSIL® Color Pellets FG.

Please note:
ELASTOSIL® Pigment Paste PT 9005 is not suitable for use with Crosslinker E. You have the option of using 9017 or 9011 instead.

ELASTOSIL® pigment additives

Name of color	Similar to RAL [1]	BfR [2]	FDA [2]	Color
Yellow	1016	+	+ [3]	
Yellow	1021	+	+ [3]	
Orange	2004	+	–	
Red	3000	+	+ [3]	
Reddish brown	3013	+	+	
Violet	4001	+	–	
Ultramarine blue	5002	+	+	
Dark blue	5010	+	+	
Pale blue	5015	+	–	
Green	6017	+	+	
Green	6032	+	+ [4]	
Gray	7040	+	–	
Light brown	8003	+	–	
Dark brown	8015	+	–	
Jet black	9005	–	–	
Jet black	9005 F	+	+	
White aluminum (silver)	9006	+	+	
White	9010	+	+	
Black	9011	–	–	
Black	9017	+	+	

[1] The RAL values in the table are only a guideline.
[2] See section on food contact on page 40/41.
[3] For additions up to max. 1 %.
[4] For additions up to max. 4 %.

We do not guarantee conformity to the above-mentioned regulations, since the requirements can change. For the latest data please ask our Technical Service.

PRIMERS AND COATINGS UNDER AND OVER

>Primers and >adhesives are necessary to improve the adhesion or bonding of silicones to any substrate. This substrate may be a metal part, a plastic or even another silicone.

>Coatings and overmoldings are necessary to achieve certain surfaces on silicones or for coating with silicones. Occasionally, coatings can also be used as primers or adhesives.

To obtain a defined layer thickness, we recommend applying the primer with a doctor blade.

Primers, adhesives and coatings – properties and applications

Primers	Properties	Applications
ELASTOSIL® Adhesive Primer 90	Peroxide-curing rubber with self-adhesive properties	E.g. for roll coatings
Primer G 3242 Primer G 3243 Primer G 3244 Primer G 3246	Colorless, low viscosity Colorless, high viscosity Red, medium viscosity Colorless, medium viscosity	For bonding silicone to metal, e.g. for rolls, sealing elements, shaft seals, rubber overmoldings
Primer G 718 Primer G 719	For smooth substrates For porous/absorbent substrates	For bonding silicone to glass, ceramics or fabrics
Primer G 790		Used e.g. for preliminary priming to prevent corrosion when bonding metal and silicone parts using room-temperature-vulcanizing, one-part systems (RTV-1 adhesives)
Primer G 795 Primer G 800		It primarily serves to promote adhesion of room-temperature-vulcanizing, two-part systems (RTV-2) to aluminum, plywood etc. This primer is also suitable for solid silicone rubbers, particularly for platinum-catalyzed grades.
Adhesives	**Properties**	**Applications**
ELASTOSIL® E 41 ELASTOSIL® E 43	Lower viscosity Higher viscosity	Room-temperature-vulcanizing, one-part silicone adhesive (RTV-1)
ELASTOSIL® R 3112 A+B	Two-part adhesives (99 : 1)	For bonding silicones to silicones at high temperature
ELASTOSIL® LR 766x A+B	Two-part pourable compounds	Pourable or spreadable liquid silicone rubbers, which can also be used for bonding. Highly transparent
ELASTOSIL® RD 3151 ELASTOSIL® LR 3153	These coatings can also be used as any adhesives.	See “Coatings”
Coatings	**Properties**	**Applications**
ELASTOSIL® RD 3151	Dry hand, excellent abrasion resistance!	Coating dispersion with excellent adhesion to textiles as well as silicones and crosslinked polyethylene surfaces (PEX)
ELASTOSIL® LR 3153 A+B	The dispersion can also be used as an adhesive for bonding silicones to the materials mentioned on the right.	Liquid silicone dispersion with excellent adhesion to textile fibers such as braided cables as well as crosslinked polyethylene surfaces (PEX)
Primer G 3242 Primer G 3243 Primer G 3244 Primer G 3246	These primers can also be used as coatings.	See “Primers”
ELASTOSIL® LR 766x A+B	These adhesives can also be used as coatings.	See “Adhesives”

LIFE IS NOWHERE NEAR AS TOUGH AS OUR TEST METHODS

On the following pages we have outlined the different properties of ELASTOSIL® R solid silicone rubbers based on their test methods. We have divided the properties into three categories: physical, physiological and resistance.[1]

>Density

- According to DIN 53 479 A
- Determined according to the buoyancy method
- Usually ranges from 1.08–1.22 g/cm³ with fumed or precipitated silica used as a filler
- Can reach 1.75 g/cm³ with appropriate amounts of inert fillers added
  This improves swelling resistance, for example.

>Hardness

- According to DIN 53 505 and DIN 53 519
- Measured in >Shore A or in >IRHD-units. Note: The results can vary, particularly with harder grades!
- Values range from 15–90° Shore A.
- Please note: Shore hardness measurements have wide tolerances: there can often be a deviation (of up to 3 points) between suppliers' and customers' measurements!

>Tensile strength and >elongation at break

- According to DIN 53 504
- Tested on an S1 dumbbell. Different values are obtained when smaller S2 and S3 test specimens are used.
- Tensile strength 5–11 N/mm²
- Elongation at break 100–900 %
- The following grades exhibit these properties:
  ELASTOSIL® R 401
  ELASTOSIL® R 411
  ELASTOSIL® R 501
  ELASTOSIL® R *plus* 4000 and 4020

>Tear strength or notch resistance

- Predominantly measured according to ASTM D 624 B (Crescent)
- Values between 20 and 50 N/mm
- Acccording to ISO 34-1 Method B-b (Graves) up to 30 % lower values
- According to ISO 34-1 Method A (Trousers) up to 50 % lower values
- Particularly suitable are platinum-catalyzed solid silicone rubbers, for example:
  ELASTOSIL® R *plus* 4020
  ELASTOSIL® R *plus* 4305
- or the peroxide grades:
  ELASTOSIL® R 402/60
  ELASTOSIL® R 411
  ELASTOSIL® R 420
  ELASTOSIL® R 562/80

>Compression set

- According to DIN 53 517, or ASTM D 395
- Tested at 175 °C for over 22 hours, harsher testing conditions than are usual for organic elastomers
- Usually between 15 and 50 %
- Indication of the recovery of the rubber and, to a limited extent, its heat resistance
- Non-postcuring grades, such as ELASTOSIL® R 701 and ELASTOSIL® R 861, are especially good. These grades have an inherently low compression set and do not require postcuring.

[1] Process-specific properties can be found in the brochure "Processing ELASTOSIL® R Solid Silicone Rubber", please ask us for it.

>Rebound resilience

- According to DIN 53 512
- Measured using 12-mm thick test specimens and determined as the ratio of the >rebound of a pendulum to its original height
- Typical values 25–65 %
- Indication of the "snap" of rubber
- Grades, such as ELASTOSIL® R 861, are particularly good.

>Abrasion resistance

- According to DIN 53 516
- Silicones do not generally have good abrasion resistance.
- This can be improved using ELASTOSIL® RD 3151 coating material.

>Gas permeability

- According to DIN 53 536
- Very high, in contrast to other elastomers
- Permeability to air is 30 times that of natural rubber and 400 times that of butyl rubber.
- Typical value of a 50 Shore A grade for air at 20 °C or 80 °C: 570 or 1330 $cm^3 \cdot mm \cdot m^2 \cdot h^{-1} \cdot bar^{-1}$.
- Disadvantage with gas containers, advantage with contact lenses, fabric coatings and medical applications
- Organic elastomers show similar behavior to silicone at high temperatures.

Gas permeability

Gas	Relative permeability at 20 °C
Air	100
Steam	190
Oxygen	170
Nitrogen	80
Carbon dioxide	1,000
Ethylene	390

Tear strength of ELASTOSIL® R

Grade	Crosslinker	ASTM 624 B	DIN 53 515	DIN 53 507 A
ELASTOSIL® R 401/60	C 1	20	18	12
ELASTOSIL® R 420/60	C 1	39	36	21
ELASTOSIL® R *plus* 4000/60	PT 2	47	40	26

A LIGHTER IS ALL YOU NEED FOR THE FLAME-RETARDANCY TEST

Silicone rubber can easily be modified for flame retardancy. And if the material does catch fire, it forms a white, ceramifying silicon dioxide ash that acts as an insulator. This remarkable property is particularly useful for safety cables.

Thermal properties

- Mechanical properties of silicones are determined at 23–25 °C.
- Unlike organic elastomers, the properties do not vary greatly over wide temperature ranges.
- Service temperatures are usually between –30 and +200 °C.
- Embrittlement sets in at very low temperatures.
- At very high temperatures, thermal aging causes gradual hardening.
- These grades are particularly good: ELASTOSIL® R 490/55 (very resistant to low temperatures) ELASTOSIL® R 701 and R 750 (very resistant to hot air) ELASTOSIL® R 755/40 (very resistant to hot air)

Thermal conductivity and specific heat

- DIN 52 612 depends on type and amount of filler.
- Generally poor >thermal conductivity
- Average at 100 °C: 0.2–0.3 $W \cdot m^{-1} \cdot K^{-1}$
- Special thermally conductive compounds achieve values of 0.8–1.2 $W \cdot m^{-1} \cdot K^{-1}$.
- Grades, such as ELASTOSIL® R 840, are particularly effective.
- >Specific heat: approx. 1.25 $kJ \cdot kg^{-1} \cdot K^{-1}$

Coefficient of linear thermal expansion or shrinkage

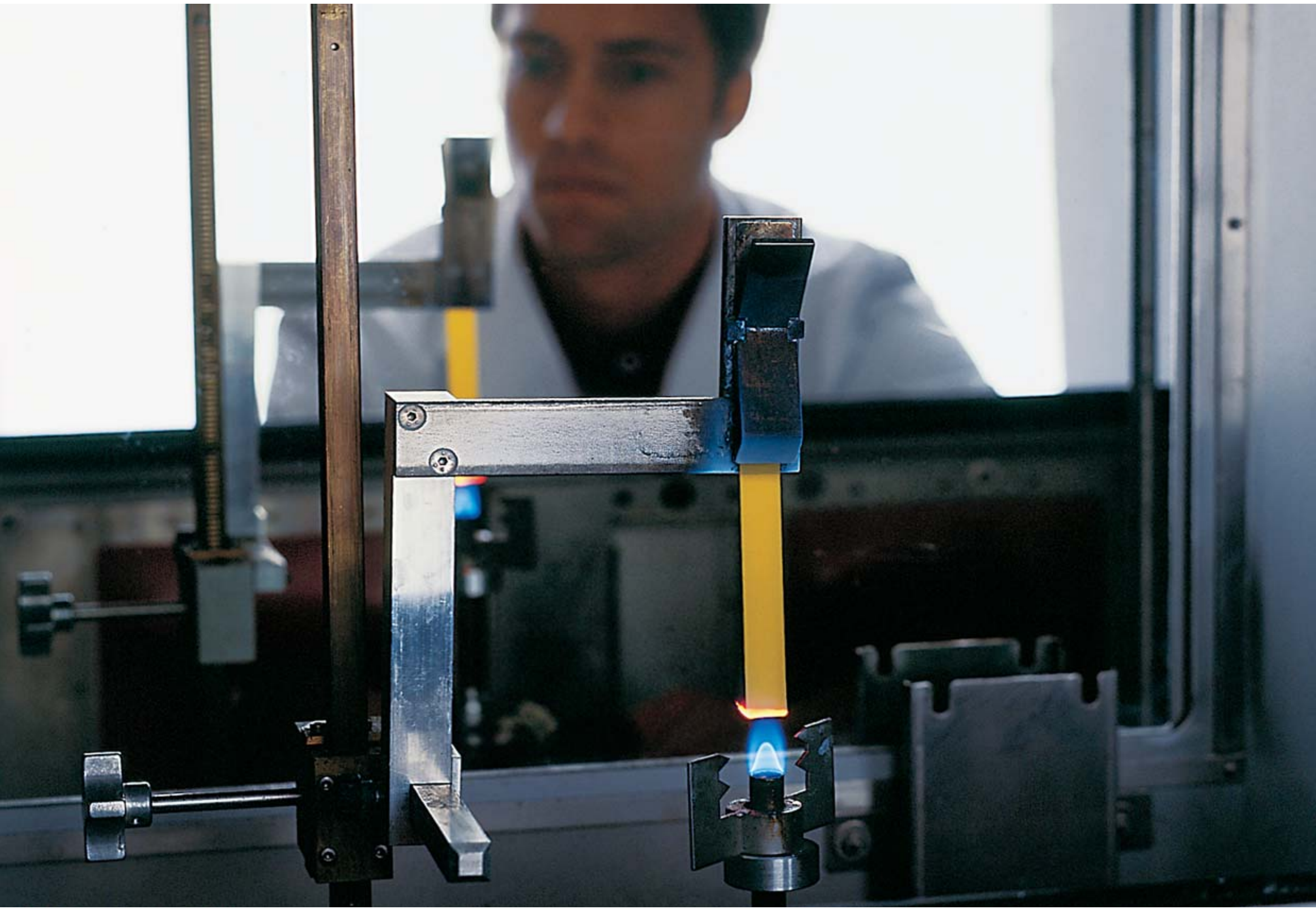
- The higher the filler content or density, the lower the >coefficient of linear thermal expansion
- Depends to a large extent on grade, plasticizer, filler etc.
- Typical values $2–4 \cdot 10^{-4} \cdot K^{-1}$
- Tool steel with $1.5 \cdot 10^{-6} \cdot K^{-1}$ causes >shrinkage of rubber parts.
- Linear shrinkage between 2 und 4 %. This amount reduces with an increase in Shore hardness and curing temperature.
- Preliminary trials should always be carried out for precision parts!

Fire behavior

- Autogenous ignition temperature of cured rubbers at 430 °C
- Flash point: approx. 750 °C
- Emitted gases are not corrosive.
- When burned, it forms a white nontoxic ash of silicon dioxide.
- Special-purpose grades (e.g. ELASTOSIL® R 502/75 and ELASTOSIL® R *plus* 543/75) are used for safety cables. They form a ceramic layer when burned.

Flame retardancy

- According to ASTM D 2863, UL 94, the flame must self-extinguish after a short time.
- This can be adjusted by adding special additives (ELASTOSIL® AUX Batch SB-2).
- Limiting Oxygen Index (LOI) values of flame retardant grades between 27 and 55 %
- The UL 94 V1 or HB standards are easily met.
- The UL 94 V0 standard can be met using special-purpose grades or additives.
- >Flame-retardant grades, e.g ELASTOSIL® R 501/75, ELASTOSIL® R 562/85 + SB-2 und ELASTOSIL® R *plus* 533/60 are especially effective.



Special formulations enable you to meet even the toughest fire-behavior demands, as in this UL test.

THE STRONGER THE CURRENT, THE BETTER SILICONE PERFORMS

WACKER has been supplying silicone rubber for the transmission and distribution industry for over 40 years now.

Silicone rubber is chemically related to inorganic insulating materials. It also retains its insulating properties at temperatures ranging from – 50 to + 200 °C. Silicone rubber displays remarkable fire behavior properties, which allow cables to remain functional for a short while in the event of fire. A safety cable can remain intact at temperatures of 1,000 °C for a long time.

>Dissipation factor
- Dissipation factor according to VDE 0303
- Tan δ ranges from $30 \cdot 10^{-4}$ to $250 \cdot 10^{-4}$.
- Increases with frequency
- Increases with filler content/density

>Dielectric constant
- According to DIN 53 482 or VDE 0303
- Typical values $\varepsilon = 2.7–3.3$ (at 25 °C and 50 Hz)
- Can reach 150 with suitable fillers

>Dielectric strength
- According to VDE 0303
- Ranges from 18–20 kV/mm
- Special-purpose grades with 36 kV/mm, for example ELASTOSIL® R 562/80

>Tracking resistance
- Standard grades reach 3.5 kV/10–30 minutes.
- POWERSIL® 350 reaches 3.5 kV/6 h.

>Arc resistance
- According to VDE 0441
- Approx. 80–100 seconds
- Special-purpose grades reach times of up to 420 seconds.

>Surface resistance
- According to VDE 0303
- Usually between $10^{12}–10^{13}\ \Omega$

>Volume resistivity
- Usually between $10^{15}–10^{16}\ \Omega \cdot$ cm
- Electrically conductive grades produce rubber parts with 2–150 $\Omega \cdot$ cm, e.g. ELASTOSIL® R 570, ELASTOSIL® R *plus* 573, ELASTOSIL® LR 3162.
- Special-purpose grades: approx. $4 \cdot 10^{-3}\ \Omega \cdot$ cm
- Temperature dependence is lower in platinum-catalyzed systems than in those cured with peroxide.
- Can be adjusted to 20–1,000 $\Omega \cdot$ cm by blending with suitable insulating grades
- At values exceeding 1,000 $\Omega \cdot$ cm, the conductivity can no longer be accurately adjusted by blending!

OUR PRODUCTS COMPLY WITH ALL SAFETY REGULATIONS

The use of silicone rubber articles in the food and pharmaceutical industries is regulated by the state according to regulations drawn up by public authorities.

WACKER healthcare guidelines
These guidelines relate to the use of silicone products in the manufacture of medical devices.

We do not supply products for long-term implants that remain for more than 30 days in the human body.

Our products should not be used for the following applications:

- Cosmetic reconstruction (e.g. plastic surgery, prosthetic devices)
- Devices for gynecological or obstetric applications (e.g. cervical caps, tampons) except for diagnosis and monitoring and surgical instruments
- Contraceptive devices (e.g. condoms, condom lubricants, intrauterine devices, cervical caps)
- Direct injection including the use of silicone fluids in applications where they can be introduced directly into tissues, body cavities or blood (e.g. syringe lubricants, intraocular fluids)

Pharmaceuticals

Germany
- „Gummiteile“ – Transfusion, Infusion, Injektion, DIN 58 367
- „Infusionsgeräte“ – Infusion, Transfusion, DIN 58 362

USA
- „Biological Tests – Plastics“, United States Pharmacopoeia

France
- „Silicone élastomère réticulé à chaud“, french Pharmacopoeia

Europe
- „Silicone Elastomers for Closures and Tubing“, European Pharmacopoeia PA/PH/Exp. 3/T (82) 57 Definitive January 22, 1985
- Commission Directive 93/11/EEC „Release of N-nitrosamines and N-nitrosable substances from elastomer or rubber tests and soothers“, (1993)

Food contact

Germany
- BfR XV, Teil A, „Silicone“, 182. Mitteilung BGBl. 32, 211 (1989)
- BfR IX, Teil A, „Farbmittel zum Einfärben von Kunststoffen und anderen Polymeren für Bedarfsgegenstände“, 178. Mitteilung BGBl. 31, 363 (1988)
- „Kennzeichnung von Bedarfsgegenständen im Sinne des Lebensmittelgesetzes“, DIN 7 725
- KTW-Empfehlung, BGBl. 28, Nr. 12 (1985)

The non-toxicity of silicone rubbers makes them perfect for food contact applications.

USA
– "Rubber Articles Intended for Repeated Use in Contact with Food," FDA Code of Federal Regulation, § 177.2600

France
– "Décrets et Circulaires du Ministère de l'Agriculture," Brochure No. 1227

United Kingdom
– BS 6920 (WRAS)

WE USE BOILING WATER, TOO, BUT THERE'S SILICONE RUBBER IN IT

The hydrophobic character of the silicone bestows silicone rubber with excellent resistance to boiling water. In general, silicones are known for their outstanding high-temperature resistance.

Water and steam

Silicones are very resistant to boiling >water. In boiling water, the increase in volume remains less than 1 %, even after prolonged immersion.

The behavior of different ELASTOSIL® R compounds in steam is not uniform. Highly flexible rubber grades are more stable than those with high strength. Steam >sterilization can be easily carried out on virtually all silicone ELASTOSIL® R grades. They can withstand continuous superheated steam at 120 °C for at least 6 months.

As the test shows, silicone rubber's reliable properties remain fully intact even after the cured rubber products have been boiled for a long time.

ELASTOSIL® R 755/60 is particularly >steam resistant.

Hot air

Silicone rubber articles remain extremely flexible under dry heat in the presence of oxygen, even at extreme temperatures. They thus surpass most organic elastomers.

Oxidative degradation

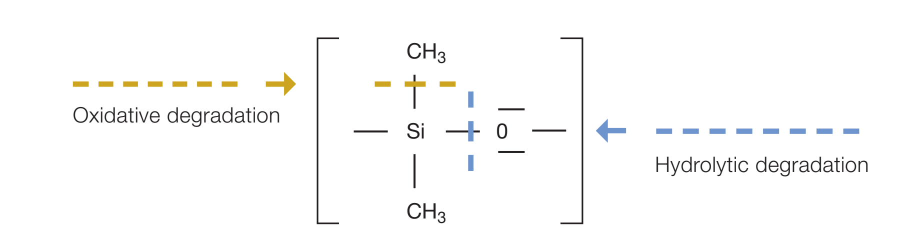
At high temperatures (approx. 180 °C and above), the organic substituents are split off from the silicon atoms to form free radicals, thus creating additional crosslinks between polymer chains. This >oxidative degradation, an irreversible chemical process, becomes evident in a loss of weight which is accompanied by shrinkage of rubber parts combined with increasing embrittlement. This in turn means an increase in hardness, but a decrease in tensile strength, elongation at break and tear strength. This process can be retarded, although not stopped completely, by oxides of polyvalent elements[1].

On the other hand, the overall increase in crosslinking density under sustained higher temperatures has a positive effect on resilience and compression set. This also explains why the insulating property of silicone rubber at high temperatures remains virtually constant for prolonged periods: the rubber's insulating properties are comparable to those of quartz.

Hot-air resistance of ELASTOSIL® R

Temperature	Resistance
< 130 °C	Several Years
150 °C	1.5 years
200 °C	8 months
250 °C	3 months
300 °C	10 days

Oxidative und hydrolytic degradation



Hydrolytic degradation

In the initial phase of oxidative degradation, a parallel reaction, >hydrolytic degradation, >depolymerization, occurs at high temperatures (200 °C and higher). Traces of moisture or the hydroxyl groups in the fillers or plasticizers present in the rubber cause the polymer chains to hydrolyze. The effect is a softening of the material.

Atmospheric oxygen inhibits this reaction. The excellent stability of silicone rubber at high temperatures only applies in the presence of sufficient oxygen[2]. This property of silicone rubber must always be taken into account in the design of seals and gaskets.

[1] E.g. Fe_2O_3
[2] More information can be found in the chapter "Postcuring" in the brochure "ELASTOSIL® R Solid Silicone Rubber"

SOME OF OUR TEST SPECIMENS ARE OLDER THAN THEIR TESTERS

Obtaining a desired test result is often just one side of the coin. In many cases, it is important to maintain a certain property over a lengthy period. Our customers can rest assured that product properties are stable.

Chemicals

The >chemical resistance of ELASTOSIL® R solid silicone rubber depends to a large extent on the cross-linking density and the amount of filler used: the higher a rubber's filler content, the less susceptible it is to swelling. This, in turn, makes the rubber more resistant.

Dilute acids, alkalis and aqueous salt solutions

Whether hot or cold: dilute >acids and alkalis as well as aqueous salt solutions hardly attack silicone rubbers.

Concentrated acids and alkalis

Silicone rubber is attacked by concentrated acids and alkalis, especially oxidizing acids, such as sulfuric acid etc.

Polar liquids

>Polar liquids, such as alcohol, acetone etc., cause hardly any swelling of silicone rubber. The sealing properties of silicone rubber parts remain unaffected.

Nonpolar liquids

>Nonpolar liquids such as hydrocarbons, mineral oils and greases cause relatively severe >swelling. Processors must set priorities here, especially as organic elastomers resistant to swelling often have unsatisfactory heat resistance. ELASTOSIL® R 861 provides relatively good >chemical and solvent resistance and ELASTOSIL® R 502/80, ELASTOSIL® R 509/65 and ELASTOSIL® R 701/40-80 grades are >oil resistant.

Weathering and UV influences

Even after years of exposure to >weathering, there is virtually no change in the properties of silicone rubber parts. ELASTOSIL® R compounds, unlike organic elastomers, require no additional additives to improve their resistance to weathering.

In an industrial climate test in accordance with DIN 50 018 - SFW 2.0 S (2 l sulfur dioxide) special compounds[1] reach 1.5 million cycles without changes in the surface. Silicone rubber articles are not sensitive to UV rays.

[1] This applies to ELASTOSIL® R 420/50, for example.

ELASTOSIL® R 401/60 compared to ELASTOSIL® R 401/60 R1

Test medium	Grade	Hardness Shore A	Tensile strength [N/mm²]	Elongation at break [%]	Volume [%]
–	ELASTOSIL® R 401/60	59	10.2	560	–
–	ELASTOSIL® R 401/60 R1[1]	60	10.5	560	–
ASTM-Fluid 1	ELASTOSIL® R 401/60	57	9.3	590	+ 3.8
	ELASTOSIL® R 401/60 R1[1]	58	10.2	530	+ 4.0
IRM 902	ELASTOSIL® R 401/60	54	9.3	630	+ 8.5
	ELASTOSIL® R 401/60 R1[1]	55	9.6	610	+ 8.9
IRM 903	ELASTOSIL® R 401/60	35	2.1	410	+ 44
	ELASTOSIL® R 401/60 R1[1]	43	6.2	420	+ 40

High-energy radiation

The resistance to high-energy >radiation and hot-air stability of silicone rubber is superior to most elastomers.

The effects of radiation are comparable to the consequences of exposure to high temperatures. VMQ rubbers can absorb a radiation dosage of approx. 40–50 Mrad. This reduces elongation at break by up to 50 %.

PVMQ grade rubbers, e.g. ELASTOSIL® R 490/55, are substantially more resistant and withstand exposures of maximum 90 Mrad.[2]

The >sterilization of silicone rubber articles by gamma radiation, often employed in the field of medicine, does not, however, impair their quality.

If silicone rubber is exposed to radiation at elevated temperatures, its chemical and mechanical resistance drops considerably. At 180 °C, the maximum permissible dose amounts to approx. 10 Mrad for VMQ grades and approx. 35 Mrad for PVMQ grades. These limits drop, however, if the silicone rubber is exposed to radiation at dosages below the limits. In this case, the crosslinking efficiency of the radiation is also higher.

Silicone rubbers are resistant to >microwaves. They are not microwave-active and thus are not heated. They can, however, be made microwave-active with additives.

[1] R1 = stabilized with 1 % Stabilizer R
[2] These values relate to a 2-mm thick test specimen that was irradiated at room temperature and with a dose of 2 Mrad/h.

COOPERATION MEANS GETTING TOGETHER ONCE IN A WHILE

Although this is the age of communication, meeting in person is becoming increasingly rare. Yet the quickest way to solve certain problems is often for people to meet up briefly. Our technical support staff know our products and their related properties. But they also know your production processes and what these processes require. They can therefore offer you expert advice – on site if necessary.

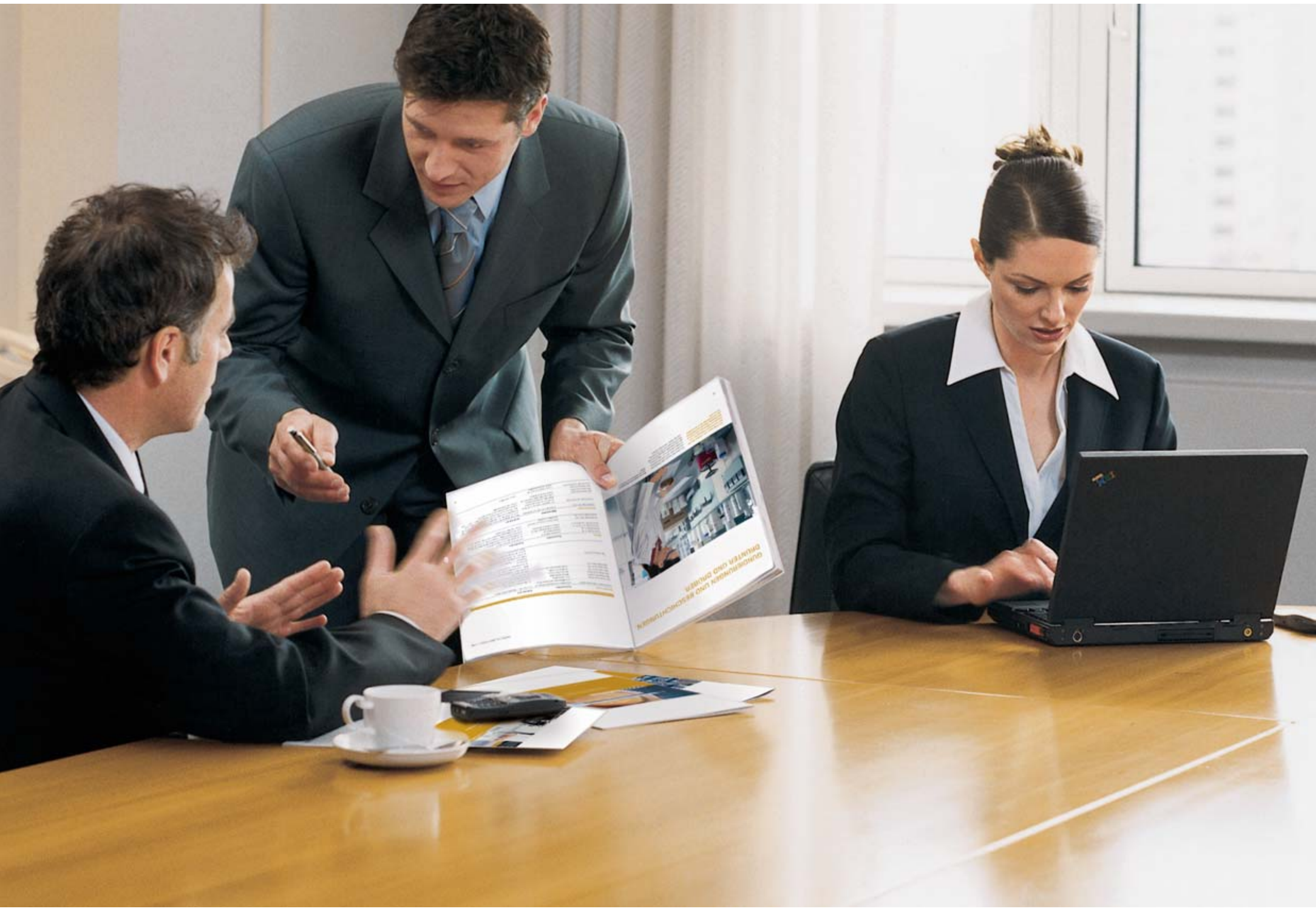
It is quite obvious that the more information you receive, the smoother your machinery will run. We strive to ensure that our complete product portfolio is very easy to understand. Our goal is to provide you with the information you need quickly and easily – through our brochures, our hotline or the internet.

However, our most important information medium will continue to be personal dialog with our customers. This is the best way for us to find out about your particular needs and to develop individual solutions to problems not dealt with in any of our brochures. Ask us. We'll be glad to help: Your rubber fabricator business team.

How to stay well informed

Please ask about our brochures or visit our web sites at www.wacker.com or www.wacker-silicones.com. Our web sites offer you a source of quick reference, plus the option to search and download specific information around the clock.

- Processing ELASTOSIL® R Solid Silicone Rubber
- ELASTOSIL® Products According to Application
- ELASTOSIL® Product Data Sheets
- Self-Adhesive ELASTOSIL® Silicone Rubber Grades
- Platinum-Catalyzed Addition Curing with ELASTOSIL® R *plus*



Even though you can find out about our product range by reading our brochures, visiting our website or calling us at any time, in some situations, nothing can beat a personal meeting.

YOU NOW KNOW OUR TEST RESULTS HERE ARE OUR QUALITY STANDARDS

General	DIN	ASTM	BS	ISO
Units	1 301	E 380		1000–1382
Definitions	53 501	D 1566		4632/1 TR 8461
Classification of elastomers	78 078	D 2000		1629
Rubber, nomenclature, categories	1 629	D 1418		
Grouping of high-polymeric materials according to temperature dependency	7 724			
Classification for automotive applications		D 2000		4632/1
Storage, cleaning	7 716			2230
Tolerances	7 715			3302
Factory certificate	50 049			
Quality control				9000 9004
Statistical evaluation	53 598	D 3488		

Silicone rubber (uncured)	DIN	ASTM	BS	ISO
Mooney viscosity	53 523	D 1646		289
Vulcanization characteristics	53 529	D 2084		667
Extrudability		D 2230		

Silicone rubber (cured)	DIN	ASTM	BS	ISO
Preparation of test specimens	53 502	D 3182 D 3183	903-A36	DP 2214 4661
Density	53 479	D 792	903-A1	1183, 2781
Hardness Shore A, IRHD	53 505 53 519	D 2240 D 1415	903-A26	868
Tensile strength, elongation at break	53 504	D 412	903-A2	37
Tension set	53 518	D 412	903-A5	2285
Tear strength	ISO 34-1	D 624	903-A3	34
Rebound resilience	53 512	D 1054	903-A8	4662
Compression set	53 517	D 395	903-A6	1653–815
Dynamic torsion test	53 445		903-A31	4663

Silicone rubber (cured)	DIN	ASTM	BS	ISO
Behavior at low temperatures	53 545 53 548 53 546	D 3847 D 797 D 1053 D 746 D 2137	903-A13 903-A25	1432 812
Electrical properties	DIN-VDE 0303	D 149, 150 D 257	903-C1 TO C5	
Tracking resistance	DIN-VDE 0441	D 2303		
Arc resistance	DIN-VDE 0441	D 495		
Flame resistance: oxygen index construction materials and components	 4 102	 D 2863	 2782 476	4589
Abrasion	53 516	D 1630	903-A9	4649
Gas permeability	53 536		903-A17	1399, 2782
Flexometer test	53 533		903-A50	
Flexing endurance test	53 522	D 813 D 430	903-A10, -A11	132, 133
Determination of adhesion to metal	52 531	D 429	903-A21	813, 814
Siloxane content of HTV silicone elastomers	53 621/10			
Pyrolysis residue of silicone rubber products	53 587			
Accelerated aging	53 508	D 573	903-A19	188, 1826
Temperature-time limits	53 446			
Water vapor permeability	53 122			
Effects of liquids, vapor and gases	53 521	D 471	903-A16	1817
Testing in a saturated atmosphere (Kesternich test)	50 018			
Weathering resistance outdoors or in equipment	53 386 53 387	D 518		4892
Resistance to ozone cracking	53 509	D 3395 D 518, 1171	903-A23	1431
Resistance to ionizing radiation		D 1672		
Flexible cellular materials		D 1056		
Heat-shrinkable tubing		D 2671		

WHERE TO FIND YOUR KEYWORD IN THE TEXT

We extend thanks to Starlim for their kind assistance with the photographs in this brochure.

WACKER AT A GLANCE

WACKER
is a technology leader in the chemical and semiconductor industries and a worldwide innovation partner to customers in many key global sectors. With around 14,700 employees, WACKER generated sales of €3.34 billion in 2006. Germany accounted for 20 % of sales, Europe (excluding Germany) for 28 %, the Americas for 20 % and Asia-Pacific, including the rest of the world, for 32 %. Headquartered in Munich, Germany, WACKER has some 20 production sites worldwide and a global network of over 100 sales offices.
With R&D spending at 5 % of sales in 2006, WACKER is among the world's most research-intensive chemical companies.

WACKER SILICONES
is a leading supplier of complete silicone-based solutions that comprise products, services and conceptual approaches. As a provider of solutions, the business division helps customers press ahead with innovations, exploit global markets fully, and optimize business processes to reduce overall costs and boost productivity. Silicones are the basis for products offering highly diverse properties for virtually unlimited fields of application, ranging from the automotive, construction, chemical, electrical engineering and electronics industries, through pulp and paper, cosmetics, consumer care and textiles, to mechanical engineering and metal processing.

WACKER POLYMERS
is the global leader for high-quality binders and polymer additives. This business division's activities encompass construction chemicals and functional polymers for lacquers, surface coatings and other industrial applications, as well as basic chemicals, i. e. acetyls. Products such as dispersible polymer powders, dispersions, solid resins, powder binders and surface coating resins from WACKER POLYMERS are used in the construction, automotive, paper and adhesives industries, as well as by manufacturers of printing inks and industrial coatings.

WACKER FINE CHEMICALS
As an expert in organic synthesis, silanes and biotechnology, WACKER FINE CHEMICALS supplies innovative biotech products and catalog chemicals for life-science and consumer-care customers worldwide. Its product portfolio includes cyclodextrins and cysteine, organic intermediates and acetyl acetone. A key specialty is the contract manufacturing of pharmaceutical proteins via microbial systems.

WACKER POLYSILICON
has been producing hyperpure silicon for the semiconductor and photovoltaics industries for over 50 years. As one of the largest global manufacturers of polycrystalline silicon, WACKER POLYSILICON supplies leading wafer and solar-cell manufacturers.

Siltronic
is one of the world's leading producers of hyperpure silicon wafers, supplying many major chip manufacturers. Siltronic develops and produces wafers up to 300 mm in diameter at facilities in Europe, the USA, Asia and Japan. Silicon wafers form the basis of state-of-the-art micro and nanoelectronics used, for example, in computers, telecommunications, motor vehicles, medical technology, consumer electronics and control systems.

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