



WACKER



CREATING TOMORROW'S SOLUTIONS



ELASTOSIL® LR – Liquid Silicone Rubber 液体硅橡胶

July 2014



WACKER ACADEMY

Agenda

- ▶ Silicones and silicone elastomers
有机硅及其弹性体

Curing mechanisms and properties of Silicones elastomer
硅橡胶弹性体的固化机理及性能

Processing of LSR
液体硅橡胶的加工工艺

ELASTOSIL® LR 牌号液体硅橡胶
Wacker LSR产品介绍

WHAT ARE SILICONE ELASTOMERS? 什么是有机硅

Silicones 有机硅:

Generic name for a class of synthetic polymers with Si-O links made from silicon metal. 由硅金属制得以Si-O键为主链的一类合成聚合物的通用名称

Silicone elastomer 有机硅弹性体:

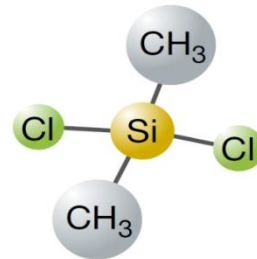
3-dimensionally cross linked polydiorganosiloxane polymers (network-like structure) 三维交联结构的聚二甲基硅氧烷聚合物(网状结构)



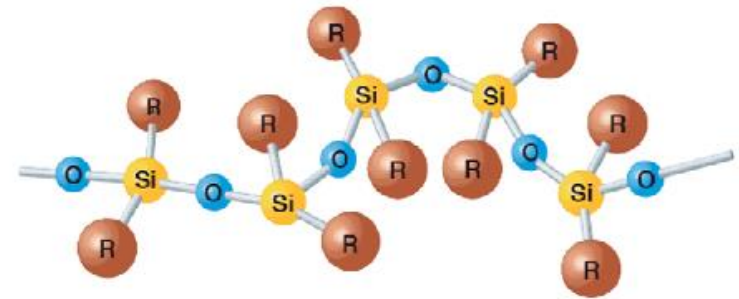
Quartz sand
石英砂



→ **Silicon**
金属硅



→ **Silanes**
硅烷

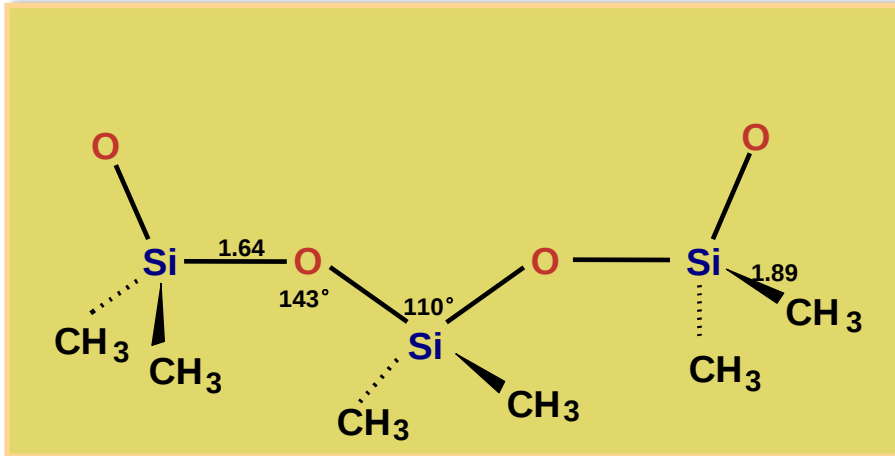


→ **Polymers**
聚合物

SILICONE ELASTOMER' S OUTSTANDING PROPERTIES

Si-O为主链结构的卓越性能

Siloxane Polymer 硅氧烷聚合物



Bond energies 键能

Bond	E_{Diss} [kJ/mol]	Bond	E_{Diss} [kJ/mol]
Si-O	422-494	Si-C	306-326
C-O	360	C-C	348

Si-O bond is stronger than C-O bond

Si-O键能高于C-O键

→ **inherent high thermal stability**

自身化学结构决定的热稳定性

High chain flexibility of PDMS

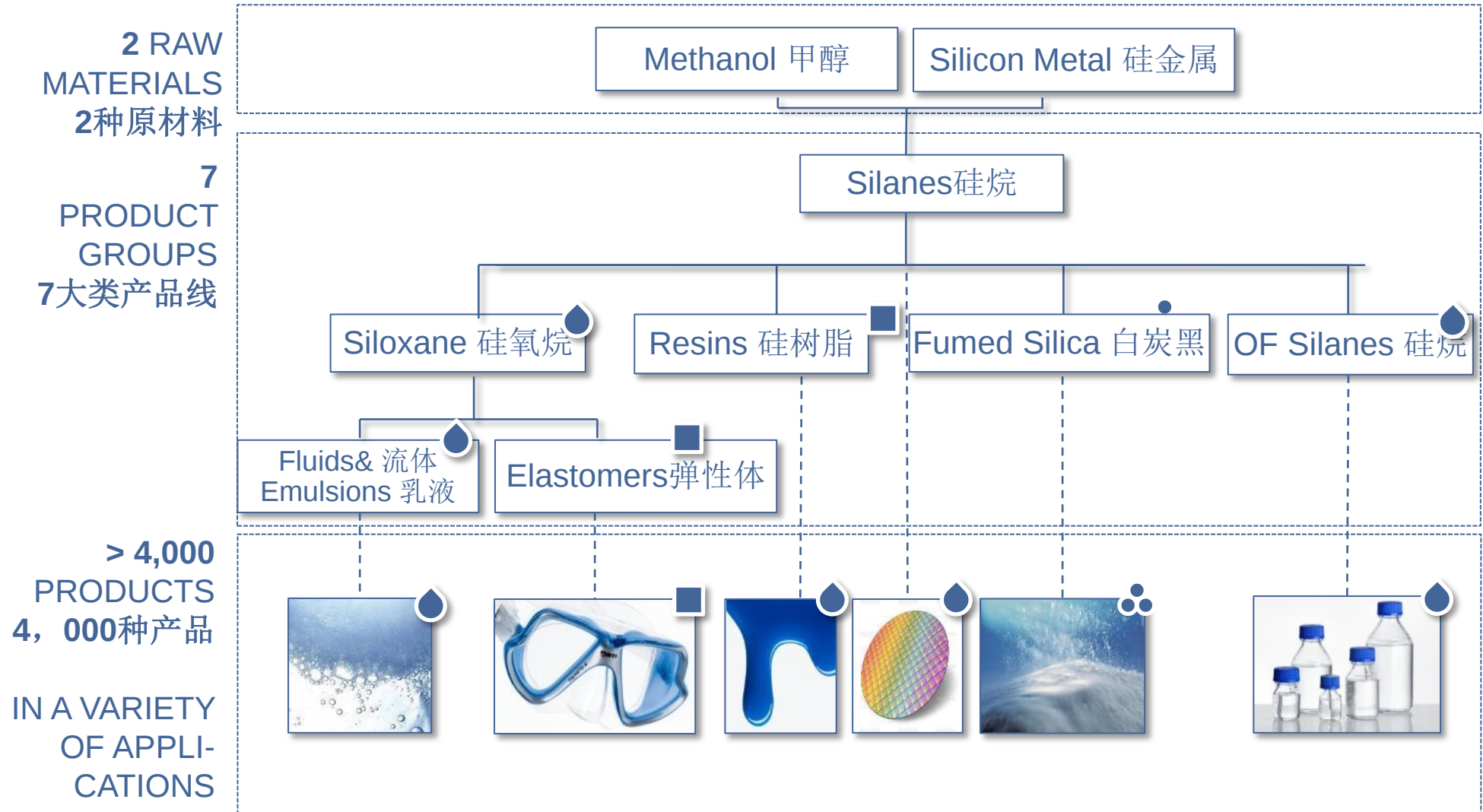
主链特有的柔性结构

→ **deep temperature flexibility**

低温仍保持很好的柔韧性

MORE THAN 4,000 PRODUCTS ARE BASED ON 7 PRODUCT GROUPS AND ONLY 2 RAW MATERIALS

两种基础原料衍生出的超过4,000种7大类的产品



THEIR UNIQUE EFFECTS AND SPECIFIC PROPERTIES ARE THE REASON FOR THIS 独特的效应及性能赋予其多种多样的用途

Effects of “Liquid” “液体”效应



Properties of “Solid” “固体”性能



SILICONES CREATE VALUE IN MANY INDUSTRIES

有机硅用于多种工业

Market Structure by Application Segment 不同应用领域的市场分布

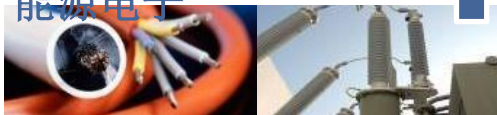
Finished Goods 成品



Coatings 涂布



Energy & Electronics 能源电子



Manufacturing Machinery 制造业



Consumer Care 消费品护理



Automotive 汽车



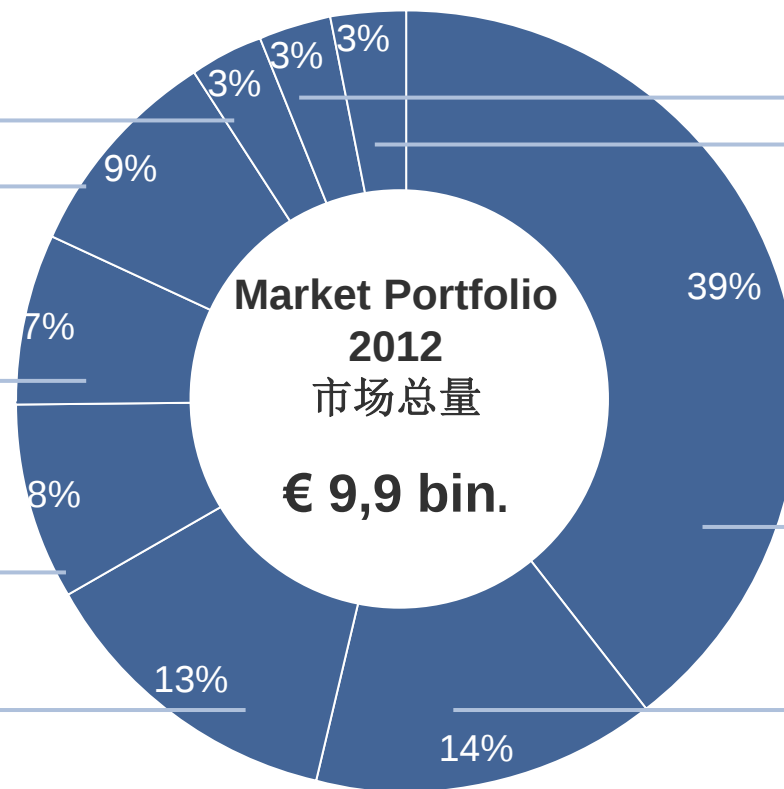
Health Care 健康护理



Advanced Processing & Performance Additives 加工改性



Construction 建筑



*w/o fumed silica

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液体硅橡胶的加工工艺

ELASTOSIL® LR 牌号液体硅橡胶

Wacker LSR产品介绍

Silicone elastomers can be categorized into high and room temperature cure silicones

有机硅弹性体可分为高温及室温硫化两种类型

Silicone Elastomers 有机硅弹性体

High Temperature Curing 高温硫化

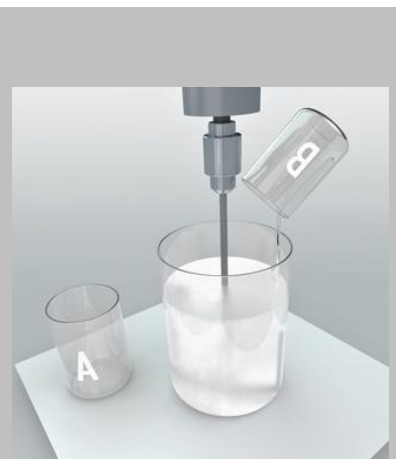
Room Temperature Curing 室温硫化

High Consistency Rubber
(HTV) 高温混炼胶

Liquid Silicone Rubber
(LSR) 液体硅橡胶

2-Component
(RTV-2) 双组分

1-Component
(RTV-1) 单组份



CHEMICAL AND PHYSICAL PROPERTIES QUALIFY SILICONE ELASTOMERS FOR SPECIAL APPLICATIONS

有机硅弹性体化学和物理特性可用特殊应用



Chemical properties 化学性能

- Thermal stability up to 180 °C, with heat stabilizers up to 300 °C
可耐温180°C; 加入耐热剂可耐温300°C
- Chemical inertness 化学惰性
- Sterilizability for single and multiple use 单次到多次使用可消毒
- Low flammability 不易燃
- Good media resistance against a variety of solvents and chemicals 可耐多种介质
- Good weathering, UV and ageing resistance 耐候, UV 即自然老化

Physical properties 物理性能

- Hydrophobicity, low surface tension 憎水性, 低表面张力
- Low temperature flexibility down to - 50 °C ($T_g = - 125$ °C) 低温柔韧性 至-50°C
- High transparency 高透明
- Pigmentable in nearly every color 可制成任意颜色
- Constant mechanical and electrical properties over a wide temperature range
在较宽的温度范围内; 机械和电气性能恒定

MECHANICAL PROPERTIES QUALIFY SILICONE RUBBER FOR A VARIETY OF APPLICATIONS

硅橡胶的机械性能可符合多种应用

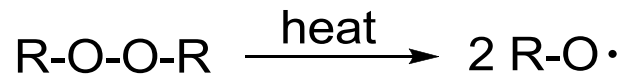
	RTV-2	LSR	HTV
Hardness (DIN 53505) 硬度	very soft - 60 ShA	3 - 85 ShA	10 - 90 ShA
Tensile strength (DIN 53504 S1) 拉伸强度	2 - 8 N/mm²	5 - 10 N/mm²	6 - 12 N/mm²
Elongation at break (DIN 53504 S1) 断裂伸长率	100-1000%	300-900%	300-1200%
Tear resistance (ASTM D 624) 撕裂强度	8 - 25 N/mm	15 - 45 N/mm	20 - 55 N/mm
Compression set (DIN ISO 815-B)* 压缩形变	10-70%	8 - 25%	10 - 40%
Rebound resilience (DIN 53512) 回弹	20 - 50%	40 - 60%	35 - 65%

HTV: CURING CHARACTERS OF HTV SILICONE RUBBER

由过氧化物参与反应的高温混炼胶的硫化特点

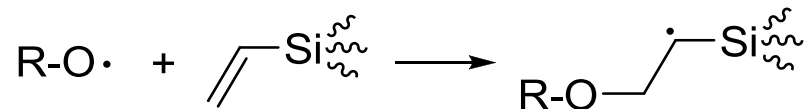
Crosslinking mechanism 交联机制

Radical formation 自由基产生



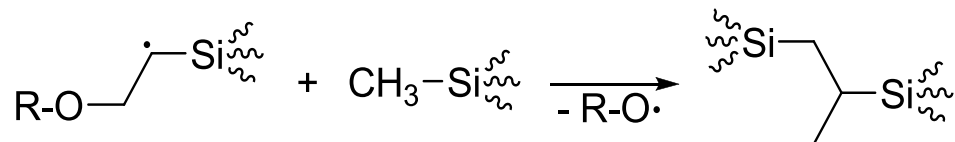
Radical addition to vinyl siloxane

自由基与双键反应



Formation of alkylene bridged siloxanes

生成亚烷基桥连硅氧烷



Peroxide Cure Characteristics 特点

- vulcanization at $T \geq 120^\circ \text{C}$

需要在120oC 以上开始反应

- + compounds with long pot life

混炼胶可长期存放

- yellowing with certain peroxides

有些过氧化物导致制品发黄

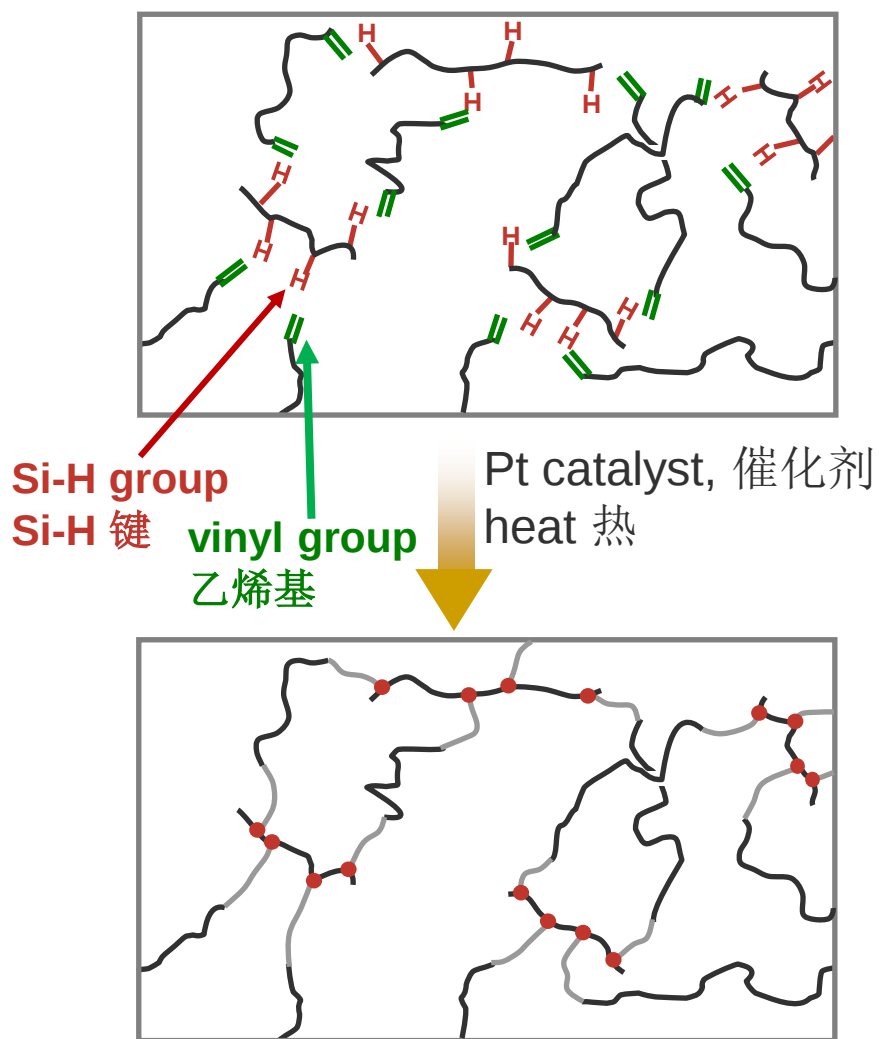
- post cure mandatory to remove

需要二段硫化

- side products from peroxide catalyst

固化会产生少量的可挥发副产物

RTV-2, LSR AND HTV SILICONE RUBBER IS VULCANIZED BY PLATINUM CATALYZED ADDITION CURE 加成型产品硫化特点



Addition Cure Characteristics 加成反应特点

vulcanization at r.t. to 200°C

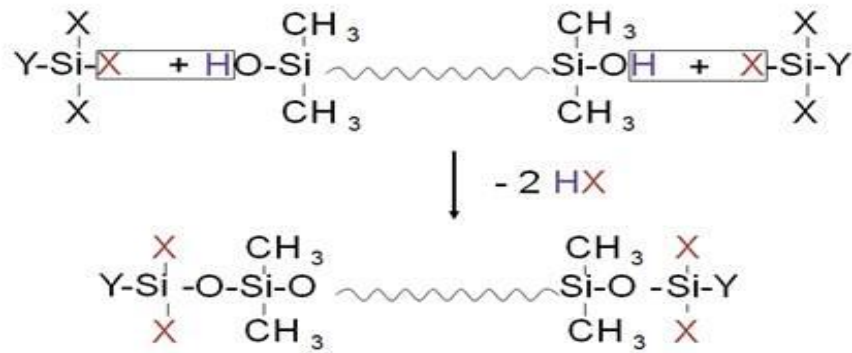
可在室温至200°C范围硫化

- + high reaction rate 反应快速
- + no peroxide split products, 无副产物
- + defined network formation (selectivity)
网络结构可预设
- + high transparency 高透明
- + low shrinkage (RTV-2 vs. RTV-1) 低收缩
- sensitive to catalyst poisons (sulfur and nitrogen compounds, heavy metals)
铂金催化剂易中毒

RTV POLYCONDENSATION

缩聚型RTV

Crosslinking mechanism 交联机制



- $\text{X} = \begin{array}{c} \text{---N---R} \\ | \\ \text{H} \end{array}$ **Amine**
- $\text{X} = \begin{array}{c} \text{---O---C---CH}_3 \\ || \\ \text{O} \end{array}$ **Acetate**
- $\text{X} = \begin{array}{c} \text{---O---N=C<} \\ || \quad \quad \quad \text{R} \\ \text{O} \quad \quad \quad \text{R} \end{array}$ **Oxime**
- $\text{X} = \text{---O---R}$ **Alcohol**

Characteristics 特点

Polycondensation RTV silicone rubber require external humidity for cure at room temperature. 缩聚型RTV 的硅胶通常需要额外的湿度参与反应

- + room temperature curing 室温硫化
- + low equipment investment 设备投资低
- humidity 需要湿度参与反应
- by products 副产物
- curing slow 硫化稍慢

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► Processing of LSR

液体硅橡胶的加工工艺

ELASTOSIL® LR 牌号液体硅橡胶

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Processing of ELASTOSIL® LR 工艺



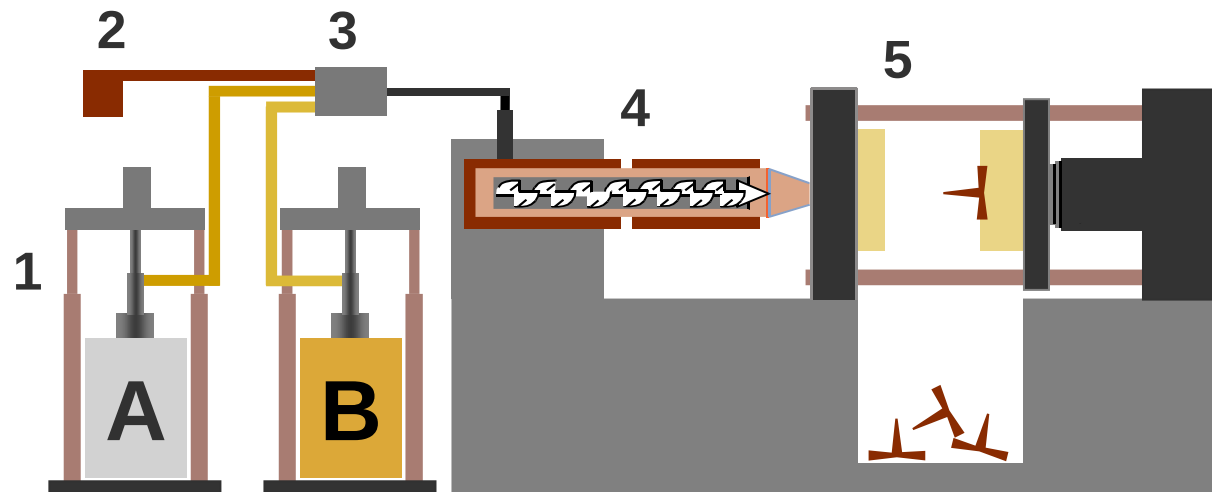
Processing advantages 工艺优点

- ▶ Short cycle times 周期短
- ▶ Fully automated processing 全自动工艺
- ▶ Mold with up to 128 cavities 模具可做128穴
- ▶ No costly pre-treatment or mechanical finishing 无需预处理
- ▶ Combination of hard and soft materials 可做软硬物料结合
- ▶ Complex geometries possible 可做复杂形状

LIQUID SILICONE RUBBER PROCESSING OF ELASTOSIL® LR

ELASTOSIL® LR液体硅橡胶的加工工艺

Injection molding / Process technology 注塑 / 加工技术



(1) Metering device for
A- and B-components
A,B 组分计量

(2) Metering device for
pigment 颜料计量

(3) Static mixer 静态混合器

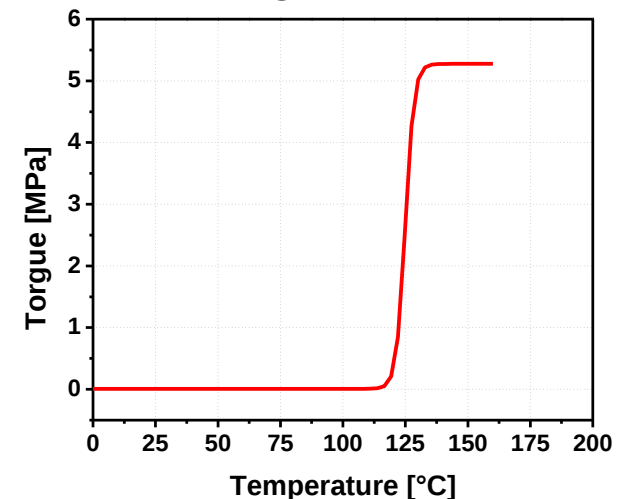
(4) Cooled metering screw
冷却计量螺杆

(5) Heated injection mould
加热注塑模具

Curing characteristics 固化条件

- 180 °C: 5-8 seconds per 1 mm of thickness

Curing behavior 硫化行为



Delivery forms: 交运包装

Pails (Hobbocks) = 20 kg

Drums = 200 kg

EQUIPMENT OF THERMAL PLASTICS COMPARED WITH LIM

热塑性塑料与液体硅橡胶的注射成型



Thermal plastics 热塑性塑料

- Material 材料: pellets 颗粒
- Injection unit 注射单元: Open loading; heated screw 开放式进料; 进料螺杆加热
- Mold: 模具: heat runner; cooling moulding 热流道; 冷却成型



Liquid Silicones rubber 液体硅橡胶

- material 材料: 2-component & Static mixer 双组分计量并静态混合
- Injection unit: 注射单元: Closed loading; cooling system 密闭进料; 进料螺杆冷却
- Mold 模具: cold runner and heating molding 冷流道; 热成型 (160~200C)

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- ▶ ELASTOSIL® LR 牌号液体硅橡胶
Wacker LSR产品介绍

LSR 液体硅橡胶

ELASTOSIL® LR

产品名	硬度	性能	用途
LR 3003	03-85	通用型	垫片,O型圈,面罩,膜
LR 3004	10-80	通用并快速固化型	奶嘴,阀,烤盘, 导尿管 ...
LR 3005	30-70	通用(无需二次硫化,低压缩形变,快速固化)	垫片,减振
LR 3013	50-70	耐油型(无需二次硫化,低压缩形变)	耐油止回阀
LR 3015	50 + 70	耐油型(无磨损,无需二次硫化,低压缩形变)	止回阀 (低磨损)
LR 3023	40-60	耐冷冻液(无需二次硫化,低压缩形变)	散热器或冷却器垫片
LR 3038	20-50	高抗撕((婴儿用品,低黄变)	安抚奶嘴,婴儿奶嘴
LR 3040	40-50	中抗撕(快速固化型)	
LR 3043	30-70	高抗撕	安抚奶嘴, 奶嘴
LR 3044	60	高抗撕,高透明(快速固化型)	潜水镜

LSR 液体硅橡胶

ELASTOSIL® LR

产品名	硬度	性能	用途
LR 3092	65	耐热性 低压缩形变(220°C / 22h < 30%) 高抗撕 (ISO 34-1 method A, 裤型) 94h / 220°C = 3 N/mm	冷热交换器用垫片
LR 3094	60	耐热性	点火塞
LR 3162	50	导电胶 9 Ohm*cm, 高粘度(优异的耐热性)	
Powersil 463	40	导电胶 60 Ohm*cm, 低粘度 -> 电缆附件	
Powersil 464	40	导电胶 70 Ohm*cm -> 电缆中间接头和终端	
Powersil 466	40	导电胶 50 Ohm*cm -> 电缆冷缩附件	

LSR 液体硅橡胶

ELASTOSIL® LR

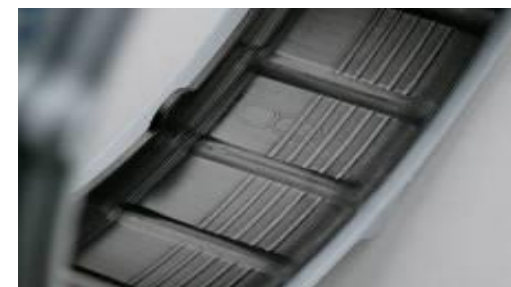
产品名	硬度	性能	用途
LR 3070	10-60	通用型 (可粘 PA/PBT)	雨刮传感器, 垫片, 多功能密封件
LR 3071	30-60	食品接触 (FDA, BfR compliant)	Perlator® 通风器
LR 3072	30-40	渗油型自润滑	放射设备用密封件
LR 3074	60	耐冷冻液	散热器密封
LR 3076	50 + 70	耐油型 (低磨损)	车用密封
LR 3077	30-50	可粘 PC/PBT	已取消
Silpuran® 6700	40-60	医疗级, 可粘 PBT ISO 10993 和 USP CLASS VI conform	
Silpuran® 6701	30-50	医疗级 可粘 PBT ISO 10993 和 USP CLASS VI conform	



LSR 液体硅橡胶

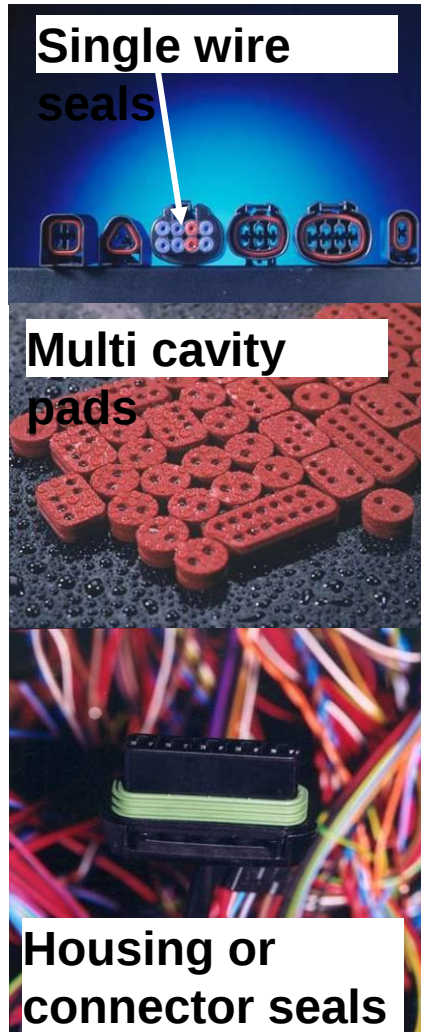
ELASTOSIL® LR

产品名	硬度	性能	用途
LR 3170	35	自粘和阻燃型 (UL 94, VO, 黑)	
FLR 3900	40 + 60	氟硅橡胶 (优异耐油性, 无需二次硫化, 低压缩形变)	垫片, 膜
FLR 3905	40 + 60	氟硅橡胶 (渗油型)	垫片, 膜
LR 7661	50	高透明, 9比1混合	
LR 7663	45	高透明, 9比1混合, A与B相同粘度	高透明性
LR 7665	50	高透明, 1比1混合, A与B相同粘度	



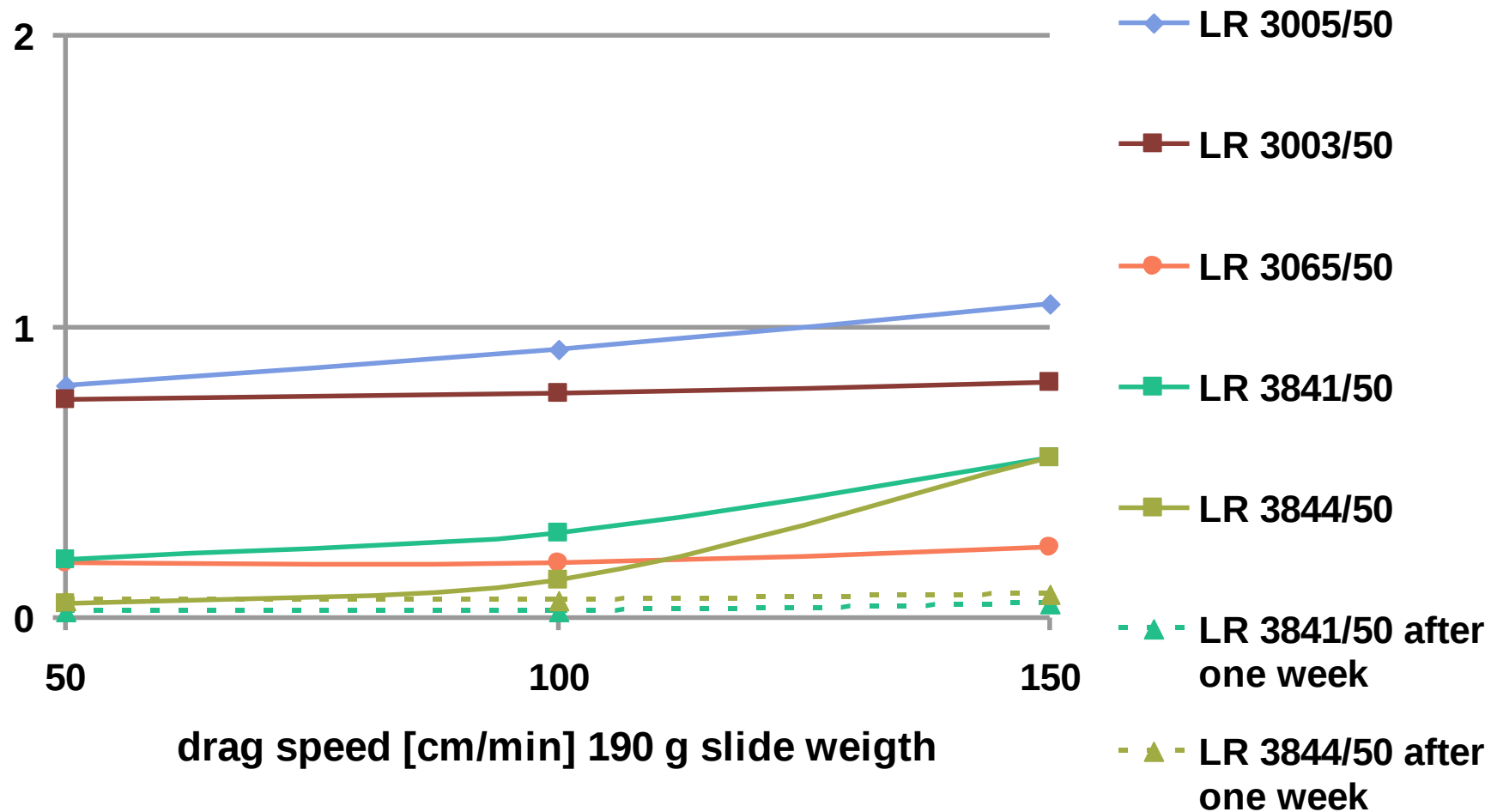
LSR 液体硅橡胶

ELASTOSIL® LR



Oil content	20 Shore A	30 Shore A	40 Shore A	50 Shore A	60 Shore A	70 Shore A
1%				LR 3841/50		
2%			LR 3842/40	LR 3842/50	LR 3842/60	LR 3842/70
3%		LR 3843/30				
4%	LR 3844/20	LR 3844/30	LR 3844/40	LR 3844/50		
5%						
6%	LR 3846/20	LR 3846/30				
7%						

ELASTOSIL® LSR 非渗油,低摩擦系数LR 3065



SILPURAN® – Medical HTV for general purpose application

通用型HTV医疗级硅橡胶

Standard grades 标准等级

Pt-cure	2K	molding	模压	SILPURAN®8020/40-70
Pt-cure	2K	extrusion	挤出	SILPURAN®8030/40-70
Peroxide-cure	过氧化物	molding/extrusion	模压/挤出	SILPURAN®8060/40-70

High-tear grade 高抗撕等级

Peroxide-cure		extrusion	挤出	SILPURAN® 8461/60
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Low surface friction grade 低摩擦系数等级

Pt-cure	2K	extrusion	挤出	SILPURAN® 8630/60
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Pt-Catalyst batches 铂催化剂

SILPURAN® Curing Agent M (for 2K moulding grades)

SILPURAN® Curing Agent X (for 2K extrusion grades)

SILPURAN® –Medical LSR for general purpose application

通用型医疗LSR

Standard grade 标准等级

LR, Pt-cure

injection molding

SILPURAN® 6000/05-70

High-tear grade 高抗撕等级

LR, Pt-cure

injection molding

SILPURAN® 6400/40-60

Low surface friction grade 低表面摩擦等级

LR, Pt-cure

injection molding

SILPURAN® 6600/40-60

Healing-free grade heal 防自愈等级

LR, Pt-cure

injection molding

SILPURAN® 6610/40-80

Self-adhesive grades 自粘等级

LR, Pt-cure

injection molding

SILPURAN® 6700/40-60

SILPURAN® – Medical Silicone for Wound Care application

伤口护理敷料

Designation	Viscosity A [mPa s]	Viscosity B [mPa s]	Penetration [1/10 mm] Hollow cone 62.5 g; 60 sec	Color	Pot life at 23° C [min]	System
SILPURAN® 2100	34,000	35,500	205	transparent	73	addition-curing
SILPURAN® 2110	18,000	54,000	200	transparent	70	addition-curing
SILPURAN® 2112	11,600	11,500	225	transparent	76	addition-curing
SILPURAN® 2120	31,000	30,500	120	transparent	22	addition-curing
SILPURAN® 2130	1,100	1,000	220	transparent	74	addition-curing

SILPURAN® – RTV2

低温硫化

	Blending ratio	Viscosity Component A D = 10 s-1	Viscosity Component B D = 10 s-1	Final hardness Shore A ISO 868	Final hardness Shore 00 ASTM 2240	Tensile strength ISO 37	Elongation at break ISO 37	Tear strength ASTM D 624 B
Designation	A : B	[mPa·s]	[mPa·s]			[N/mm ²]	[%]	[N/mm]
SILPURAN® 2400/18	1:1	1,700	1,700	< 0	20	0.5	400	1.4
SILPURAN® 2400/25	1:1	3,500	2,000	< 0	25	1	550	1.7
SILPURAN® 2400	1:1	1,800	1,800	7	55	1.7	550	2.4
SILPURAN® 2420/30	1:1	2,500	3,500	< 0	30	1.7	500	3.5
SILPURAN® 2420	1:1	2,500	3,500	12	60	3	600	12
SILPURAN® 2430	1:1	8,000	10,000	20	-	6	500	24
SILPURAN® 2440	1:1	15,000	10,000	30	-	6	400	22
SILPURAN® 2445	1:1	10,000	10,000	40	-	6	400	15
SILPURAN® 2450	1:1	35,000	20,000	50	-	6	200	7

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

Thank you for your attention!

