

Silfit Z 91 and alternative fillers in white peroxide-cured EPDM building profile

Author: Diego Mojica

HOFFMANN MINERAL®
We supply materials for good ideas

Contents

- Introduction
- Experimental details
- Results
- Summary
- Appendix
  - Results in tabular form

Objective

To broaden the range of filler options for white peroxide-cured EPDM building-profile formulations, alternative fillers are evaluated alongside Silfit Z 91.

Comparative assessment of alternative fillers versus Silfit Z 91 in a white peroxide-cured EPDM building-profile formulation.



Experimental details

- Base formulation
- Fillers
- Mixing and curing
- Test standards overview

Base formulation

Material	Description	phr
Keltan 5470 C	Ethylene-propylene-diene-rubber, semi-crystalline, ML 1+4 (125 °C): 55 MU	100
Zinkoxyd aktiv	Zinc oxide	5
Edenor C18 98-100 GW	Stearic acid	0.5
Filler	*see "Fillers and characteristics"*	200
Kronos 2222	Titanium dioxide, white pigment	15
Primol 352	Plasticizer, paraffinic white mineral oil	45
PEG 4000	Polyethylene glycol	2
Aflux 42	Processing aid	2
Vulkanox HS/LG	2,2,4-Trimethyl-1,2-dihydroquinoline (TMQ), polymerized, antioxidant	0.75
Kezadol GR	Calcium oxide preparation	10
Rhenofit TRIM/S	Trimethylolpropane trimethacrylate, 70 %, coactivator	1
Trigonox 29/40 B pd	1,1-Di(tert-butylperoxy)-3,3,5-trimethylcyclohexane, 40 %, curing agent	3
Perkadox 14/40 B pd s	Bis(tert-butylperoxyisopropyl)benzene, 40 %, curing agent	3
Total		**387.25**

Fillers and characteristics

	Silfit Z 91	Sillitin Z 89	Gloxil bright
Particle size D_{50}, [µm]	2.1	2.1	1.9
Particle size D_{97}, [µm]	9.5	9.5	12.0
Specific surface area (BET) [m^2/g]	10	11	9
Oil absorption [g/100 g]	65	55	65
Color value L*	96.5	96.1	98.6
Color value b*	1.0	4.2	2.1
Calcination	✓	-	✓

Mixing and curing

Compound preparation	
Two-roll mill	Ø 150 x 300 mm
Batch size	approx. 700 g
Roll temperature	50 °C
Mixing time	approx. 15 min

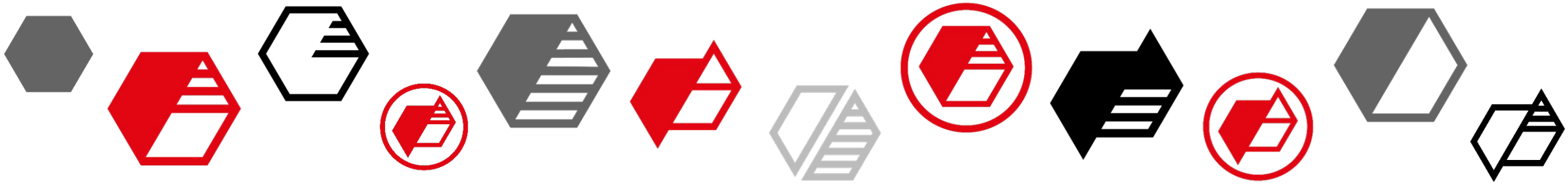
Press curing	
Temperature	180 °C
Time	5 min

Test standards overview

Test	Standard
Mooney viscosity ML 1+4 (100 °C)	DIN ISO 289-1
Mooney scorch ML +5 (120 °C)	DIN ISO 289-2
Garvey die extrusion profile test, method A Quantitative: maximum haul-off speed with a smooth profile (rating 4444)	ASTM D 2230 (based on)
Cure characteristics	DIN 53 529, parts 1 – 4
Tensile test	DIN 53 504, S2
Compression set	DIN ISO 815-1, type B
Hardness test	DIN ISO 7619-1
Tear resistance – Trousers specimen	DIN ISO 34-1, A
Tear resistance – Graves specimen	DIN ISO 34-1, Bb
Aging behavior in air	ISO 188, D

Results

- Garvey die extrusion profile, 4444-rating
- Rheological properties
- Properties of the vulcanizates
- Aging in hot air 168 h / 100 °C



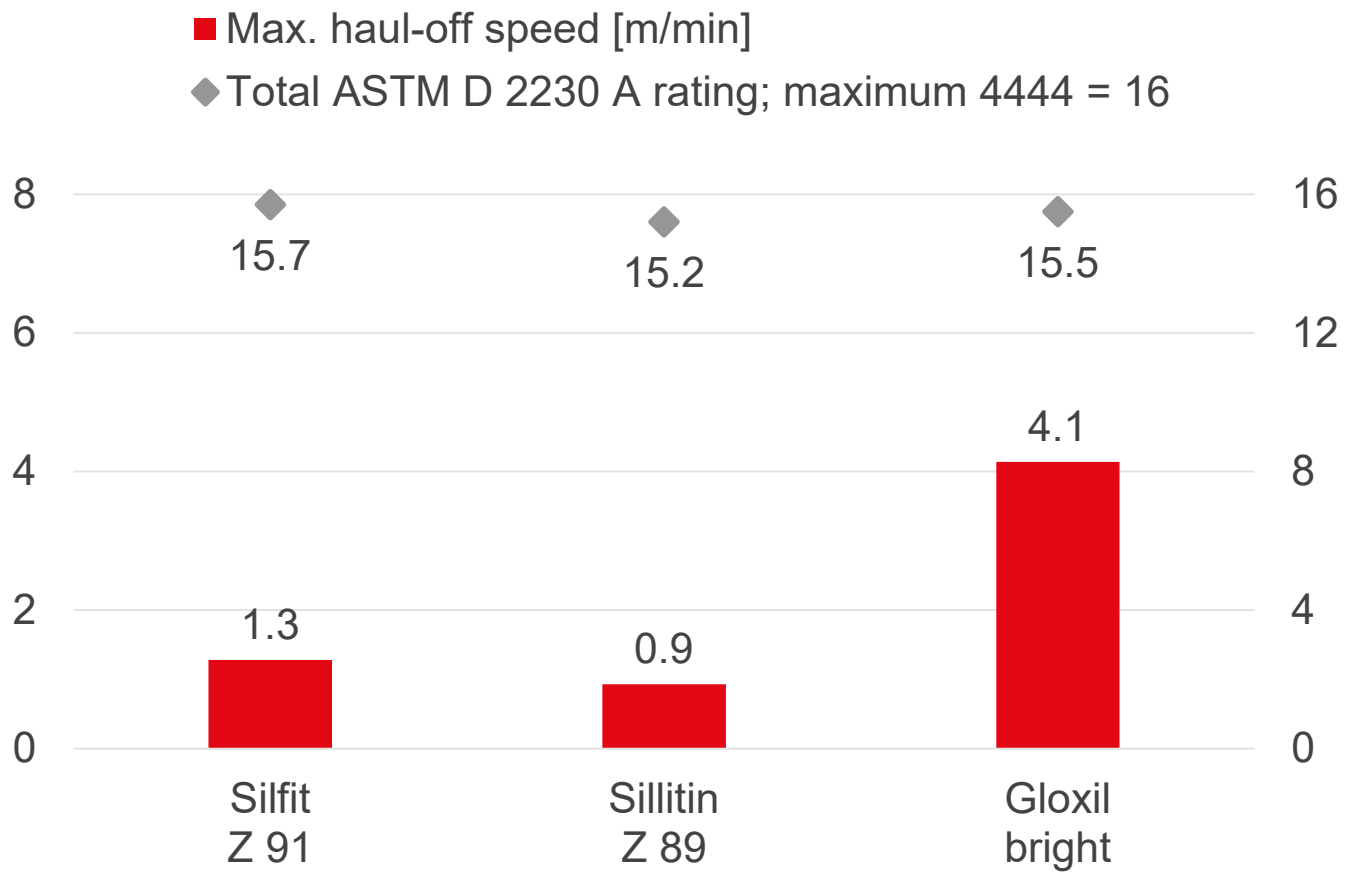
Garvey die extrusion profile, 4444-rating

ASTM D 2230

HOFFMANN MINERAL®

Wir geben Stoff für gute Ideen

Maximum haul-off speed for a smooth Garvey profile



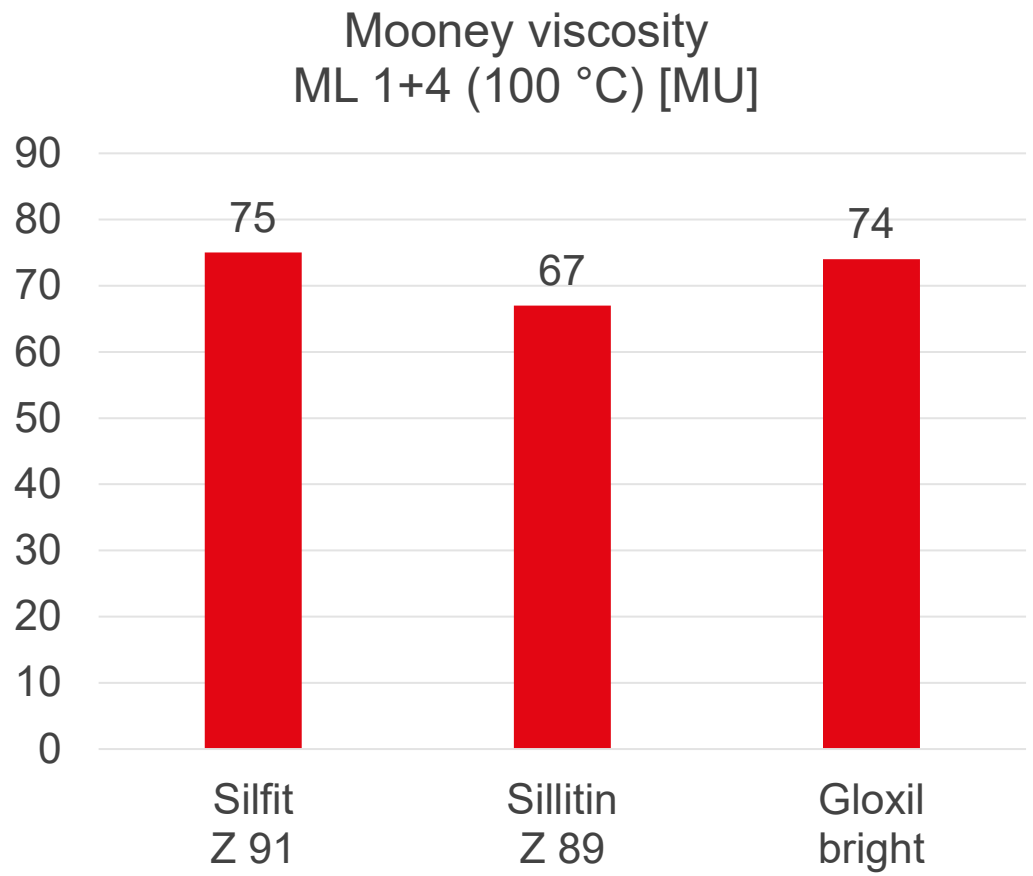
- Gloxil bright shows the best performance in Garvey profile extrusion.

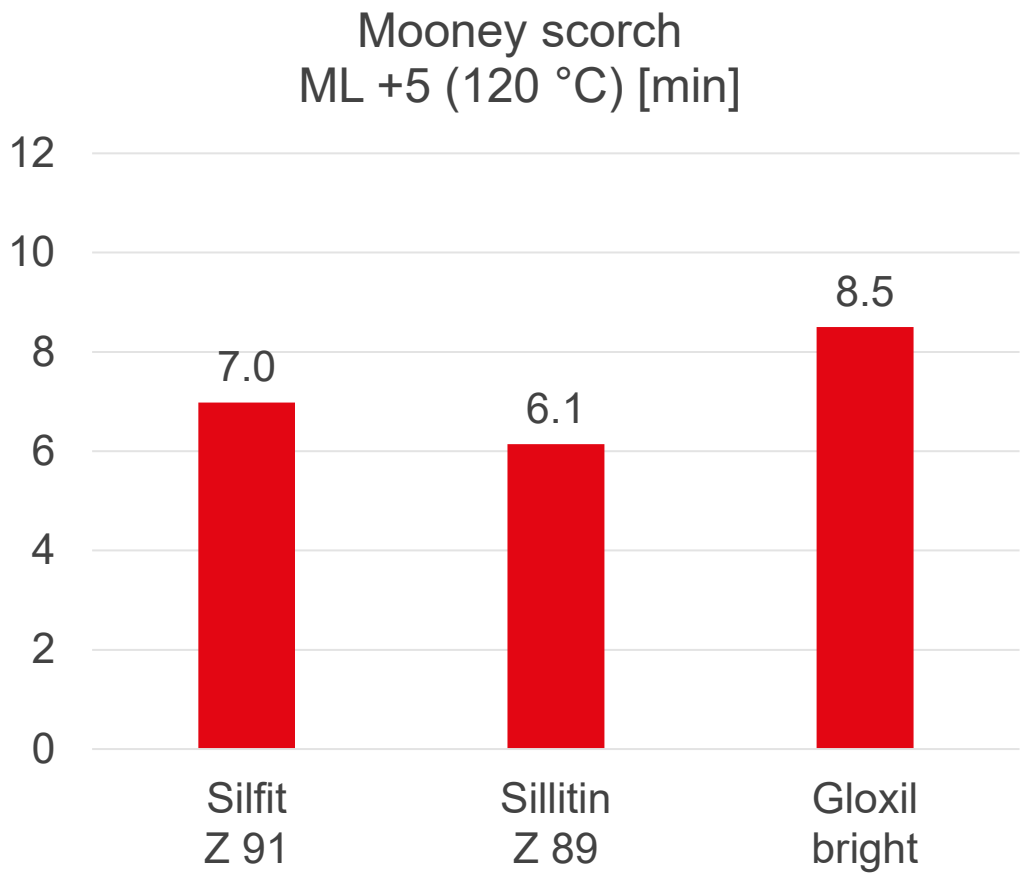
Rheological properties

DIN ISO 289-1
DIN ISO 289-2
DIN 53 529, parts 1 – 4

HOFFMANN MINERAL®
We supply materials for good ideas

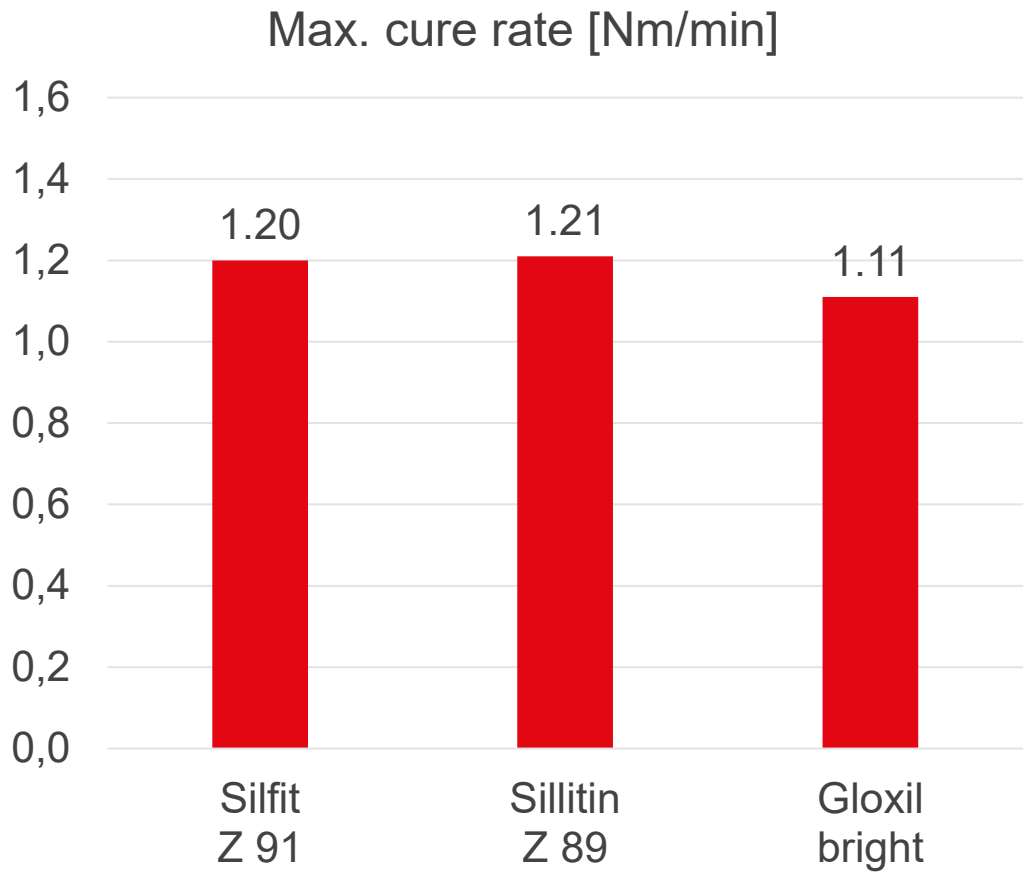
Mooney test

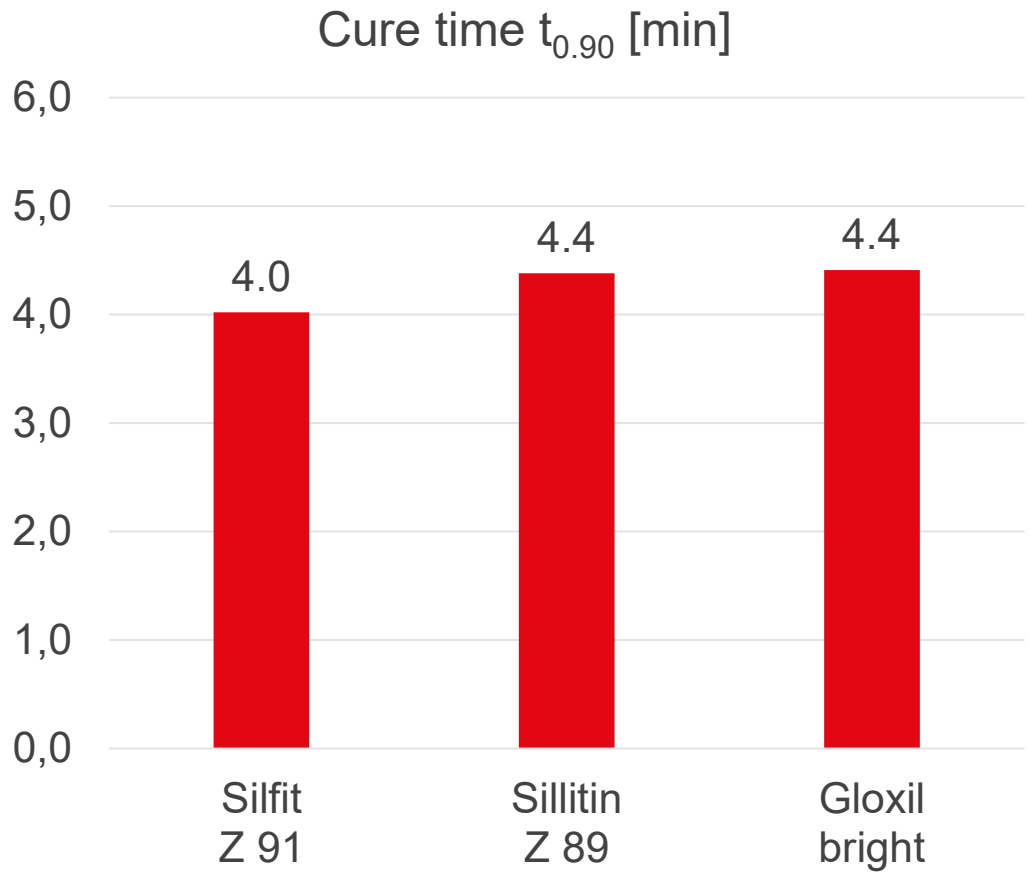




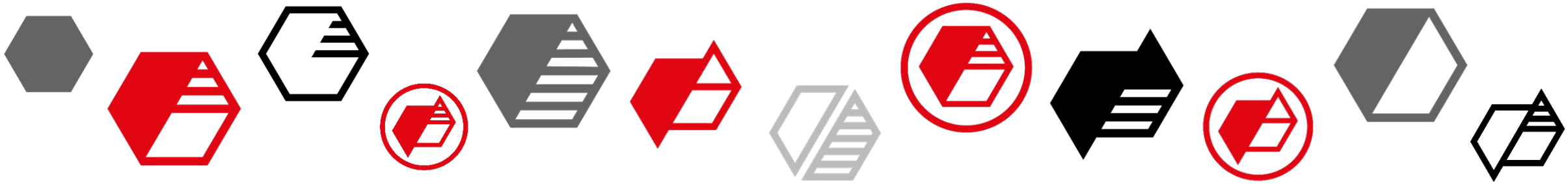
- Lower viscosity for the non-calcined product Sillitin Z 89.
- Slightly longer scorch time for Gloxil bright.

Rheology – Moving die rheometer, 180 °C , 0.2° arc





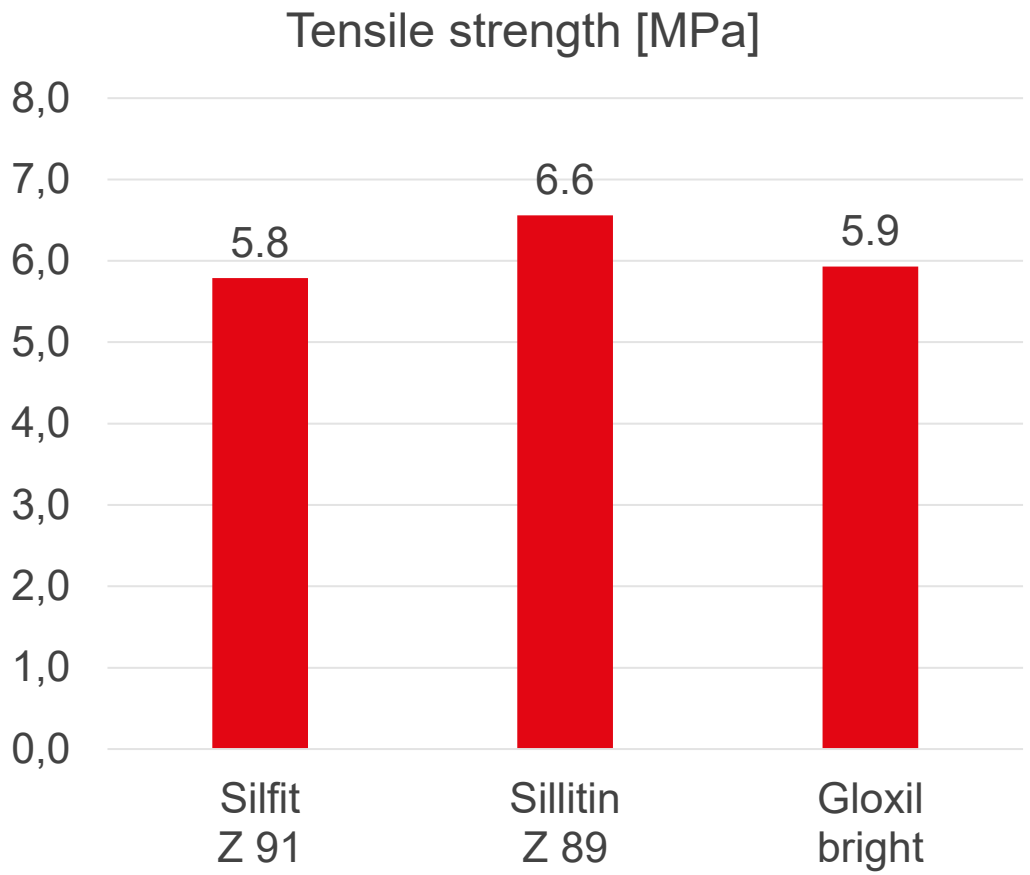
- Similar maximum cure rate and optimum cure time $t_{0.90}$ for all products.

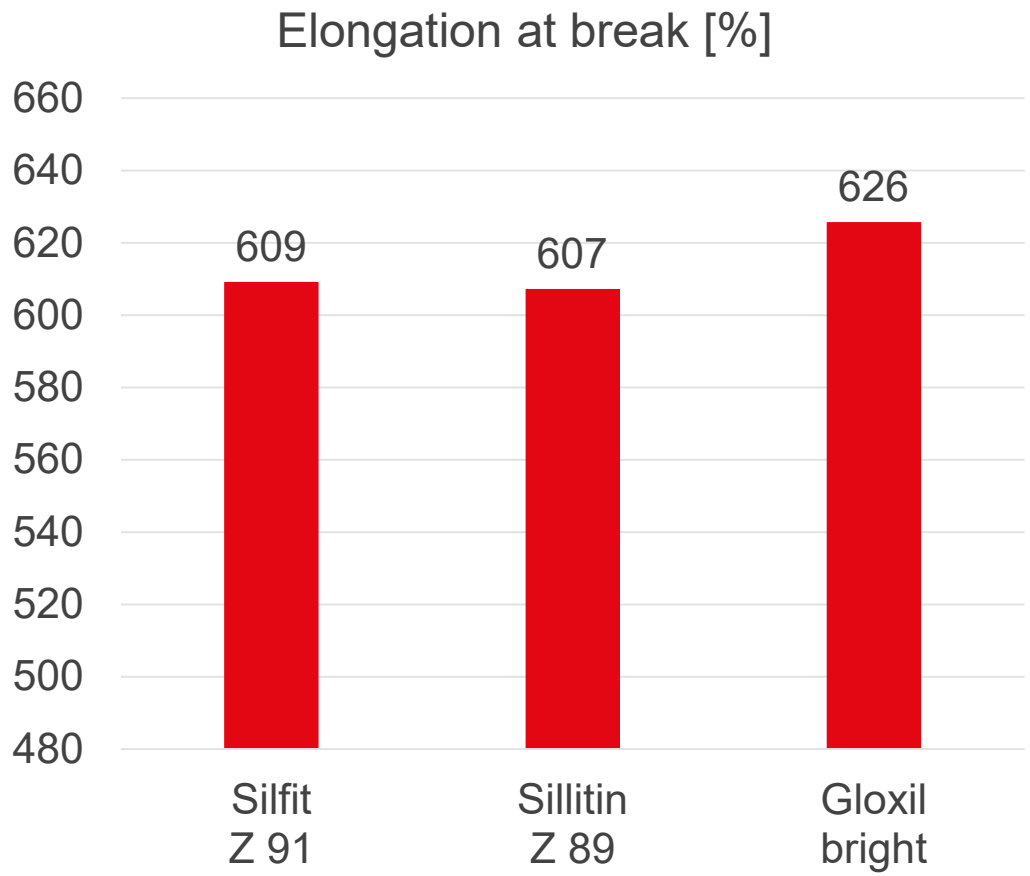


Properties of the vulcanizates

HOFFMANN MINERAL®
We supply materials for good ideas

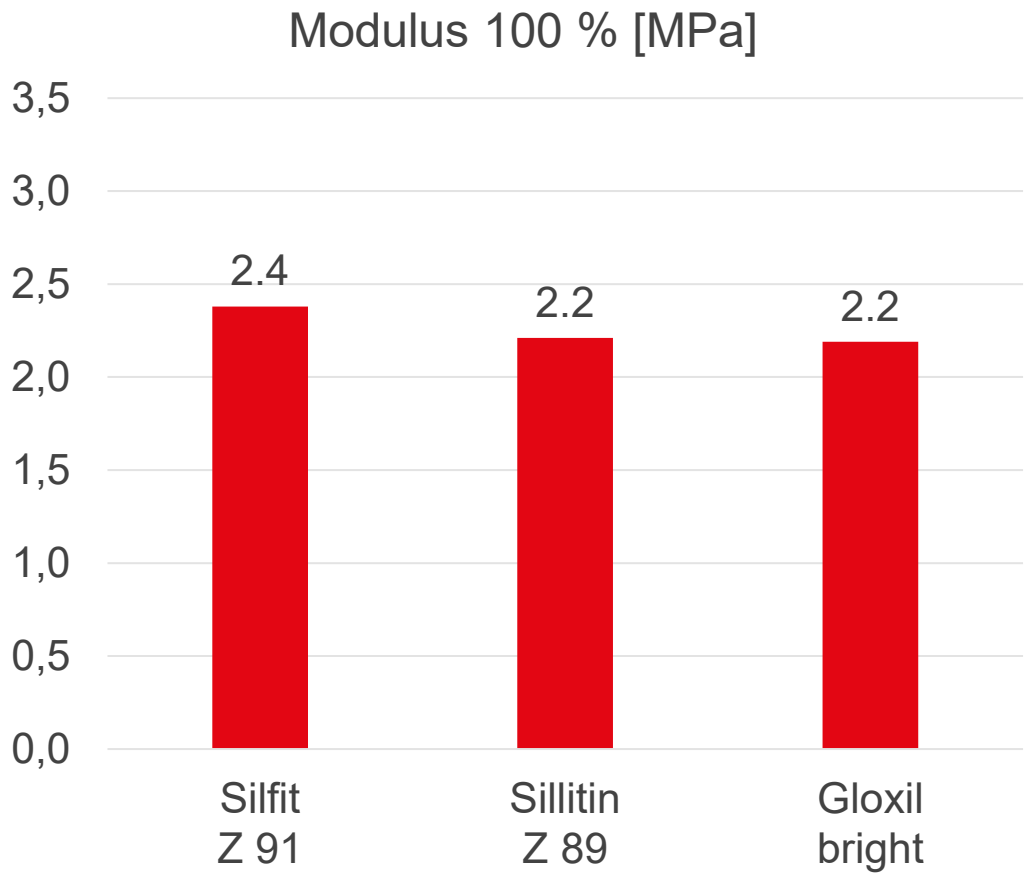
Mechanical properties

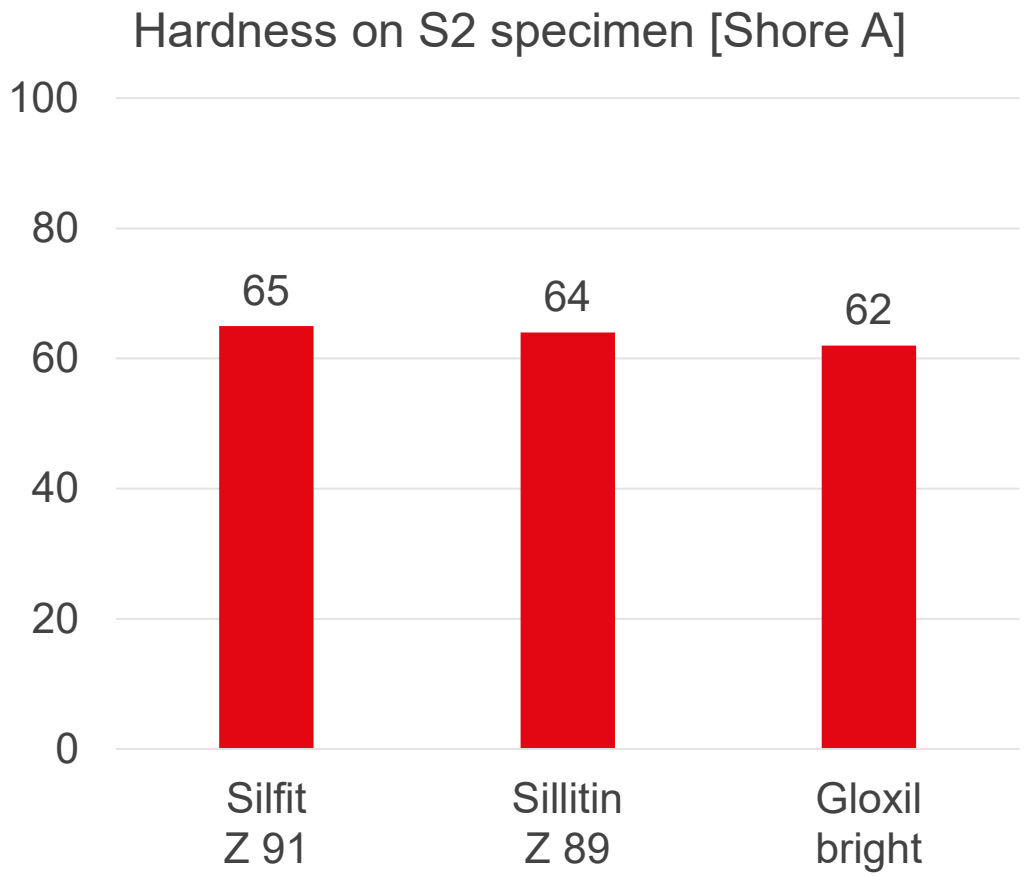




- Slightly higher tensile strength for the non-calcined product Sillitin Z 89.
- Similar elongation at break among all products.

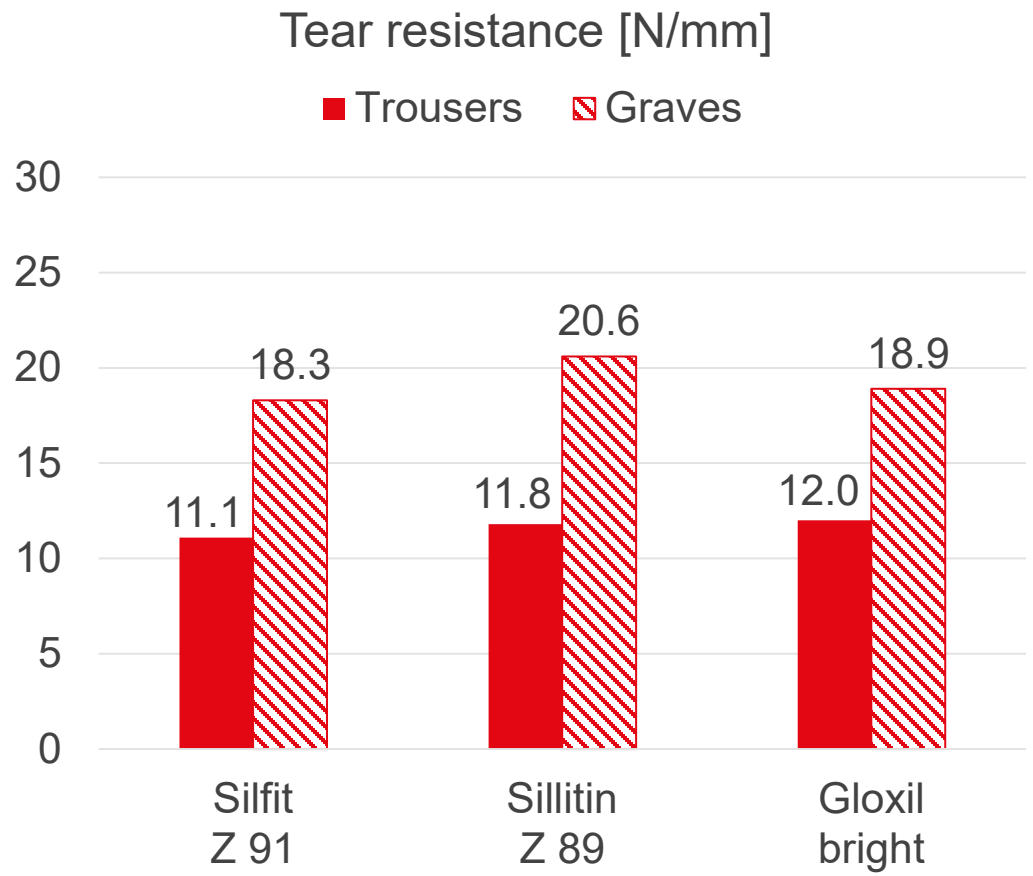
Mechanical properties

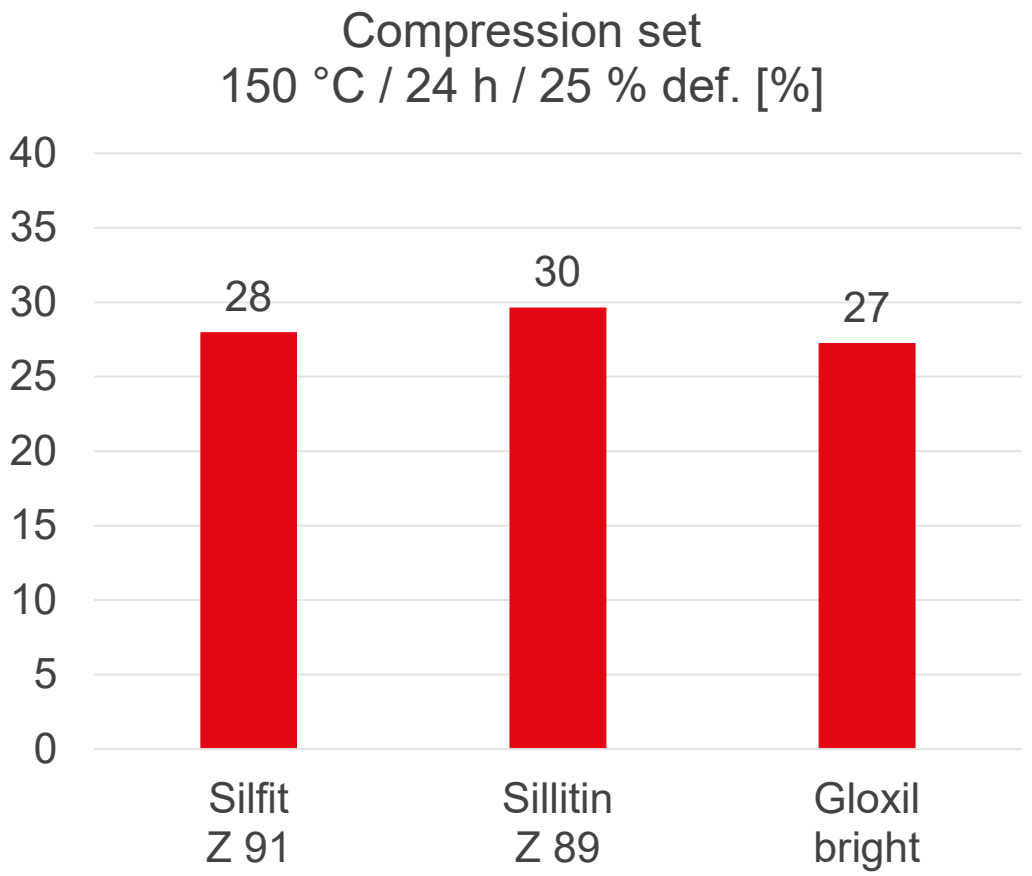




- Similar modulus 100 % and hardness for all products.

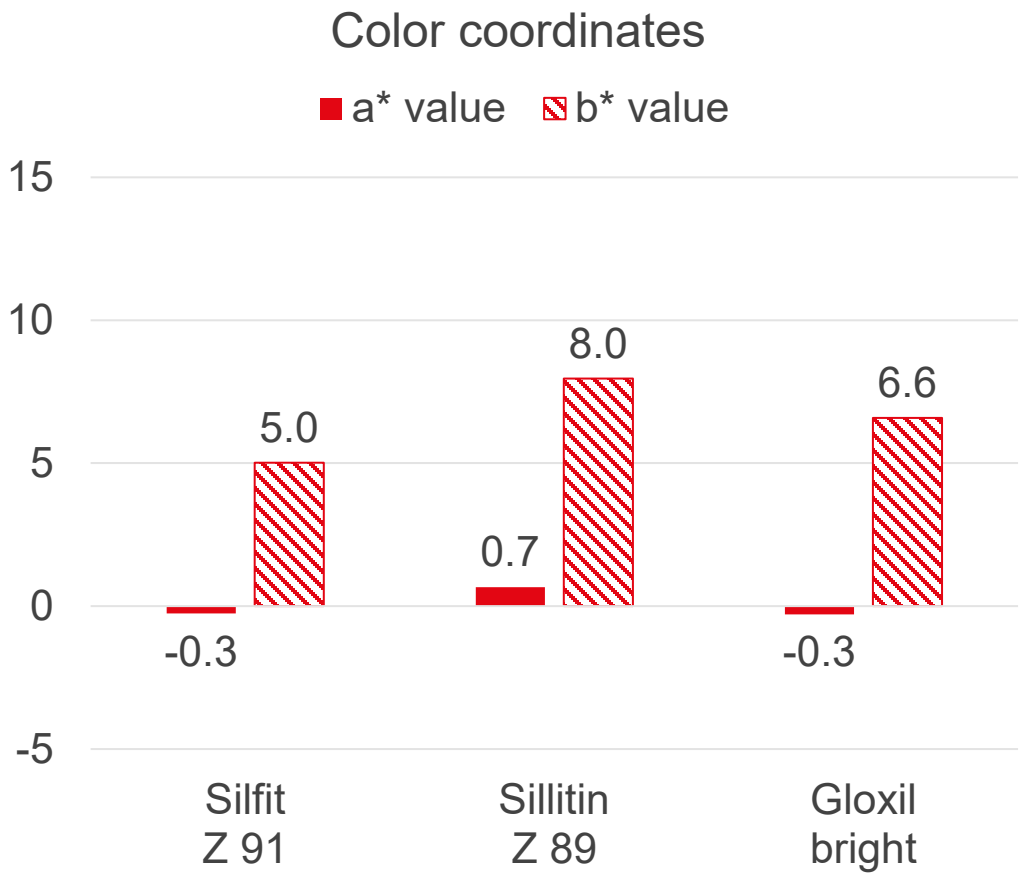
Mechanical properties

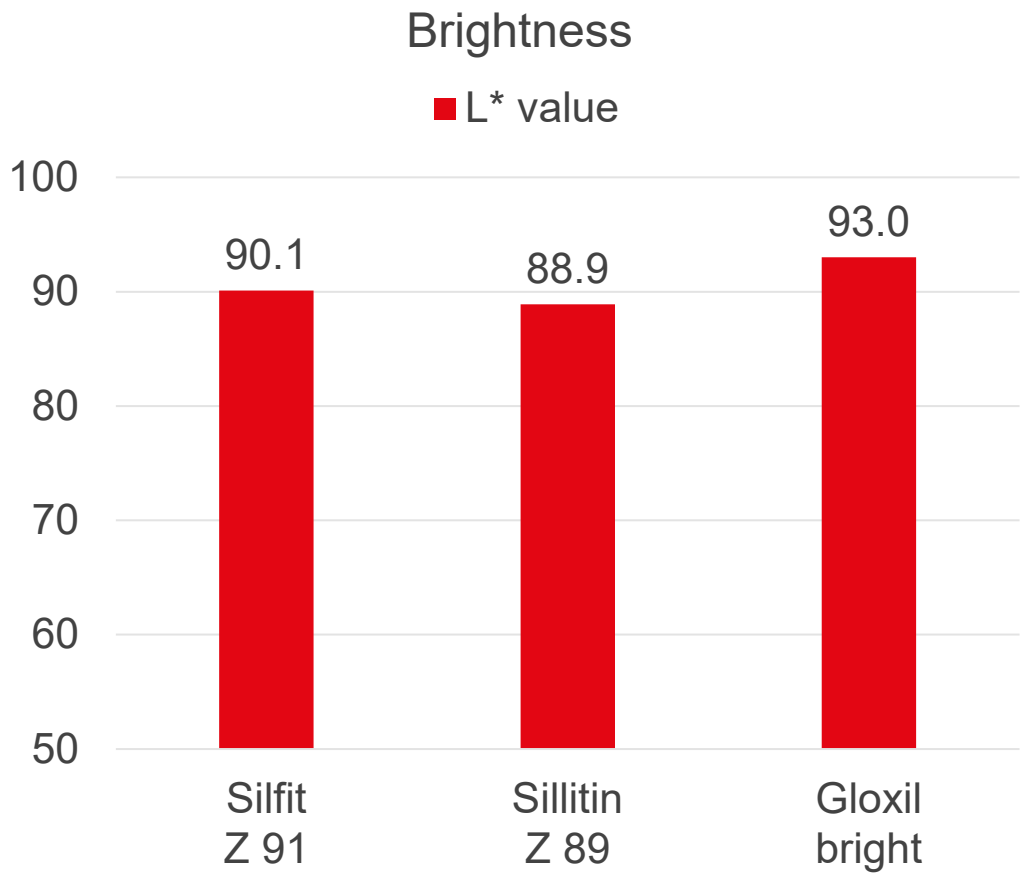




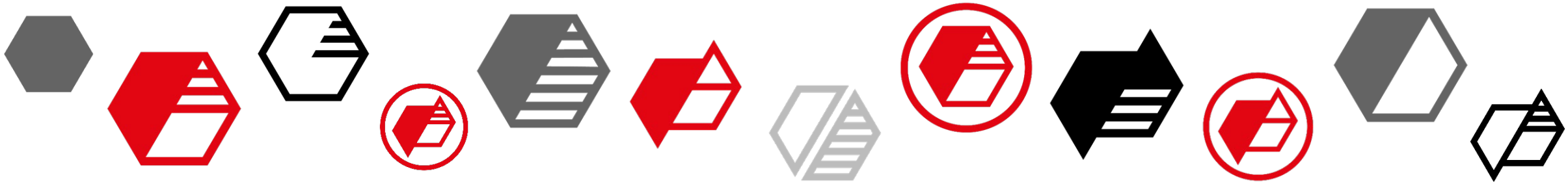
- Slightly higher tear resistance for Sillitin Z 89 in Graves specimens.
- Similar compression set for all products.

Color – Color coordinates and brightness





- Similar color coordinates and highest brightness for Gloxil bright.

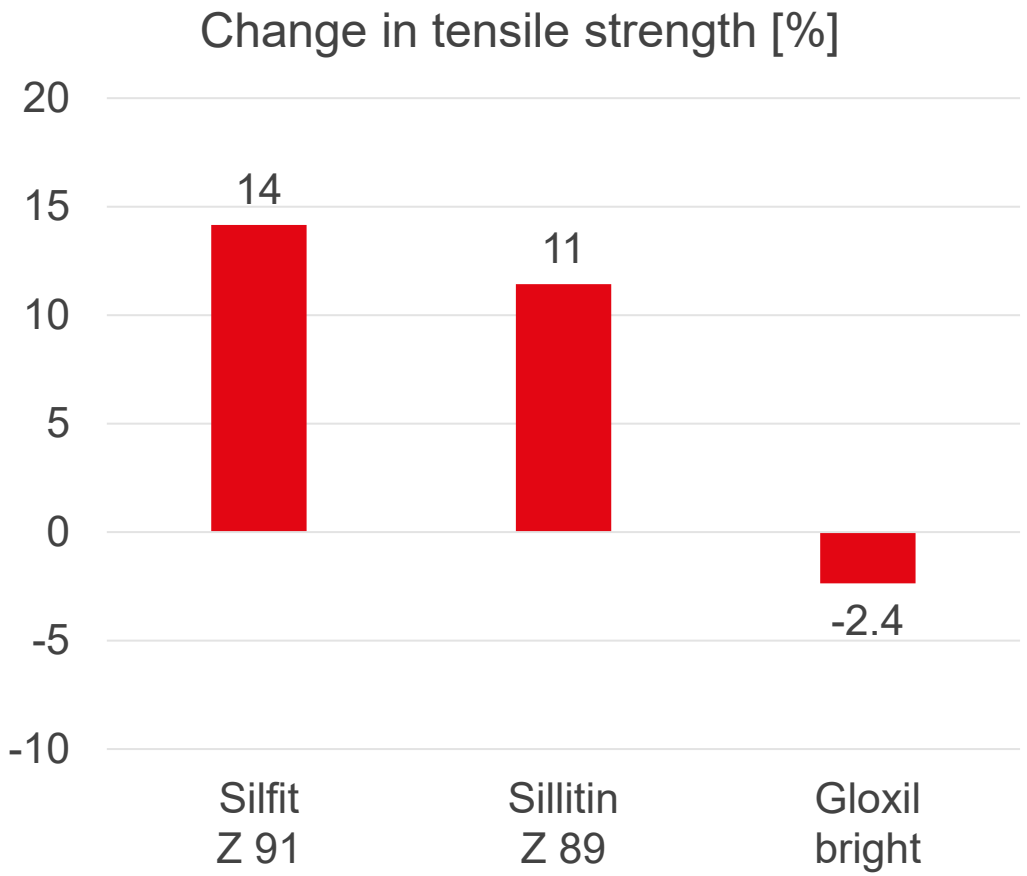


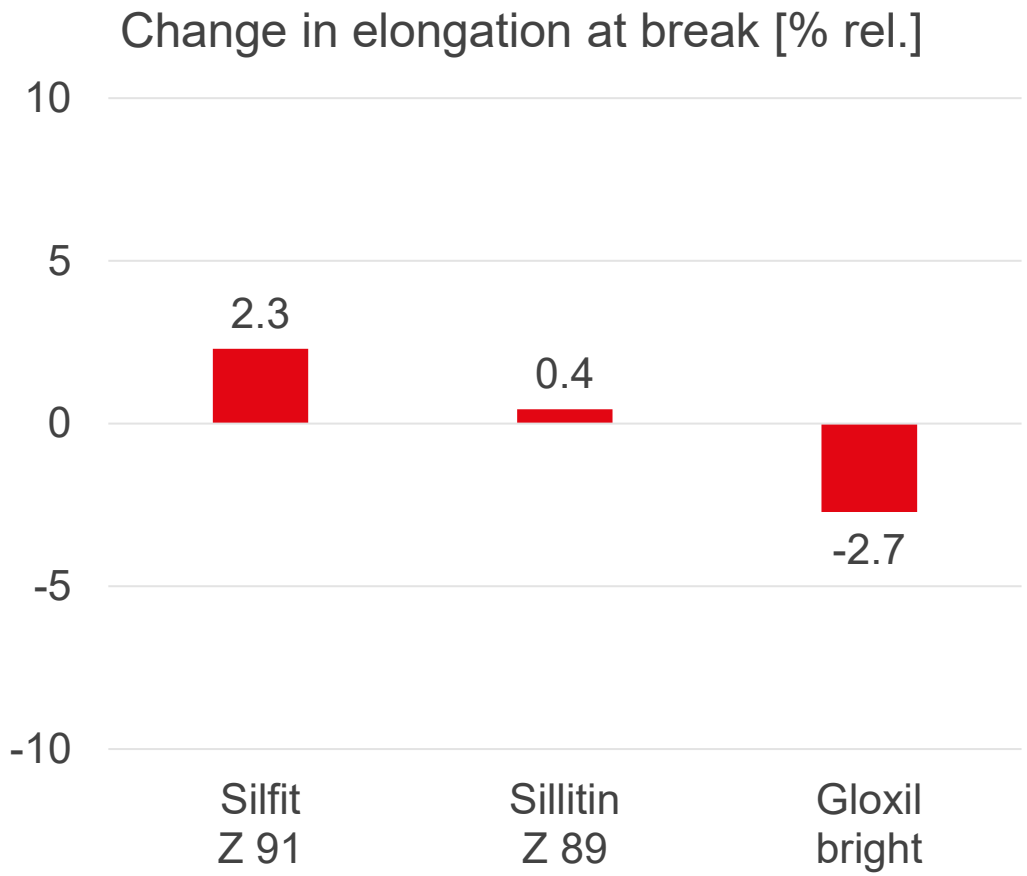
Aging in hot air 168 h / 100 °C

ISO 188, D

HOFFMANN MINERAL®
We supply materials for good ideas

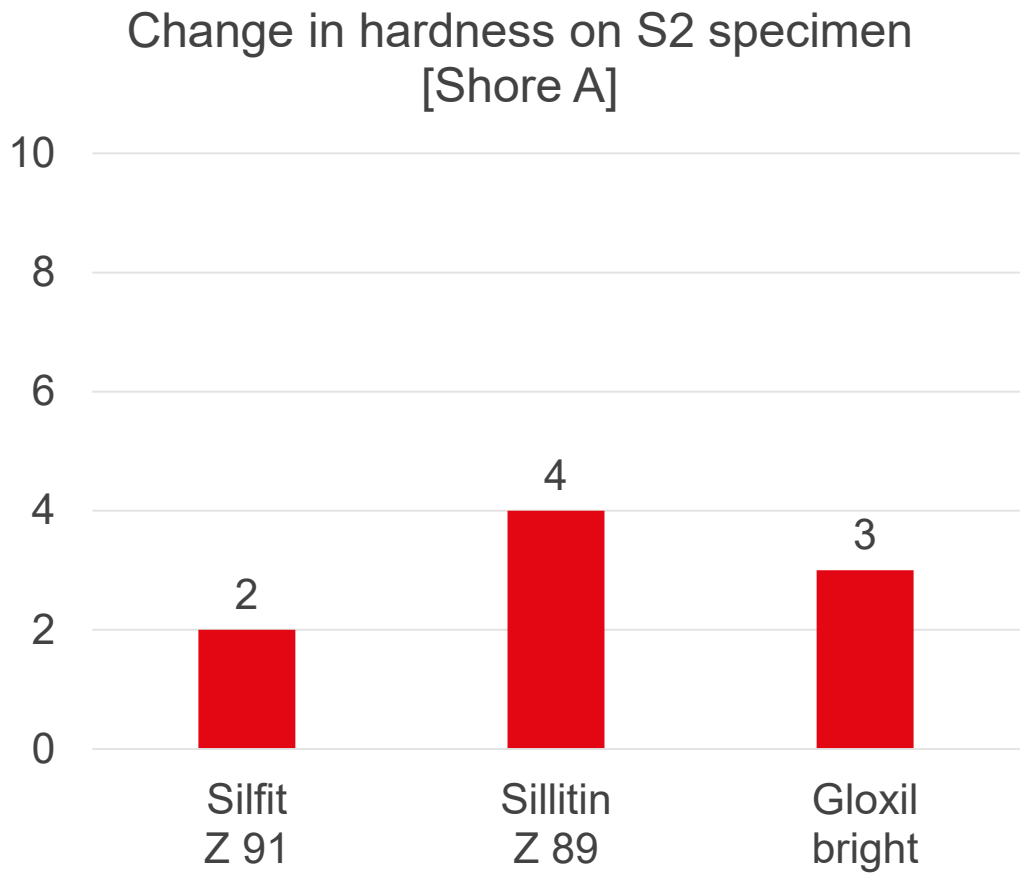
Aging in hot air 168 h / 100 °C





- Similar change in tensile strength for Sillitin Z 89.
- Similar change in elongation at break for all products.

Aging in hot air 168 h / 100 °C



- Similar change in hardness among all products.

Alternative fillers vs. Silfit Z 91

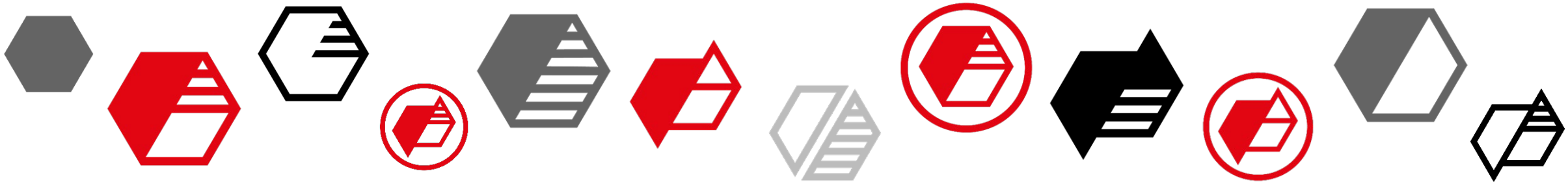
65 Shore A	Sillitin Z 89	Gloxil bright
Mooney viscosity	+	=
Scorch time	=	+
Max. cure rate	=	=
Cure time $t_{0.90}$	=	=
Max. extrusion speed for the Garvey profile		+
Tensile strength	+	=
Elongation at break	=	=
Modulus 100 %	=	=
Tear resistance – Trousers	=	=
Tear resistance – Graves	+	=
Compression set 150 °C , 24 h	=	=
Hot-air resistance 100 °C , 168 h	=	=
Color – Color coordinates		=
Color – Brightness		+

We supply materials for good ideas!

HOFFMANN MINERAL GmbH
Muenchener Straße 75
DE-86633 Neuburg (Donau)

Phone: +49 8431 53-0
Internet: www.hoffmann-mineral.com
E-mail: info@hoffmann-mineral.com

Our applications engineering advice and the information contained in this memorandum are based on experience and are made to the best of our knowledge and belief, they must be regarded however as non-binding advice without guarantee. Working and employment conditions over which we have no control exclude any damage claim arising from the use of our data and recommendations. Furthermore we cannot assume any responsibility for patent infringements, which might result from the use of our information.



Results in tabular form

HOFFMANN MINERAL®
We supply materials for good ideas

Results in tabular form – Garvey die extrusion test

			Silfit Z 91	Sillitin Z 89	Gloxil bright
Maximum haul-off speed		m/min	1.3	0.9	4.1
4444-rating	Extrusion swelling	-	4	4	4
	30° edge	-	4	4	3.5
	Surface appearance	-	4	4	4
	Corners	-	3.7	3.2	4.0
	Total	-	15.7	15.2	15.5

Results in tabular form – Rheological and mechanical properties

		Silfit Z 91	Sillitin Z 89	Gloxil bright
Mooney viscosity, ML 1+4, 100 °C	MU	75	67	74
Mooney scorch, ML +5, 120 °C	min	7.0	6.1	8.5
Max. cure rate, 180 °C	Nm/min	1.20	1.21	1.11
Cure yield, 180 °C	Nm	0.781	0.755	0.753
Cure time $t_{0.05}$, 180 °C	min	0.25	0.23	0.27
Cure time $t_{0.90}$, 180 °C	min	4.0	4.4	4.4
Tensile strength	MPa	5.8	6.6	5.9
Elongation at break	%	609	607	626
Modulus 100 %	MPa	2.4	2.2	2.2
Modulus 300 %	MPa	3.5	3.3	3.1
Hardness	Shore A	65	64	62
Tear resistance – Trousers specimen	N/mm	11.1	11.8	12.0
Tear resistance – Graves specimen	N/mm	18.3	20.6	18.9
Compression set 24 h / 150 °C / 25 % deformation	%	28	30	27

Results in tabular form – Aging in hot air

		Silfit Z 91	Sillitin Z 89	Gloxil bright
Aging in hot air 168 h / 100 °C				
Tensile strength	MPa	6.6	7.3	5.8
Elongation at break	%	623	610	609
Modulus 100 %	MPa	2.7	2.6	2.4
Hardness	Shore A	67	68	65
Δ Tensile strength	%	14	11	-2.4
Δ Elongation at break	% rel.	2.3	0.4	-2.7
Δ Modulus 100 %	%	11	17	8.7
Δ Hardness	Shore A	2	4	3