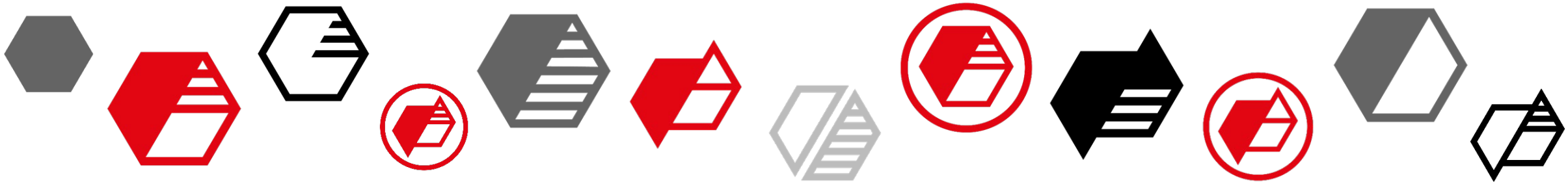

Neuburg Siliceous Earth
vs wollastonite and barium sulfate
in peroxide cured FKM

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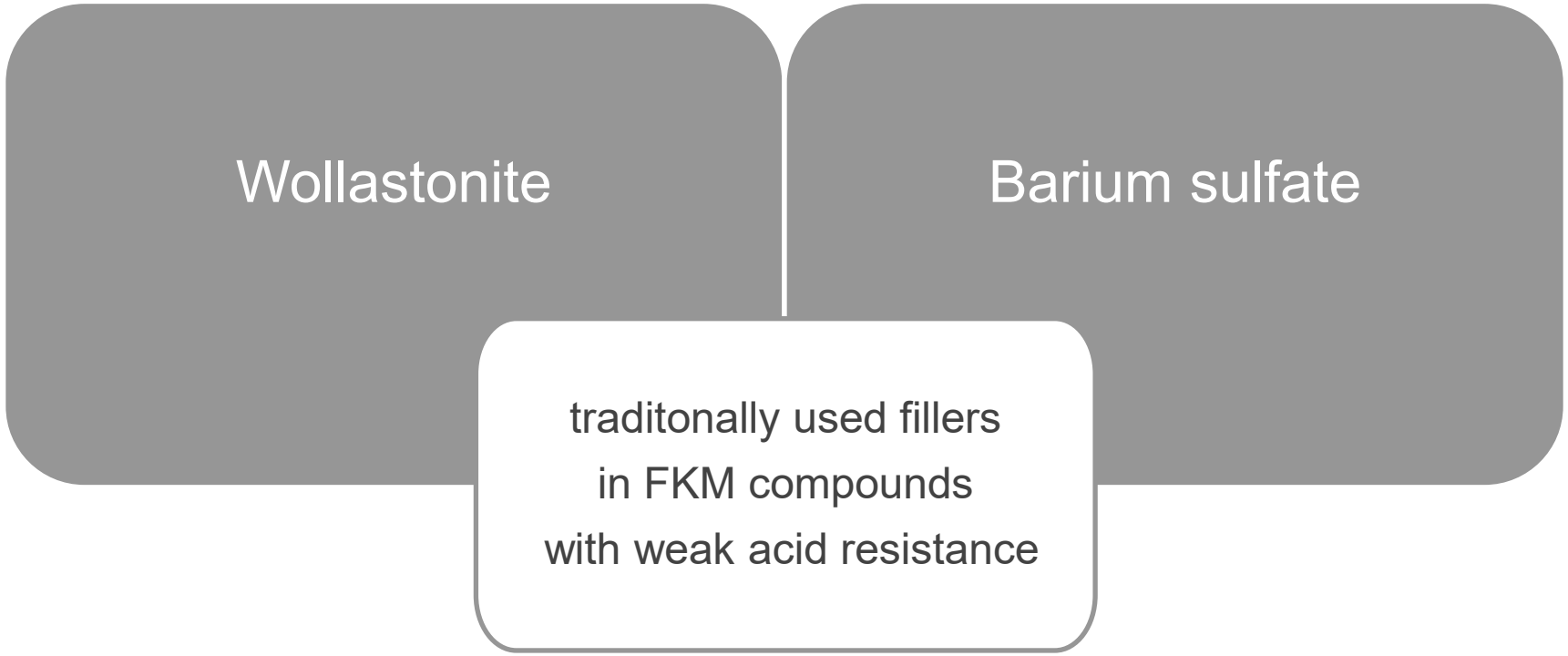
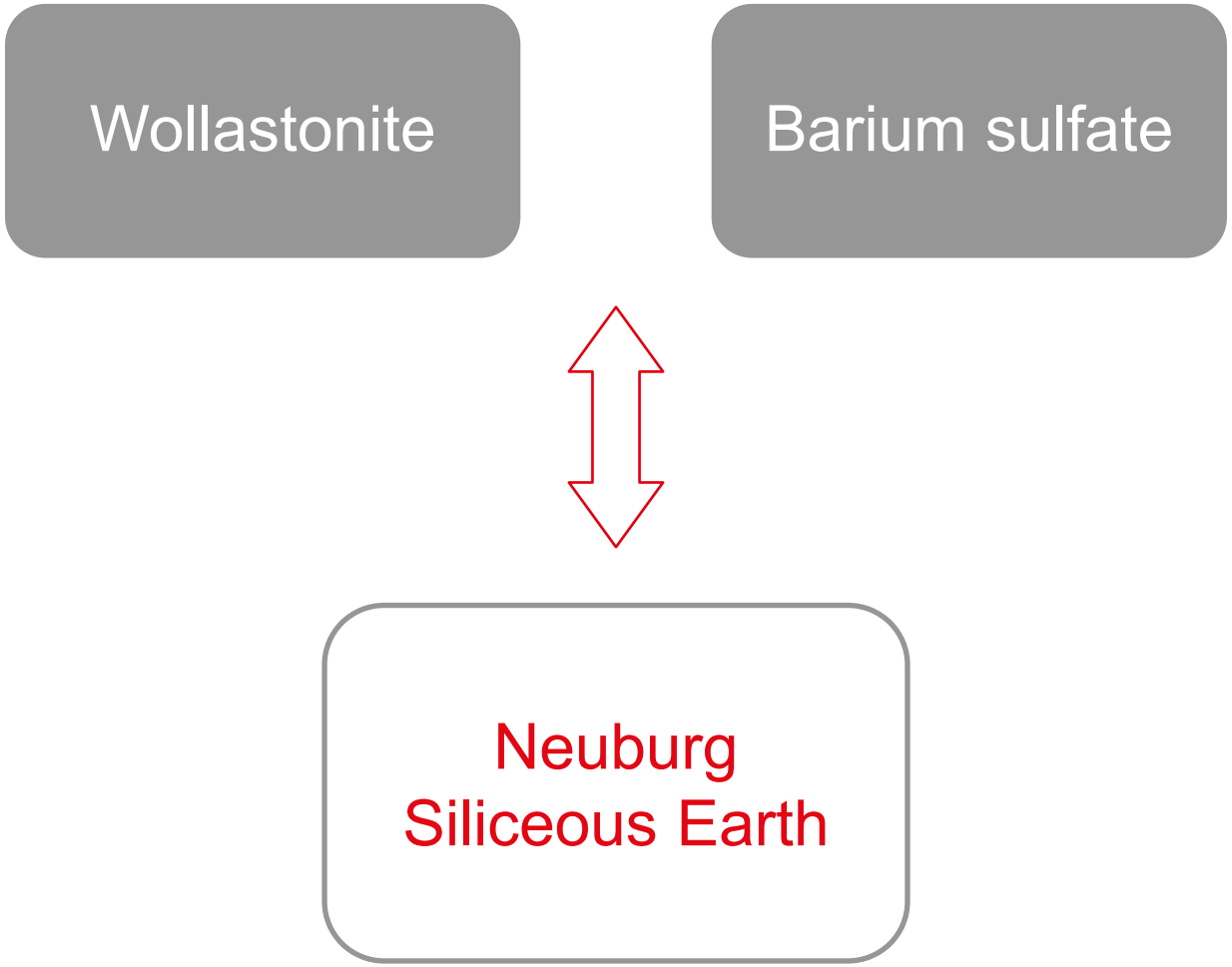
Status quo


Wollastonite
Barium sulfate
traditonally used fillers
in FKM compounds
with weak acid resistance

Objective



Fillers and characteristics

Filler	Description	Functionalization
Wollastonite AST	Calcium silicate, d_{50}: 3.5 µm	Amino
Wollastonite EST	Calcium silicate, d_{50}: 3.5 µm	Epoxy
Barium sulfate	ppt. barium sulfate, d_{50}: 3.0 µm	-
Sillitin Z 86	Neuburg Siliceous Earth d_{50}: 2.4 µm	-
Sillitin V 88	Neuburg Siliceous Earth, d_{50}: 5.0 µm	-
Aktisil AM	Neuburg Siliceous Earth, d_{50}: 2.4 µm	Amino
Aktisil VM 56	Neuburg Siliceous Earth, d_{50}: 2.4 µm	Vinyl
Aktisil Q	Neuburg Siliceous Earth, d_{50}: 5.0 µm	Methacryl

Formulation

		Woll. AST	Woll. EST	Bar.sulf.	NSE
Viton GAL-200S	66 % flourine, 25 MU (ML 1+10, 121 °C) terpolymer (HFP+VFD+TFE)	100	100	100	100
Zinkoxyd aktiv	Zink oxyde	3	3	3	3
Diak No. 7	co-activator TAIC	3	3	3	3
Varox DBPH-50	2,5-dimethyl-2,5-di(tertbutylperoxy)-hexan e	2	2	2	2
Wollastonite AST	Filler	30	-	-	-
Wollastonite EST	Filler	-	30	-	-
Barium sulfate	Filler	-	-	49	-
NSE	Filler	-	-	-	30
Hardness range: 65 Shore A					

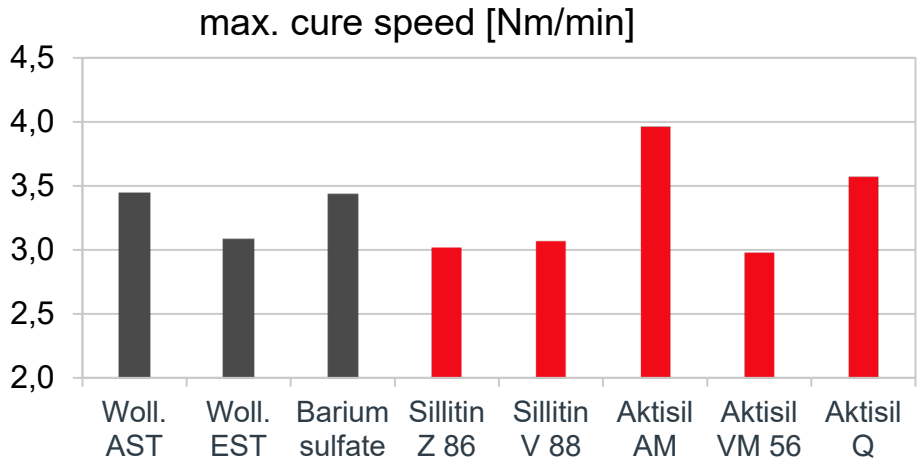
Compound preparation and curing

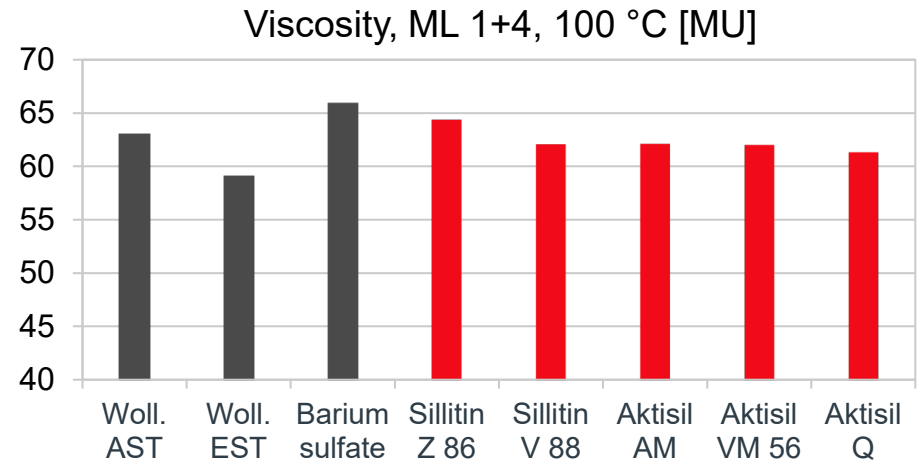
Mixing	
Open mill	Ø 150 x 300 mm
Batch weight	ca. 1 kg
Temperature	50 °C 30 °C for removing the sheet off the mill
Mixing time	approx. 15 min.
Curing and post-cure	
Cure	7 min. / 177 °C
Post-cure	2 h / 232 °C
All values shown refer to post-cured specimens unless otherwise noted.	

Tests

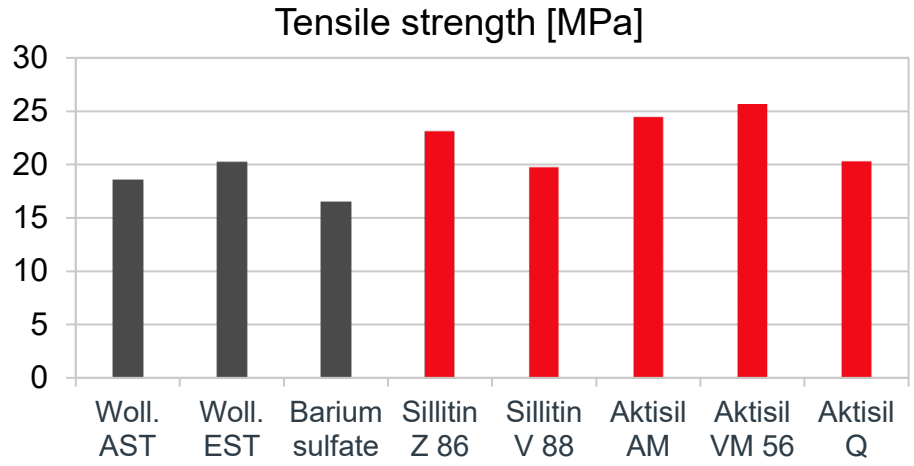
Test	Standard	Conditions
Mooney Viscosity ML 1+4	DIN 53 523, part 3	100 °C
Curemeter testing	DIN 53 529, part 1 – 4	177 °C, 0.2 ° deflection
Tensile test	DIN 53 504, S2	
Compression set	DIN ISO 815-1, type B	70 h / 200 °C / 25 % defl. 70 h / 232 °C / 25 % defl..
Compression set	VW PV 3307	94 h / 23 °C / 50 % defl.. / 5 s 94 h / 150 °C / 50 % defl. / 5 s
Tear resistance	DIN ISO 34-1, A	
Storage in hot air	DIN 53 508	504 h / 210 °C, measured 30‘ after exposure 94 h / 230 °C, measured 30‘ after exposure
Immersion in liquid media	DIN ISO 1817	Fuel FAM B, 70 / 23 °C Oil OS206304, 168 h / 150 °C Acetic acid pH3, 168 h / 100 °C

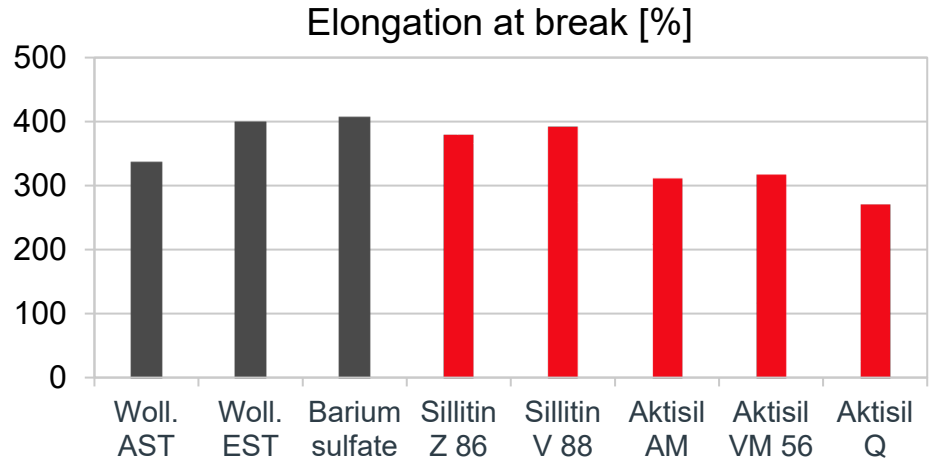
Rheology

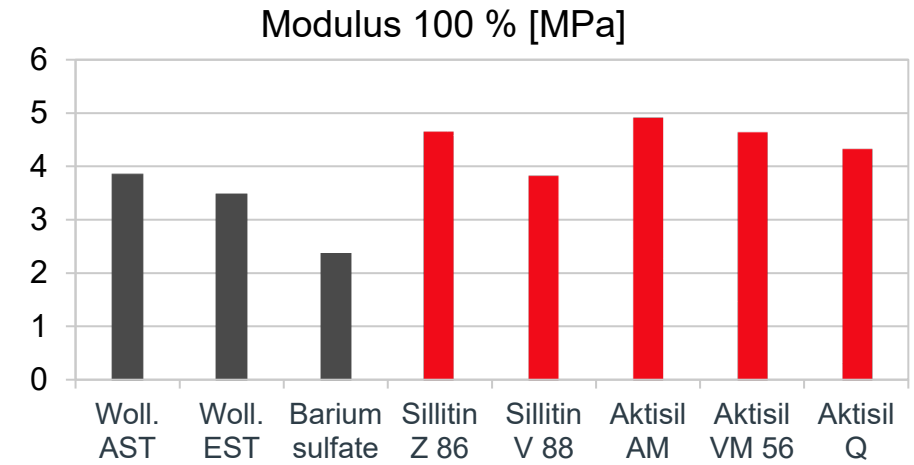

max. cure speed [Nm/min]
4,5
4,0
3,5
3,0
2,5
2,0
Woll. AST
Woll. EST
Barium sulfate
Sillitin Z 86
Sillitin V 88
Aktisil AM
Aktisil VM 56
Aktisil Q

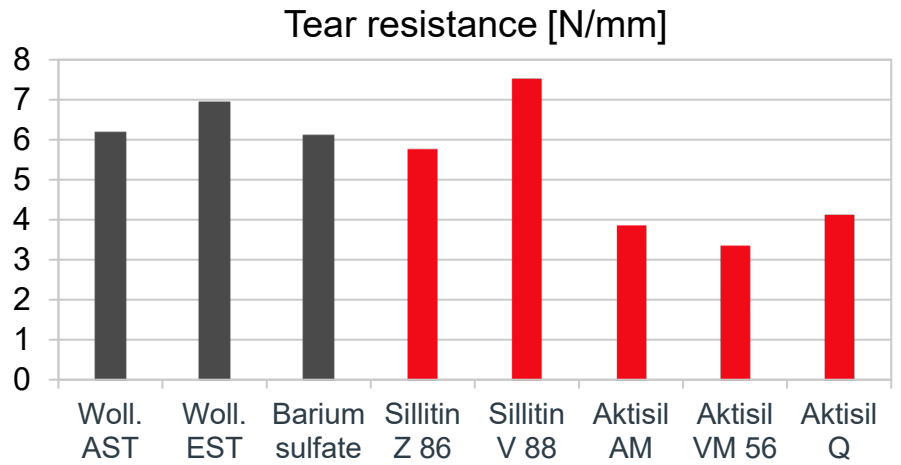

Viscosity, ML 1+4, 100 °C [MU]
70
65
60
55
50
45
40
Woll. AST
Woll. EST
Barium sulfate
Sillitin Z 86
Sillitin V 88
Aktisil AM
Aktisil VM 56
Aktisil Q

Tensile tests

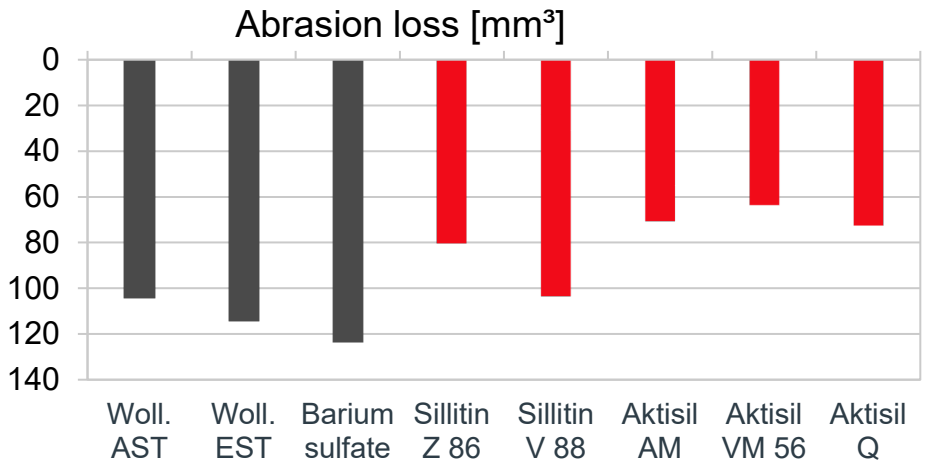




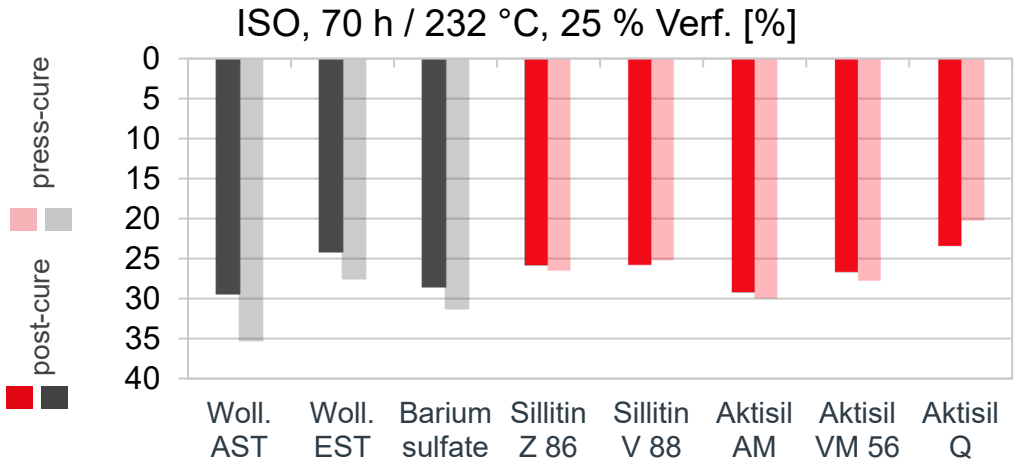


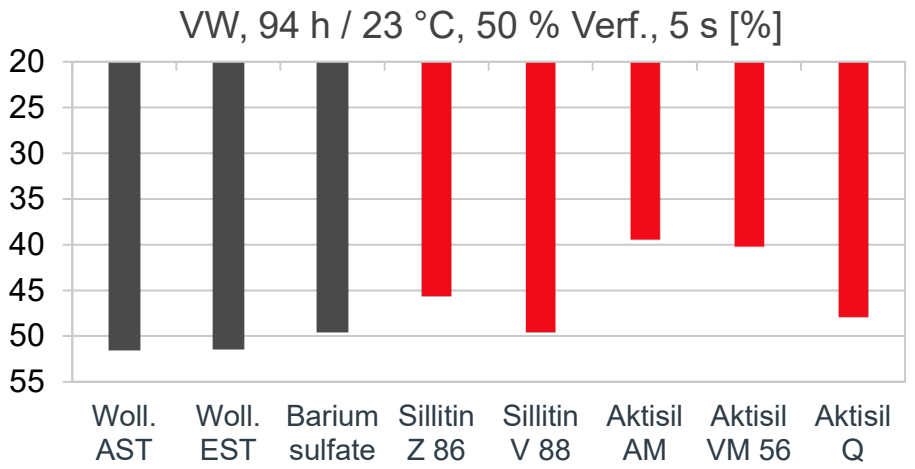


Abrasion resistance

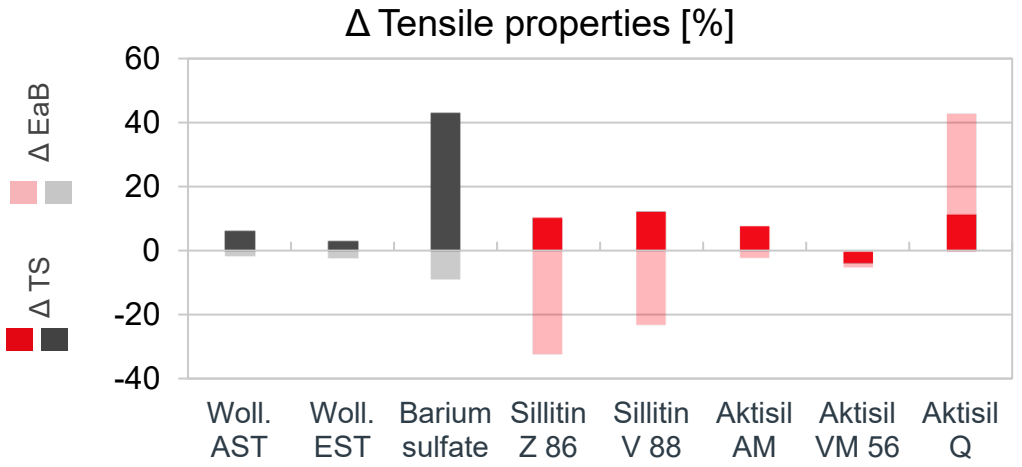


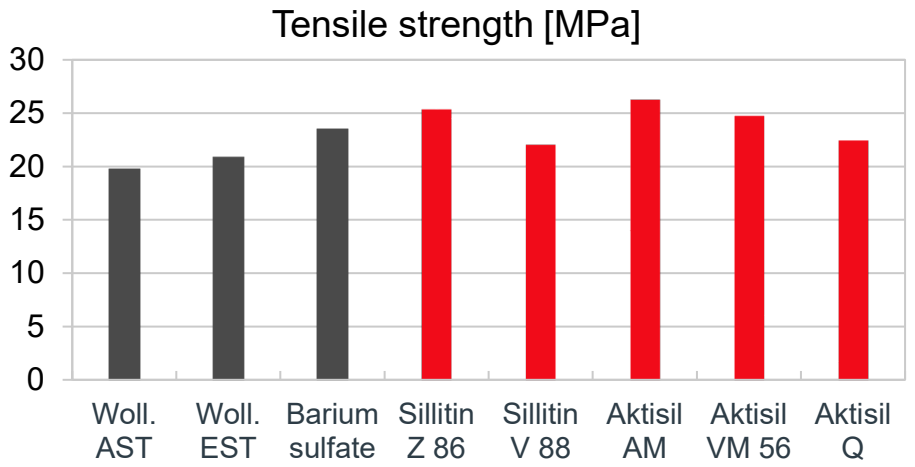
Compression set



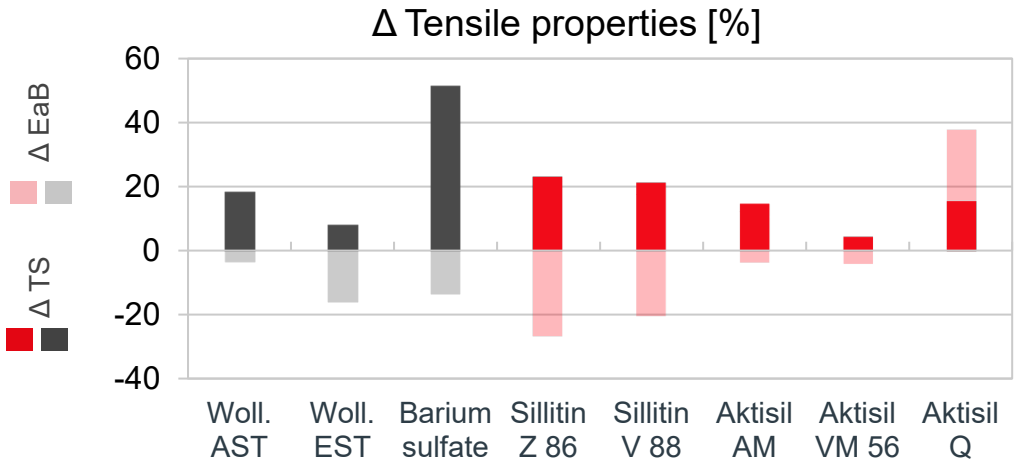


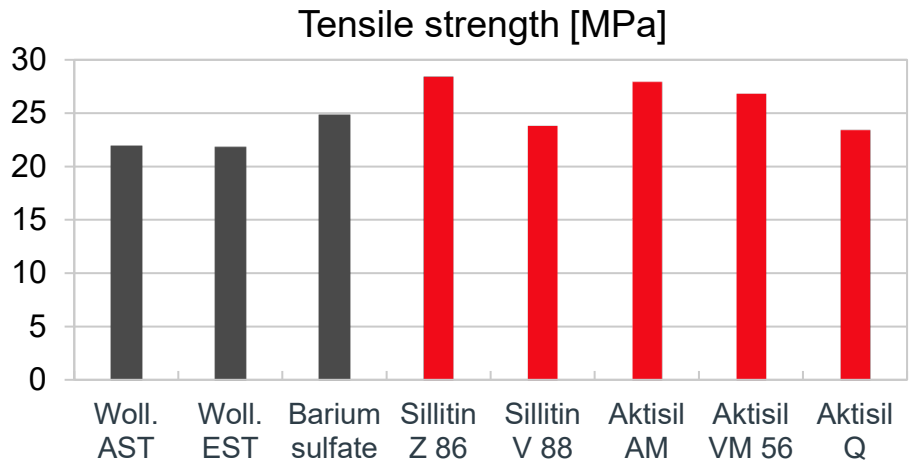
Resistance to hot air, 504 h / 210 °C



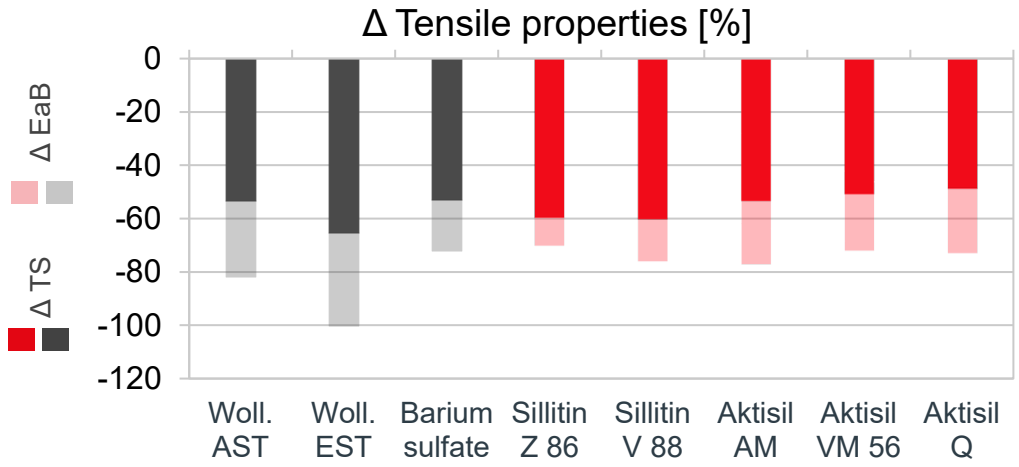


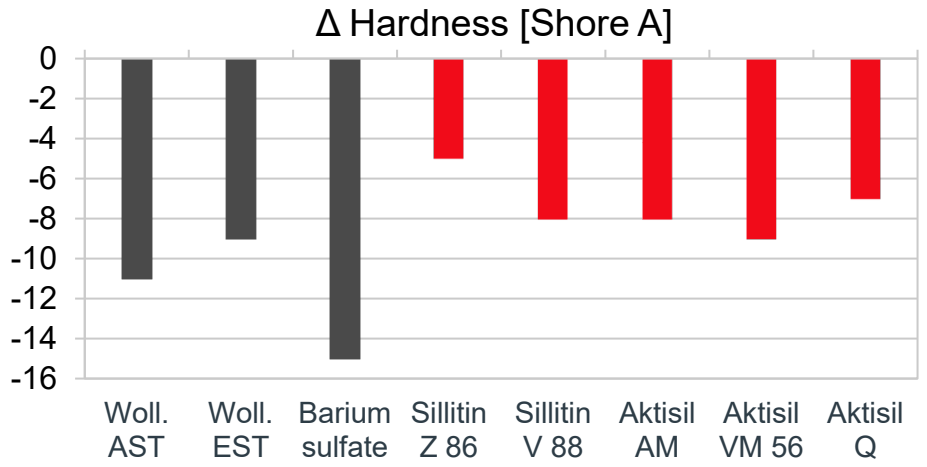
Resistance to hot air, 94 h / 230 °C

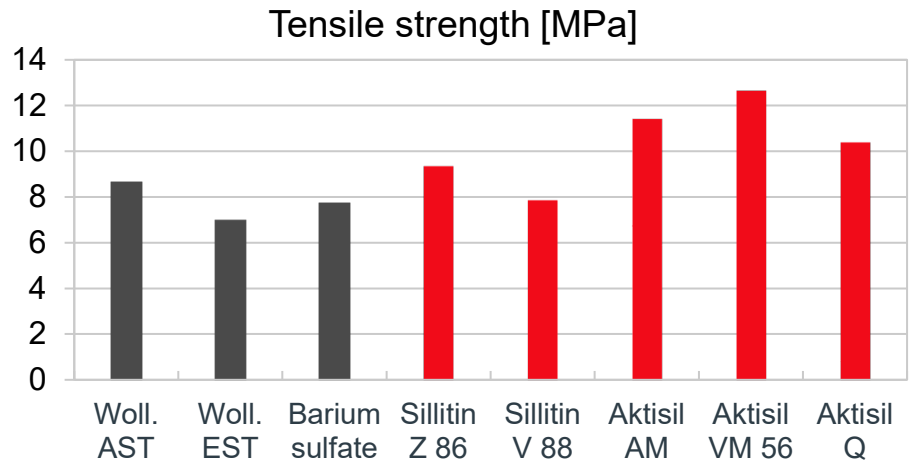




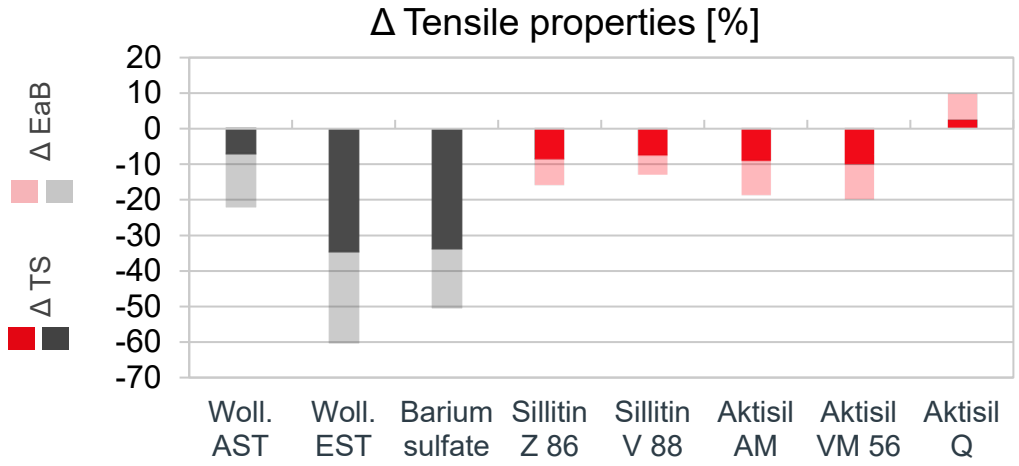
Resistance to fuel, 72 h / 23 °C

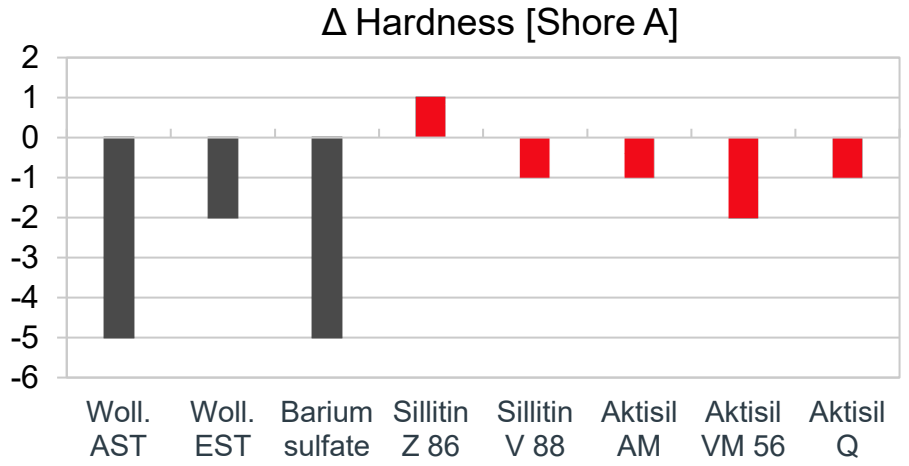


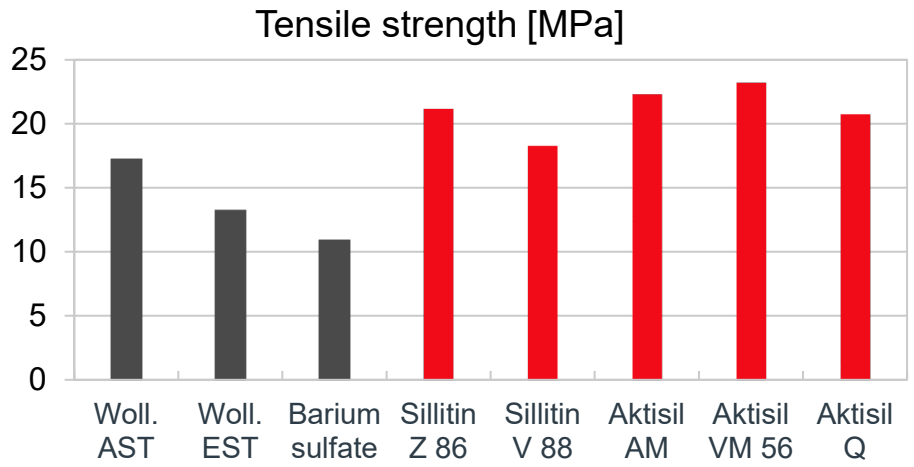




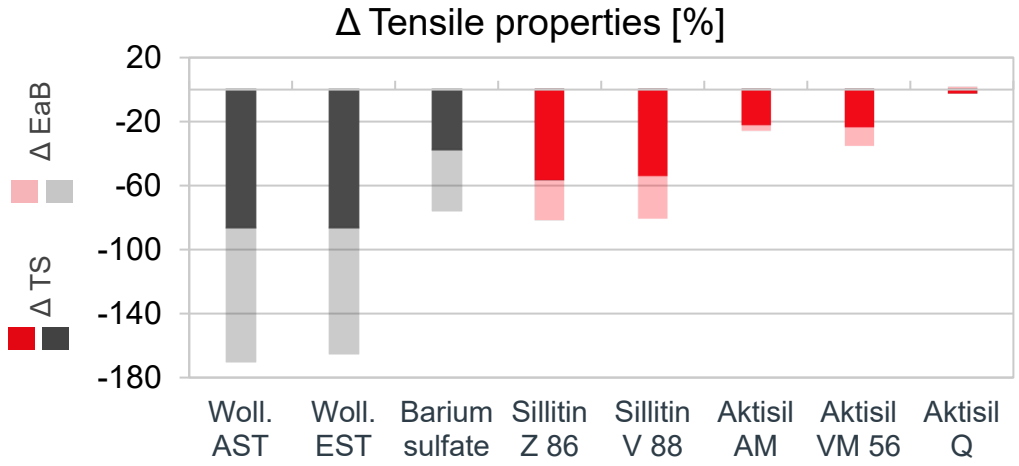
Resistance to oil, 168 h / 150 °C

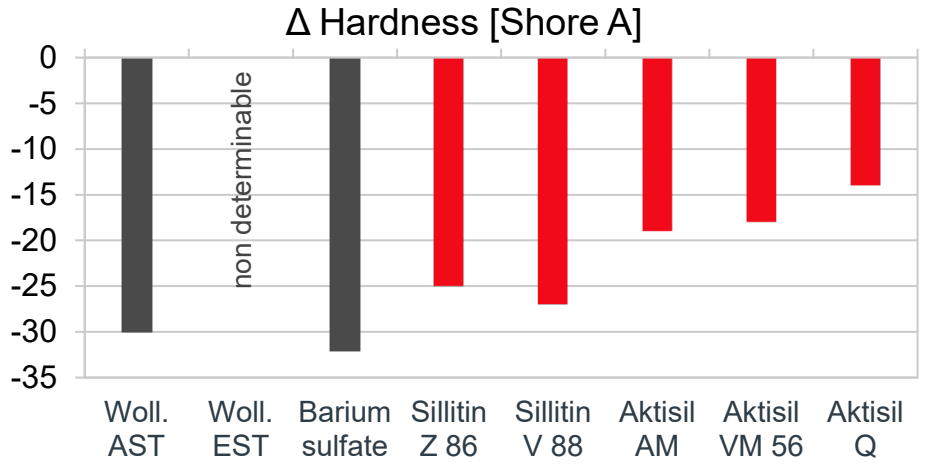


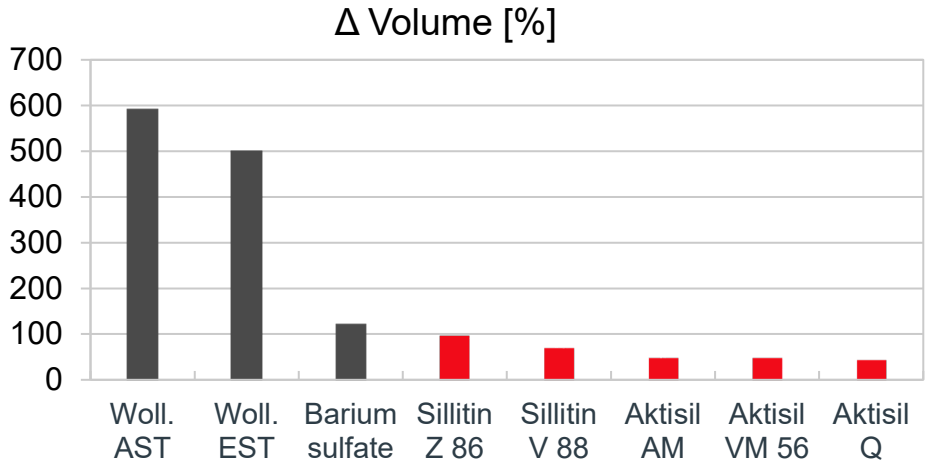


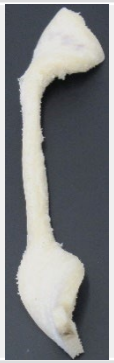


Resistance to acetic acid pH3, 168 h / 100 °C



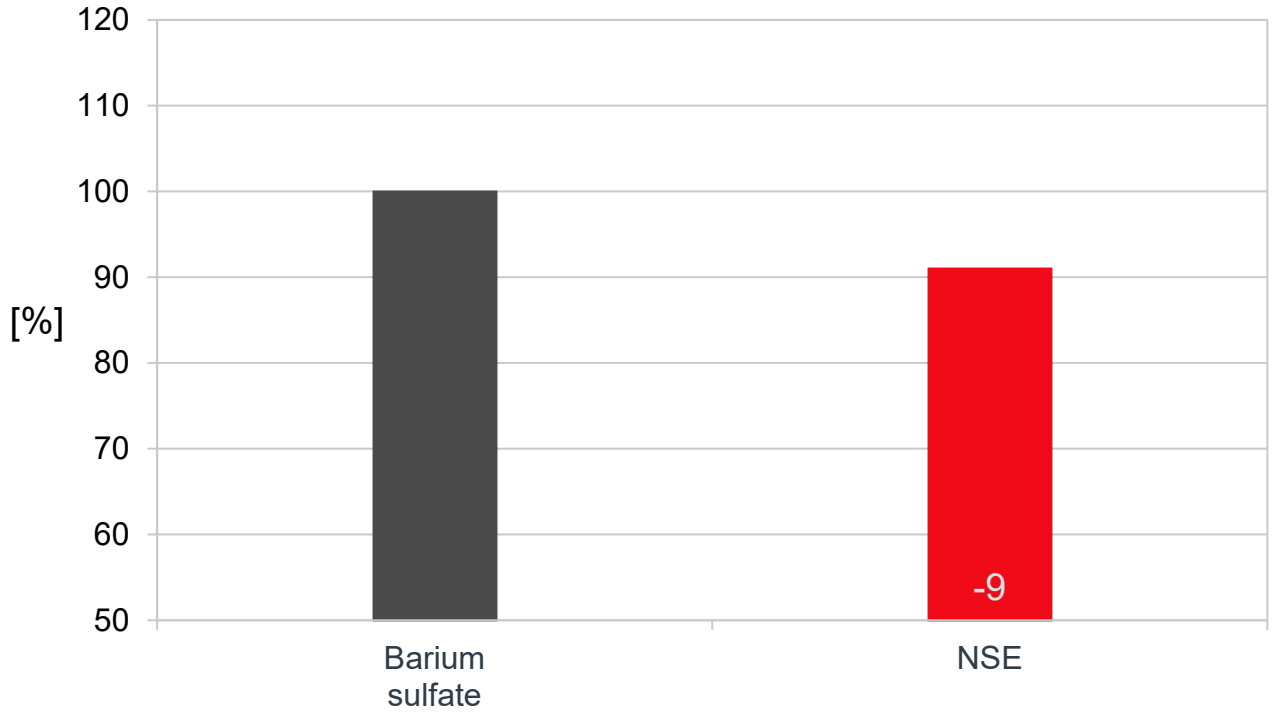




before	after		
	Woll. AST	Woll. EST	Barium sulfate
			
Δ Weight:	+288 %	+227 %	+55 %
Δ Volume:	+593 %	+500 %	+121 %

An additional benefit…

Reduction of CO_2 eq. after replacing barium sulfate with NSE, volume based



NSE vs. Wollastonite AST

65 Shore A	Sillitin Z 86	Sillitin V 88	Aktisil AM	Aktisil VM 56	Aktisil Q
Cure speed			+		+
Viscosity	=	=	=	=	=
Tensile strength TS	+	=	+	+	=
Elongation at break	+	+	=	=	
Modulus 100 %	+	=	+	+	+
Tear resistance	=	+			
CS ISO 200 °C	=	=	=	=	=
CS ISO 200 °C, no post-cure	=	=	=	=	+
CS ISO 232 °C	=	=	=	=	+
CS ISO 232 °C, no post-cure	+	+	+	+	+
CS VW 23 °C	+	=	+	+	=
CS VW 150 °C		=	=		=
Abrasion resistance	+	=	+	+	+
Resistance to hot air 210 °C			=	=	=
TS after hot air 210 °C	+	=	+	+	=
Resistance to hot air 230 °C			=	=	=
TS after hot air 230 °C	+	=	+	+	=
Resistance to fuel	=	=	=	=	=
TS after fuel	=	=	+	+	+
Resistance to oil	=	=	=	=	+
TS after oil	+	=	+	+	+
Resistance to acetic acid	+	+	+	+	+

NSE vs. Wollastonite EST

65 Shore A	Sillitin Z 86	Sillitin V 88	Aktisil AM	Aktisil VM 56	Aktisil Q
Cure speed	=	=	+	=	+
Viscosity	=	=	=	=	=
Tensile strength TS	+	=	+	+	=
Elongation at break	=	=			
Modulus 100 %	+	=	+	+	+
Tear resistance	=	=			
CS ISO 200 °C	=	=	=	=	=
CS ISO 200 °C, no post-cure	=	=	=	=	+
CS ISO 232 °C	=	=		=	=
CS ISO 232 °C, no post-cure	=	=	=	=	+
CS VW 23 °C	=	=	+	+	=
CS VW 150 °C		=	=		=
Abrasion resistance	+	=	+	+	+
Resistance to hot air 210 °C			=	=	=
TS after hot air 210 °C	+	=	+	+	=
Resistance to hot air 230 °C			=	=	=
TS after hot air 230 °C	+	=	+	+	=
Resistance to fuel	+	+	+	+	+
TS after fuel	+	=	+	+	+
Resistance to oil	+	+	+	+	+
TS after oil	+	+	+	+	+
Resistance to acetic acid	+	+	+	+	+

NSE vs. Barium sulfate

65 Shore A	Sillitin Z 86	Sillitin V 88	Aktisil AM	Aktisil VM 56	Aktisil Q
Cure speed			+		=
Viscosity	=	+	+	+	+
Tensile strength TS	+	+	+	+	+
Elongation at break	=	=			
Modulus 100 %	+	+	+	+	+
Tear resistance	=	+			
CS ISO 200 °C	=	=	=	=	=
CS ISO 200 °C, no post-cure	=	=	=	=	+
CS ISO 232 °C	=	=	=	=	+
CS ISO 232 °C, no post-cure	+	+	=	=	+
CS VW 23 °C	+	=	+	+	=
CS VW 150 °C		=	=		=
Abrasion resistance	+	+	+	+	+
Resistance to hot air 210 °C	=	=	+	+	=
Resistance to hot air 230 °C	=	=	+	+	=
Resistance to fuel	+	+	+	+	+
Resistance to oil	+	+	+	+	+
Resistance to acetic acid	+	+	+	+	+

We supply materials for good ideas!

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Internet: www.hoffmann-mineral.com
E-mail: info@hoffmann-mineral.com

Results in tabular form

		Woll. AST	Woll. EST	Barium sulfate	Sillitin Z 86	Sillitin V 88	Aktisil AM	Aktisil VM 56	Aktisil Q
Rheology									
Mooney Viscosity, ML 1+4, 100 °C	MU	63	59	66	64	62	62	62	61
Rotorless Curemeter, M_{min}, 177 °C	Nm	0.03	0,03	0.04	0.04	0,04	0.04	0,04	0,04
Rotorless Curemeter, V_{max}, 177 °C	Nm/min.	3.4	3.1	3.4	3.0	3.1	4.0	3.0	3.6
Rotorless Curemeter, t_{90}, 177 °C	min.	0.9	0.9	0.9	0.9	0.9	0.8	0.9	0.8
Mechanical properties (cured 7 min. / 177 °C, no post-cure)									
Hardness	Shore A	61	63	61	67	64	64	64	63
Tensile strength	MPa	18	16	15	17	14	19	21	16
Elongation at break	%	397	393	421	404	390	312	330	257
Modulus 50 %	MPa	1.9	1.6	1.4	1.9	1.7	1.8	1.7	1.6
Modulus 100 %	MPa	4.2	3.2	2.1	3.7	3.1	4.2	3.9	3.6
Tear resistance	N/mm	6.0	5.9	4.7	6.4	6.2	4.5	3.2	4.0
Compression set ISO 70 h / 200 °C / 25 %	%	24	21	22	23	22	21	24	18
Compression set ISO 70 h / 232 °C / 25 %	%	35	28	31	26	25	30	28	20

Results in tabular form

		Woll. AST	Woll. EST	Barium sulfate	Sillitin Z 86	Sillitin V 88	Aktisil AM	Aktisil VM 56	Aktisil Q
Mechanical properties (cured 7 min. / 177 °C, post-cure 2 h / 232 °C)									
Hardness	Shore A	67	64	67	65	65	66	66	65
Tensile strength	MPa	19	20	16	23	20	24	26	20
Elongation at break	%	337	399	407	379	392	311	318	271
Modulus 50 %	MPa	1.7	1.7	1.4	2.1	1.8	1.9	1.8	1.7
Modulus 100 %	MPa	3.9	3.5	2.4	4.6	3.8	4.9	4.6	4.3
Tear resistance	N/mm	6.2	6.9	6.1	5.8	7.5	3.9	3.4	4.1
Compression set ISO 70 h / 200 °C / 25 %	%	22	18	22	21	20	21	22	20
Compression set ISO 70 h / 232 °C / 25 %	%	29	24	28	26	26	29	27	23
Compression set VW 94 h / 23 °C / 50 %	%	51	51	49	46	50	39	40	48
Compression set VW 94 h / 150 °C / 50 %	%	35	36	36	40	34	34	42	38
Abrasion loss	mm^3	104	114	124	80	103	71	64	73

Results in tabular form

		Woll. AST	Woll. EST	Barium sulfate	Sillitin Z 86	Sillitin V 88	Aktisil AM	Aktisil VM 56	Aktisil Q
Hot air aging, 504 h / 210 °C, measured 30‘ after exposure									
Hardness	Shore A	64	64	65	70	68	69	68	67
Tensile strength	MPa	20	21	24	25	22	26	25	22
Elongation at break	%	331	390	372	257	302	304	312	356
Δ Hardness	Shore A	-3	0	-2	+5	+3	+3	+2	+2
Δ Tensile strength	%	+6.1	+3.1	+43	+10	+12	+7.5	-3.6	+11
Δ Elongation at break	rel.%	-1.7	-2.3	-8.6	-32	-23	-2.3	-1.6	+31
Hot air aging, 94 h / 230 °C, measured 30‘ after exposure									
Hardness	Shore A	65	65	65	69	67	68	67	65
Tensile strength	MPa	22	22	25	28	24	28	27	23
Elongation at break	%	325	335	353	278	312	299	304	331
Δ Hardness	Shore A	-2	+1	-2	+4	+2	+2	+1	0
Δ Tensile strength	%	-18	+7.9	+51	+23	+21	+15	+4.5	+16
Δ Elongation at break	rel.%	-3.6	-16	-13	-27	-20	-3.8	-4.3	+22

Results in tabular form

		Woll. AST	Woll. EST	Barium sulfate	Sillitin Z 86	Sillitin V 88	Aktisil AM	Aktisil VM 56	Aktisil Q
Exposure to fuel FAM B, 70 h / 23 °C									
Hardness	Shore A	56	55	52	60	57	58	57	58
Tensile strength	MPa	8.6	7.0	7.7	9.3	7.8	11	13	10
Elongation at break	%	241	261	329	340	331	238	251	206
Δ Hardness	Shore A	-11	-9	-15	-5	-8	-8	-9	-7
Δ Tensile strength	%	-53	-66	-53	-60	-60	-53	-51	-49
Δ Elongation at break	rel.%	-28	-35	-19	-10	-16	-24	-21	-24
Δ Weight	%	+7.6	+7.2	+7.4	+7.9	+7.7	+6.8	+7.8	+8.0
Δ Volume	%	+19	+18	+20	+19	+18	+17	+19	+19

Results in tabular form

		Woll. AST	Woll. EST	Barium sulfate	Sillitin Z 86	Sillitin V 88	Aktisil AM	Aktisil VM 56	Aktisil Q
Exposure to engine oil OS206304, 168 h / 165 °C									
Hardness	Shore A	62	62	62	66	64	65	64	64
Tensile strength	MPa	17	13	11	21	18	22	23	21
Elongation at break	%	286	297	340	351	370	281	286	291
Δ Hardness	Shore A	-5	-2	-5	+1	-1	-1	-2	-1
Δ Tensile strength	%	-7.1	-35	-34	-8.4	-7.4	-8.8	-9.7	+2.3
Δ Elongation at break	rel.%	-15	-26	-17	-7.4	-5.6	-9.8	-10	+7.3
Δ Weight	%	+0.6	+0.6	+0.5	+0.6	+0.6	+0.7	+0.8	+0.6
Δ Volume	%	+1.2	+1.1	+1.3	+1.1	+0.7	+1.2	+1.4	+0.7

Results in tabular form

		Woll. AST	Woll. EST	Barium sulfate	Sillitin Z 86	Sillitin V 88	Aktisil AM	Aktisil VM 56	Aktisil Q
Exposure to acetic acid pH3, 168 h / 100 °C									
Hardness	Shore A	37	n.d.	35	40	38	47	48	51
Tensile strength	MPa	2.6	2.8	10	10	9.1	19	19	20
Elongation at break	%	54	84	252	285	288	300	281	274
Δ Hardness	Shore A	-30	n.d.	-32	-25	-27	-19	-18	-14
Δ Tensile strength	%	-86	-86	-37	-56	-54	-22	-24	-3.0
Δ Elongation at break	rel.%	-84	-79	-38	-25	-27	-3.7	-12	+1.2
Δ Weight	%	+288	+227	+55	+49	+36	+24	+25	+23
Δ Volume	%	+593	+499	+121	+94	+68	+47	+47	+43