

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

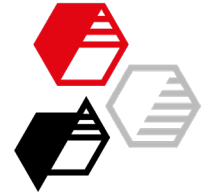


Status quo

Wollastonite

Barium sulfate

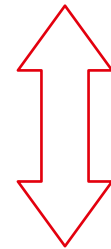
traditionally used fillers
in FKM compounds
with weak acid resistance



Objective

Wollastonite

Barium sulfate



Neuburg
Siliceous Earth



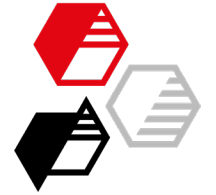
Fillers and characteristics

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 sulfat	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.	

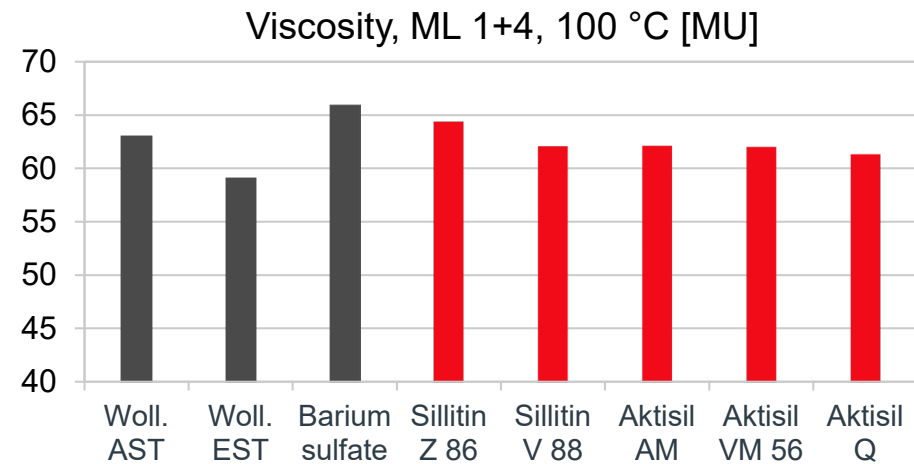
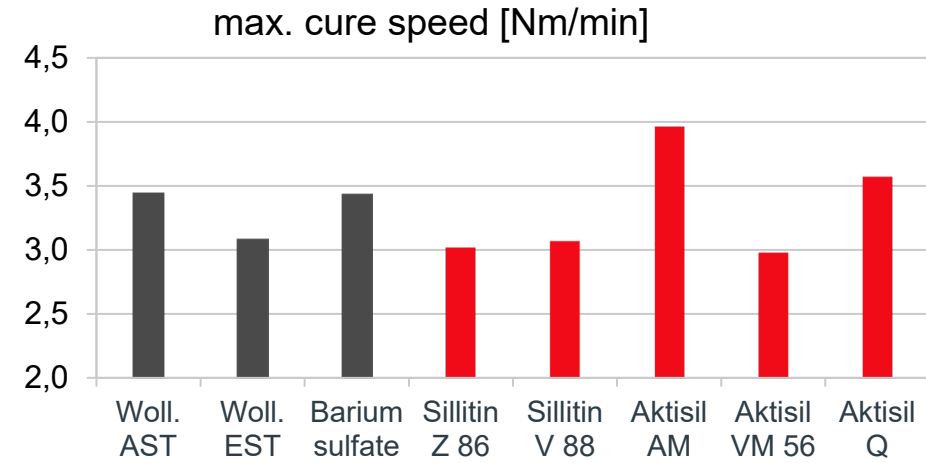


Tests

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

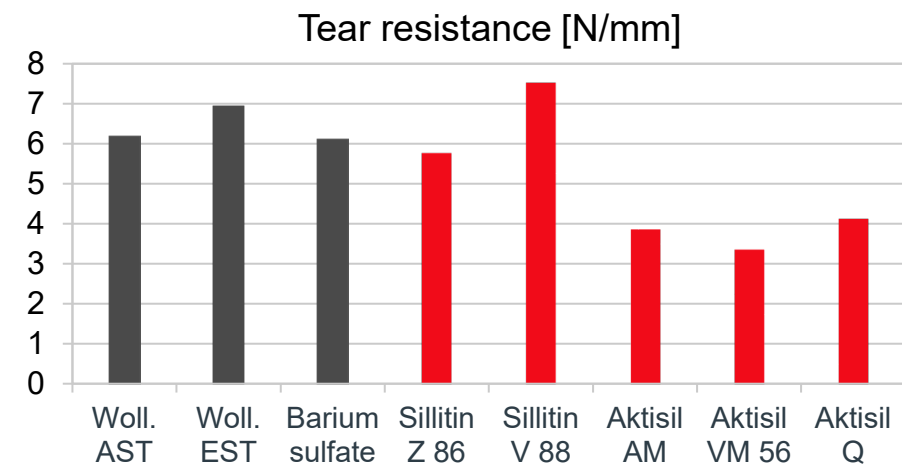
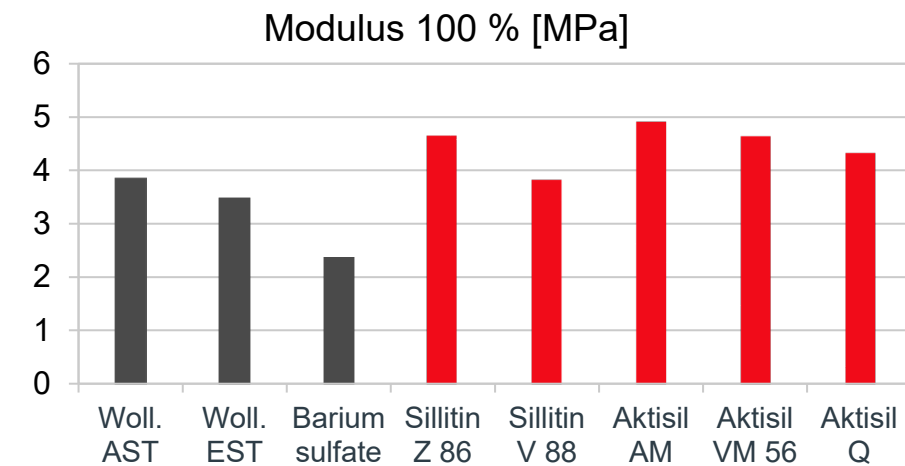
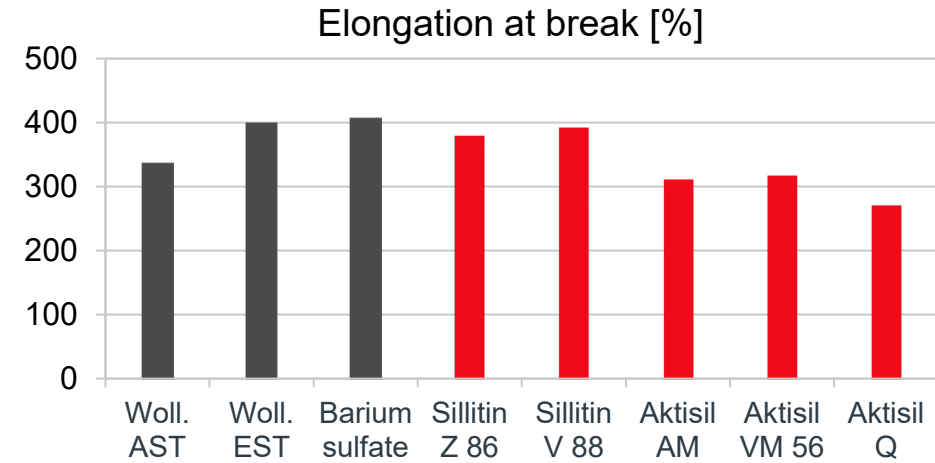
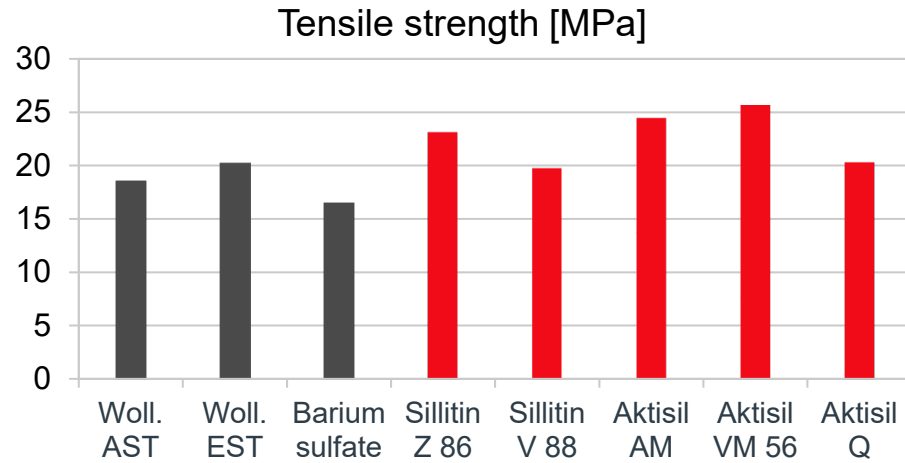


Rheology



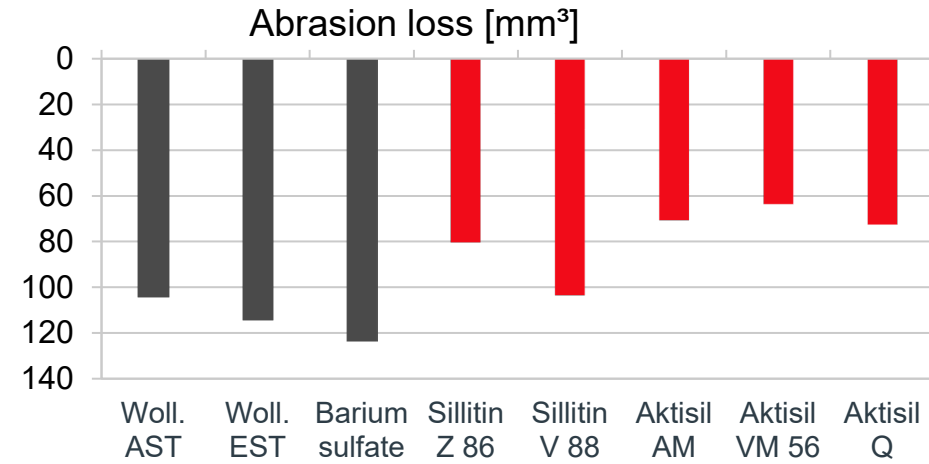


Tensile tests



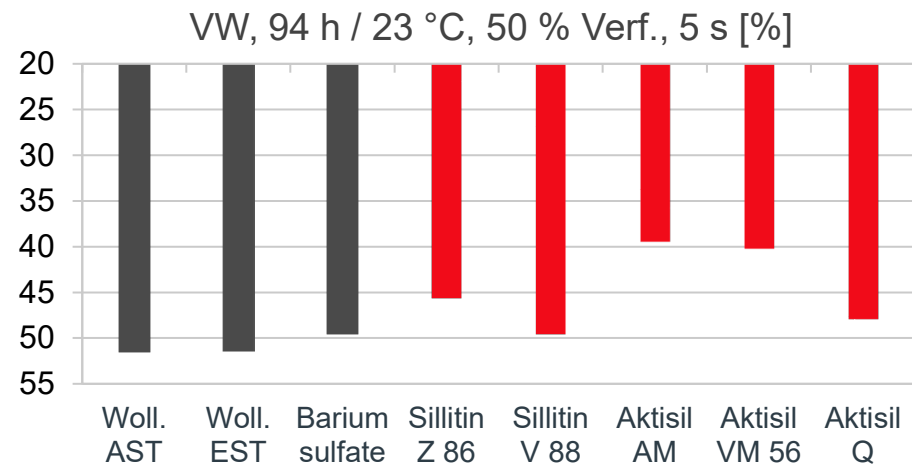
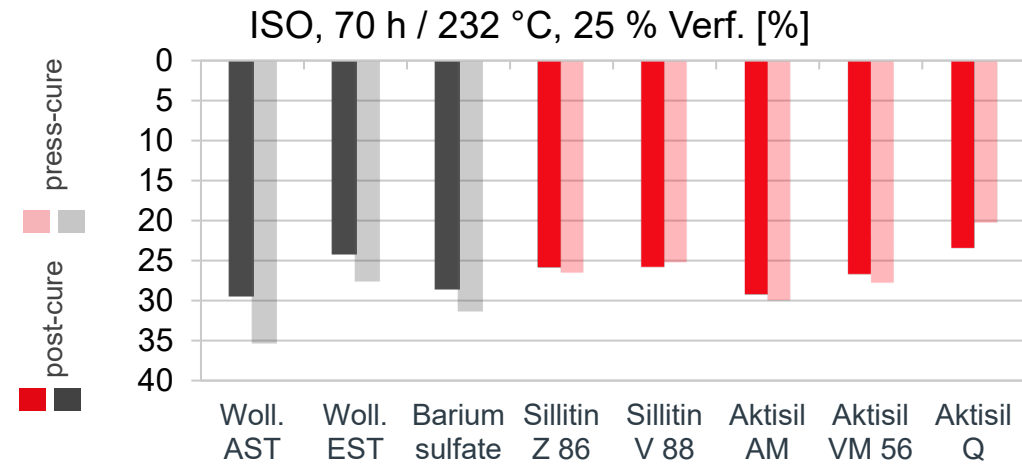


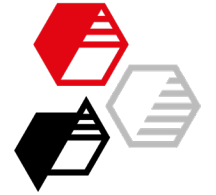
Abrasion resistance



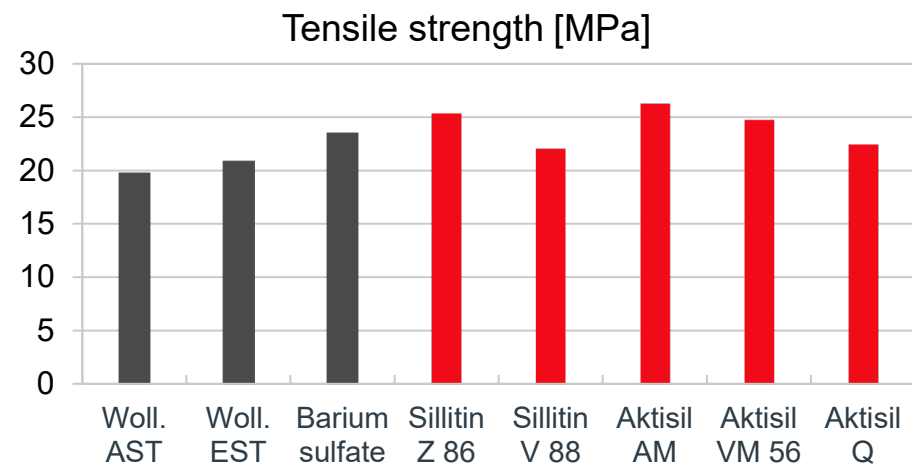
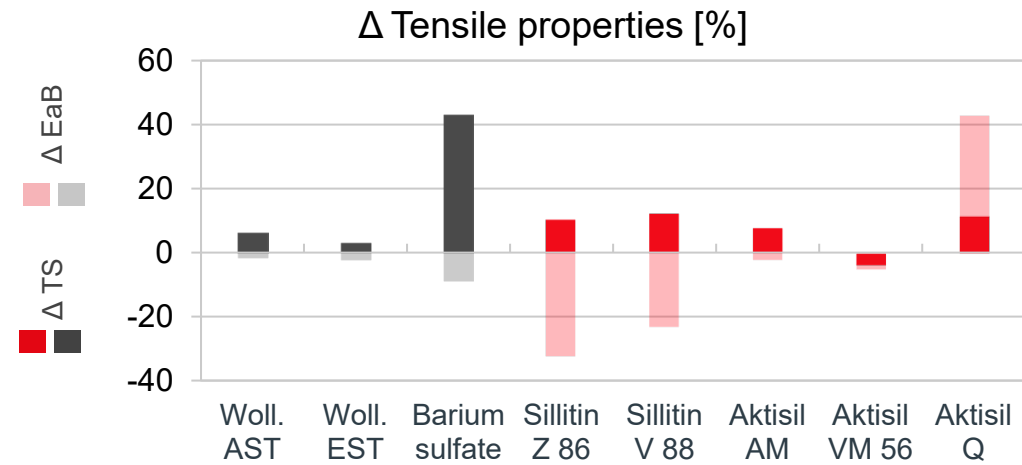


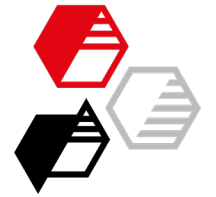
Compression set



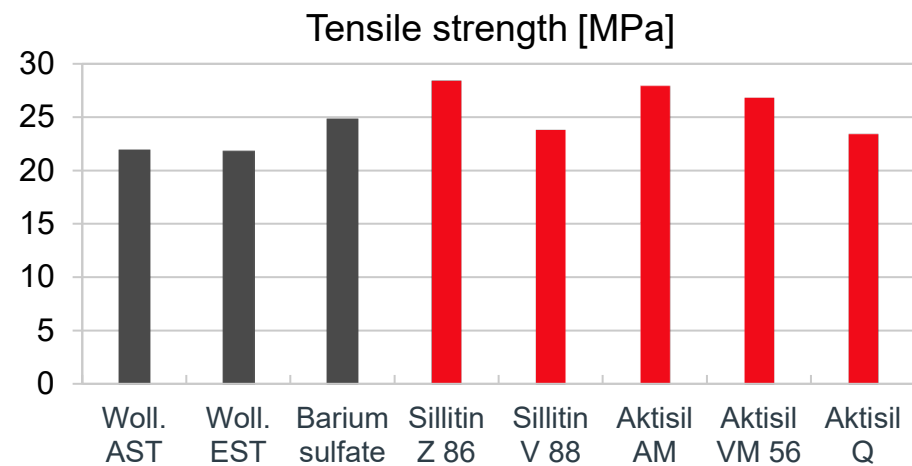
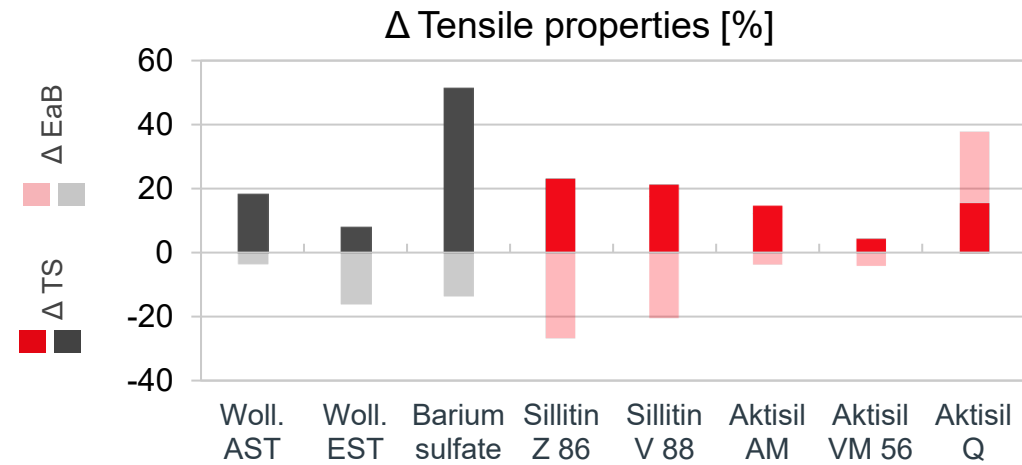


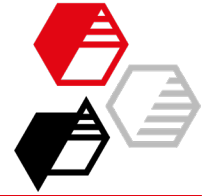
Resistance to hot air, 504 h / 210 °C



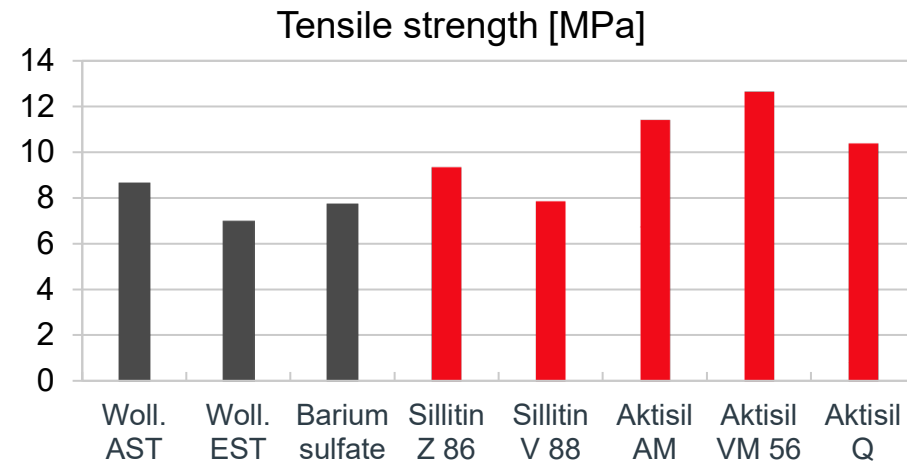
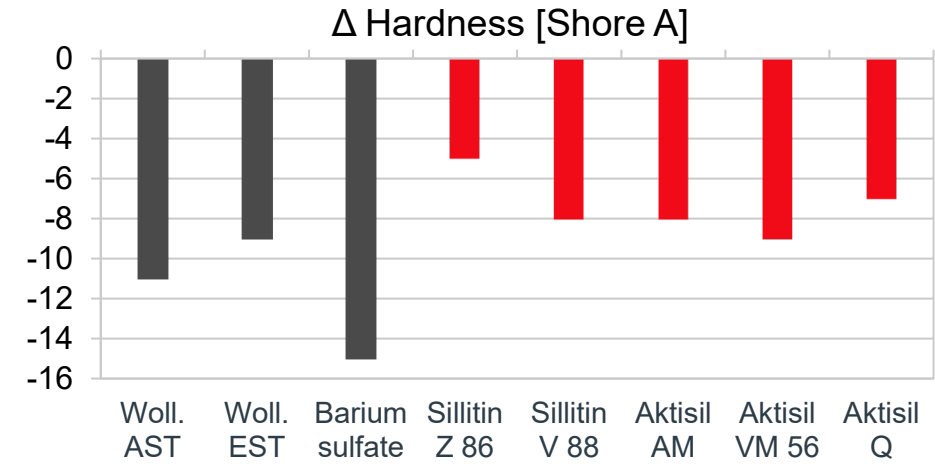
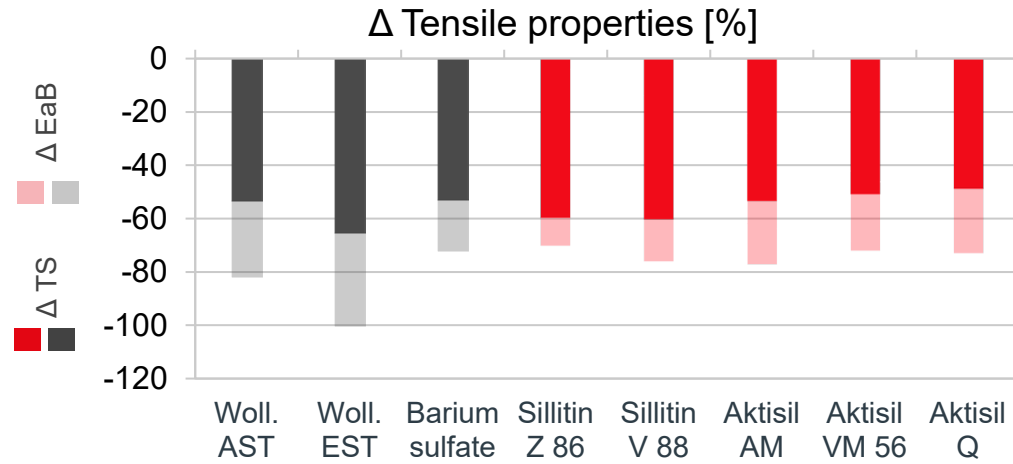


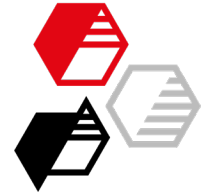
Resistance to hot air, 94 h / 230 °C



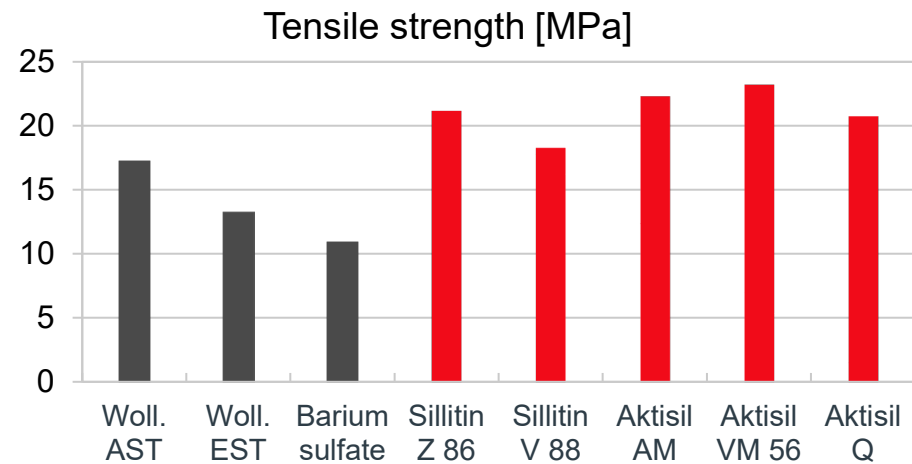
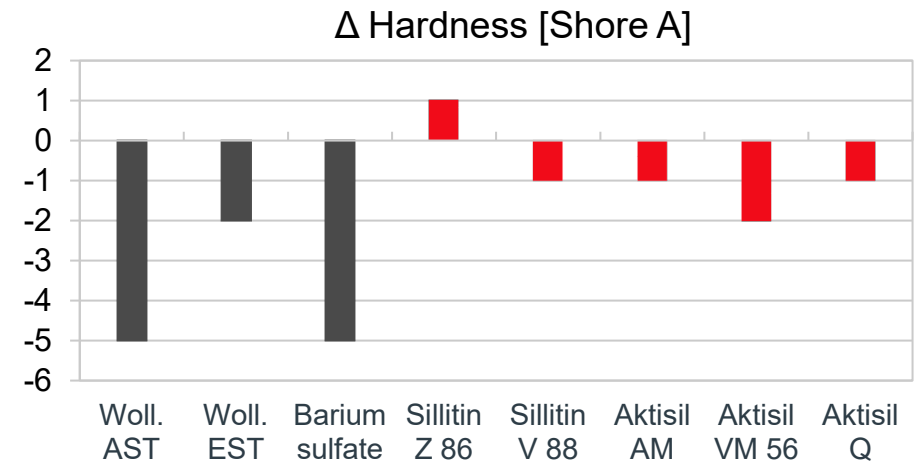
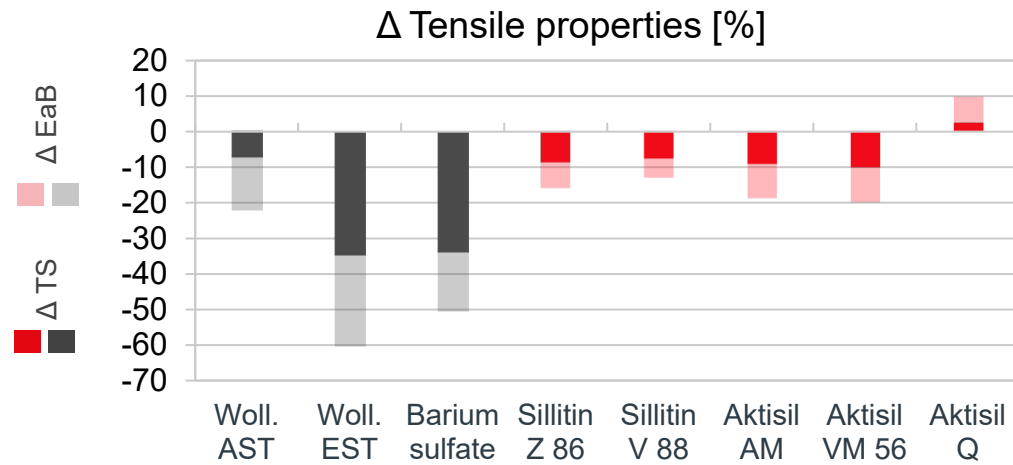


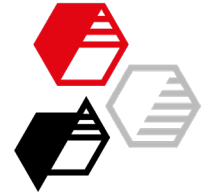
Resistance to fuel, 72 h / 23 °C



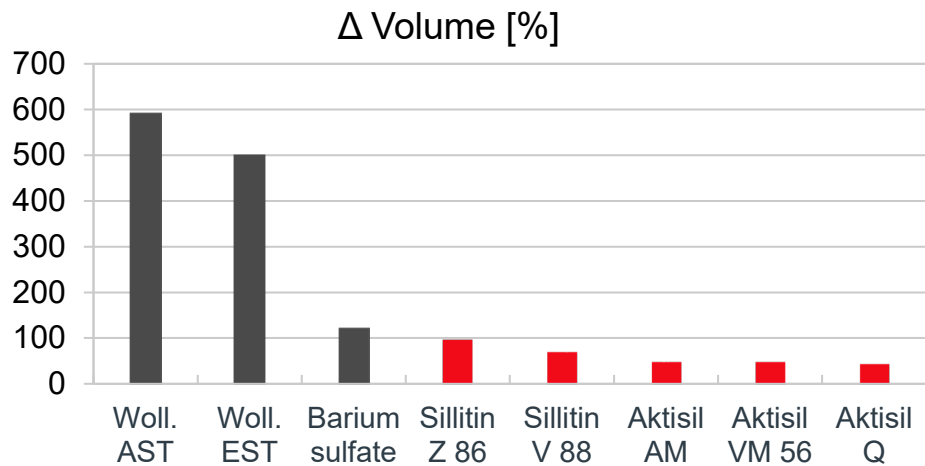
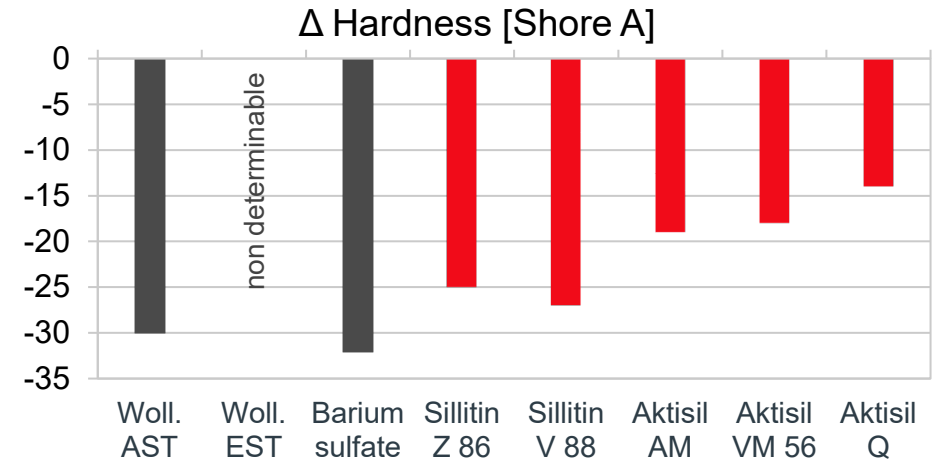
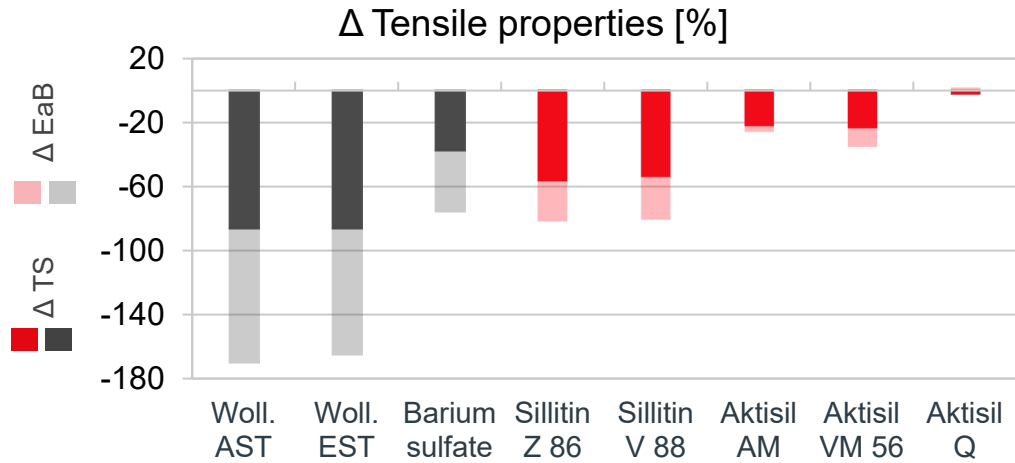


Resistance to oil, 168 h / 150 °C





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

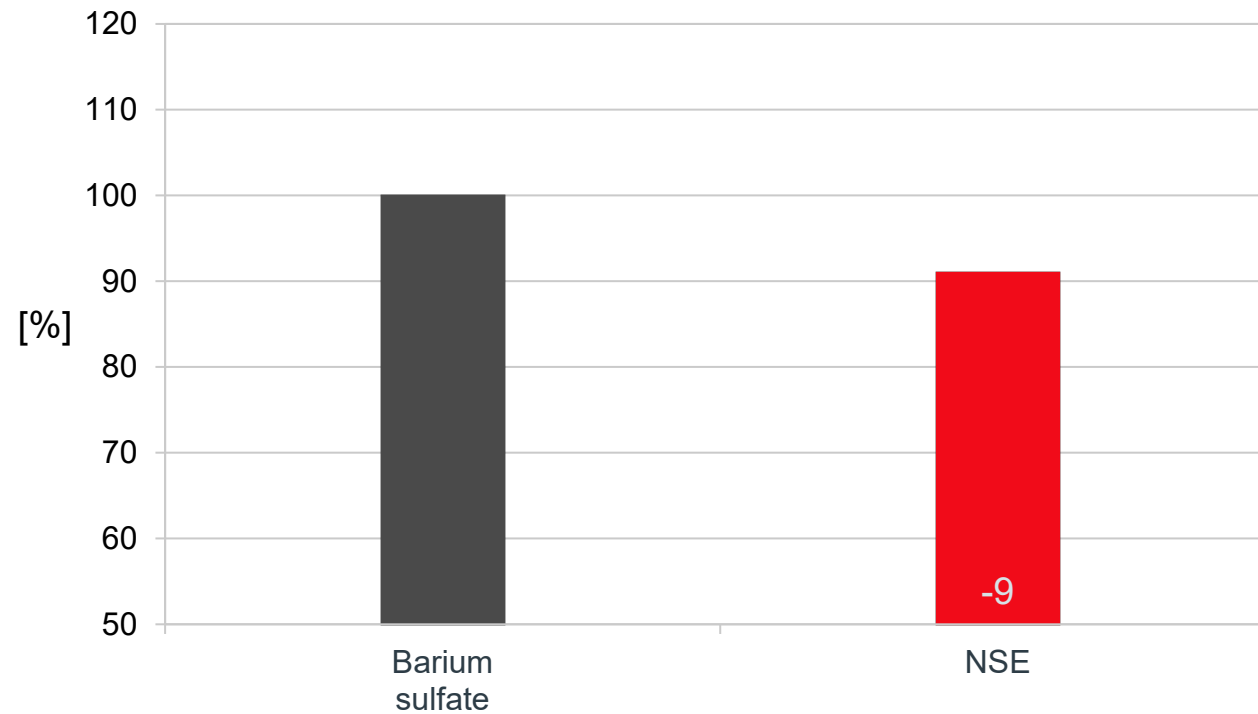


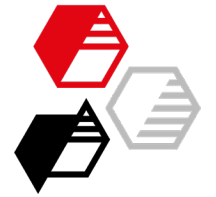
before	after		
	Woll. AST	Woll. EST	Barium sulfate
Δ Weight:	+288 %	+227 %	+55 %
Δ Volume:	+593 %	+500 %	+121 %



An additional benefit...

Reduction of CO₂ eq. after replacing barium sulfate with NSE, volume based





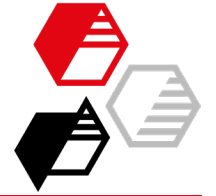
NSE vs. Wollastonite AST

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	+	+	+	+	+



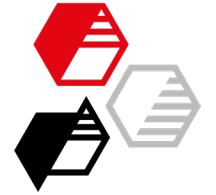
NSE vs. Wollastonite EST

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	+	+	+	+	+

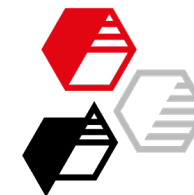


We supply materials for good ideas!

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

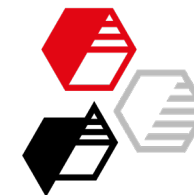
Phone: +49 8431 53-0
Internet: www.hoffmann-mineral.com
E-mail: info@hoffmann-mineral.com

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.



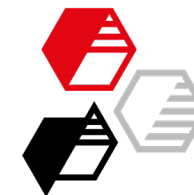
Results in tabular form

		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 / 150 °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