Neuburg Siliceous Earth
as an acid resistant, tintable alternative to carbon black N990 in peroxide cured FKM

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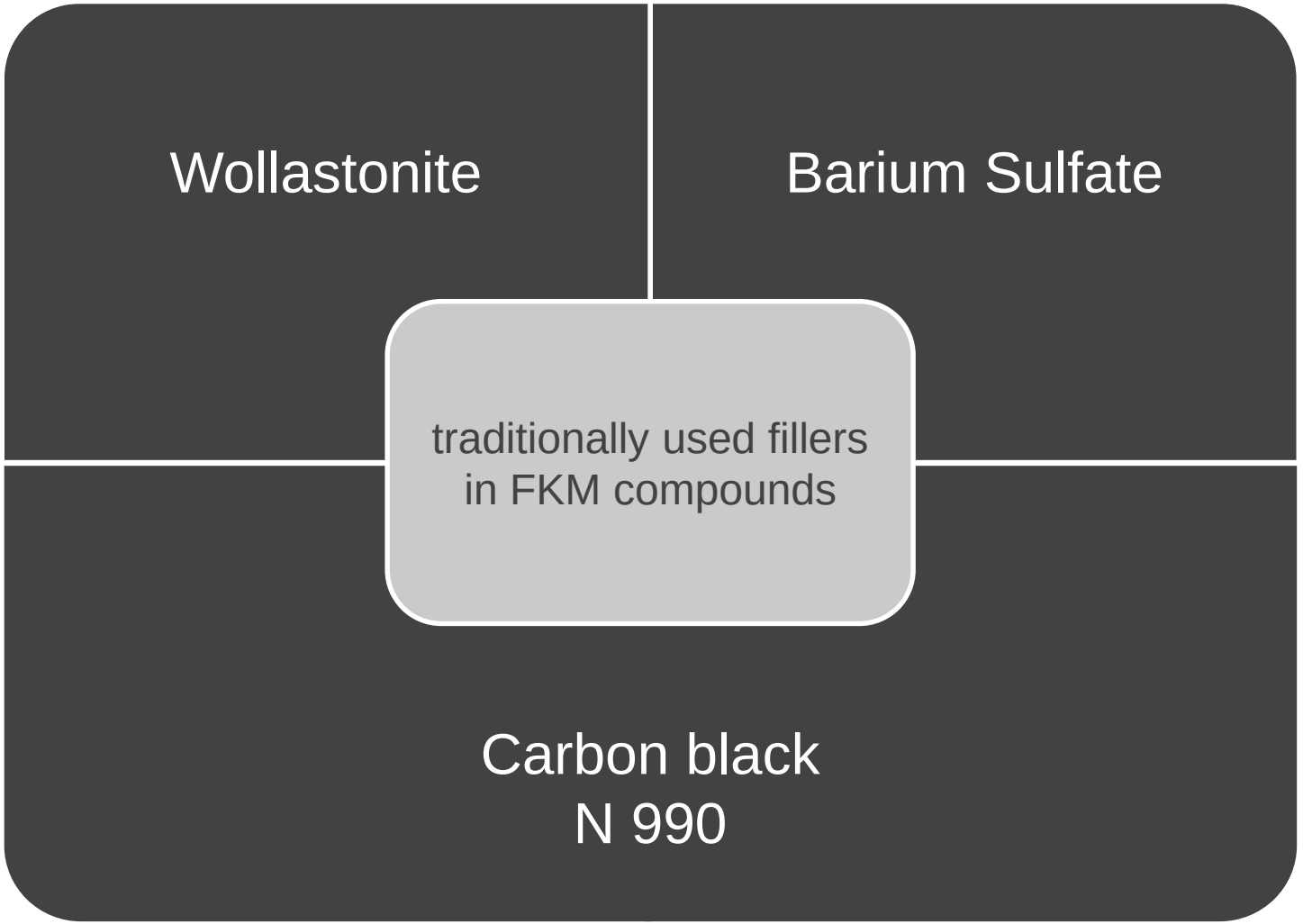
Status Quo



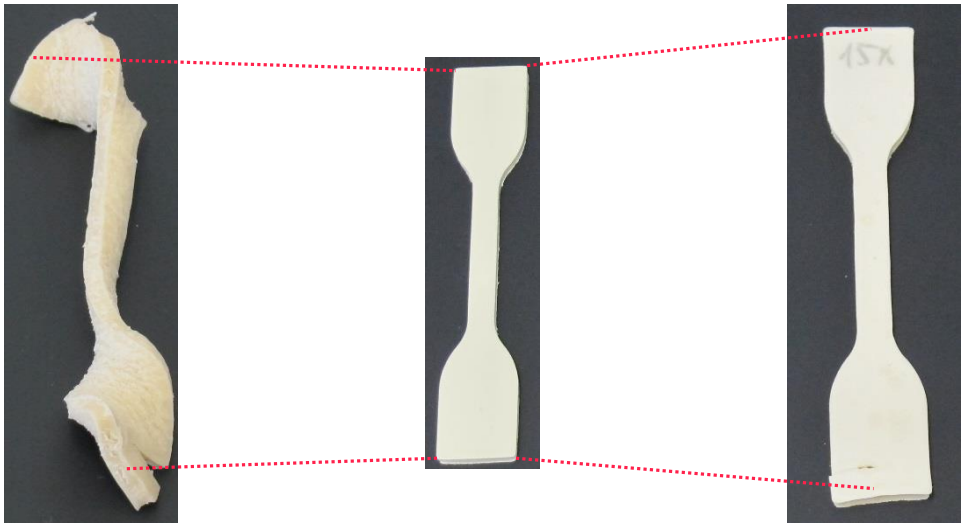
Status Quo
Acid Resistance

Wollastonite

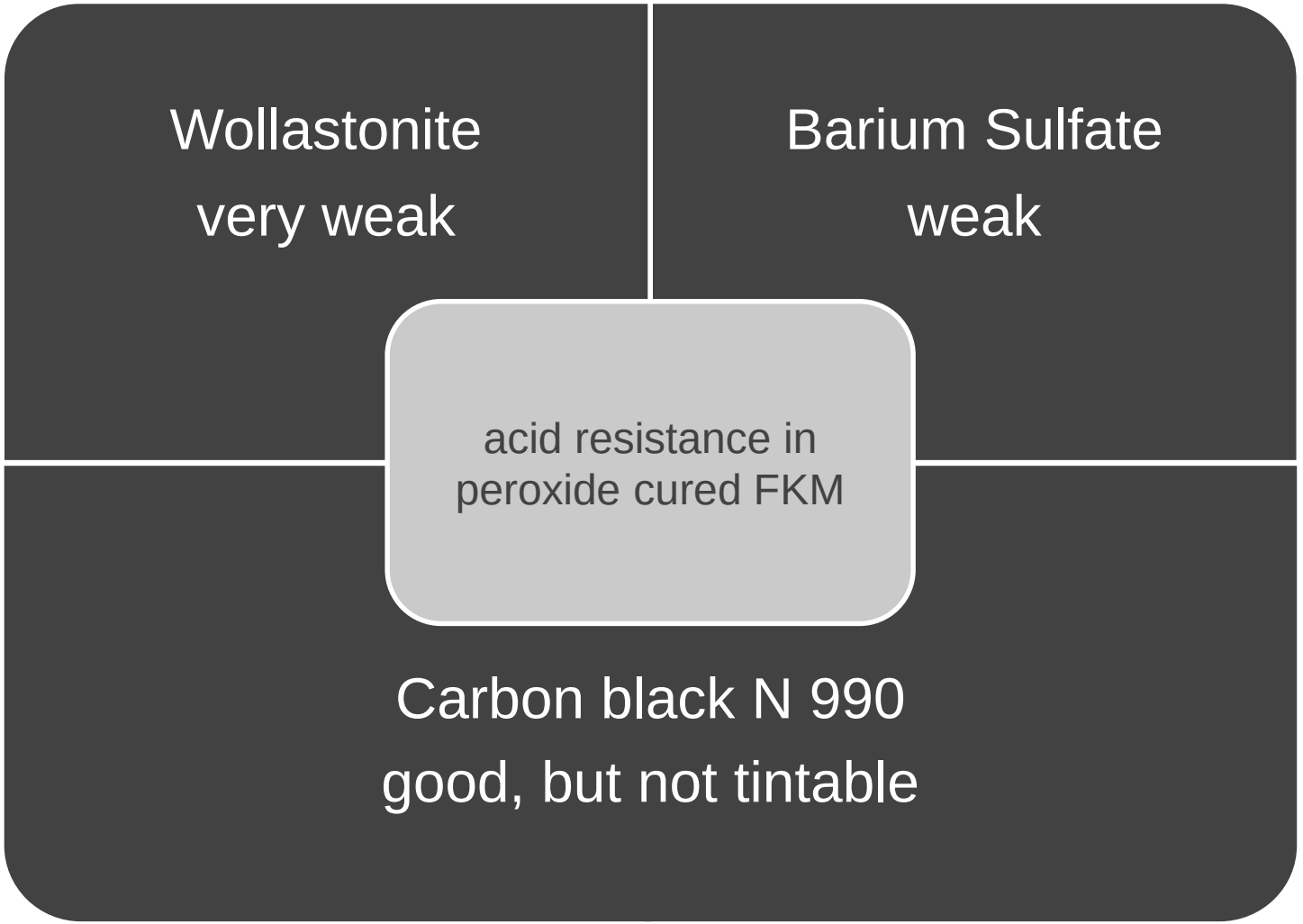
Volume: +500 %
Hardness: -30 Sh.A
Tensile Str.: -86 %

Barium Sulfate

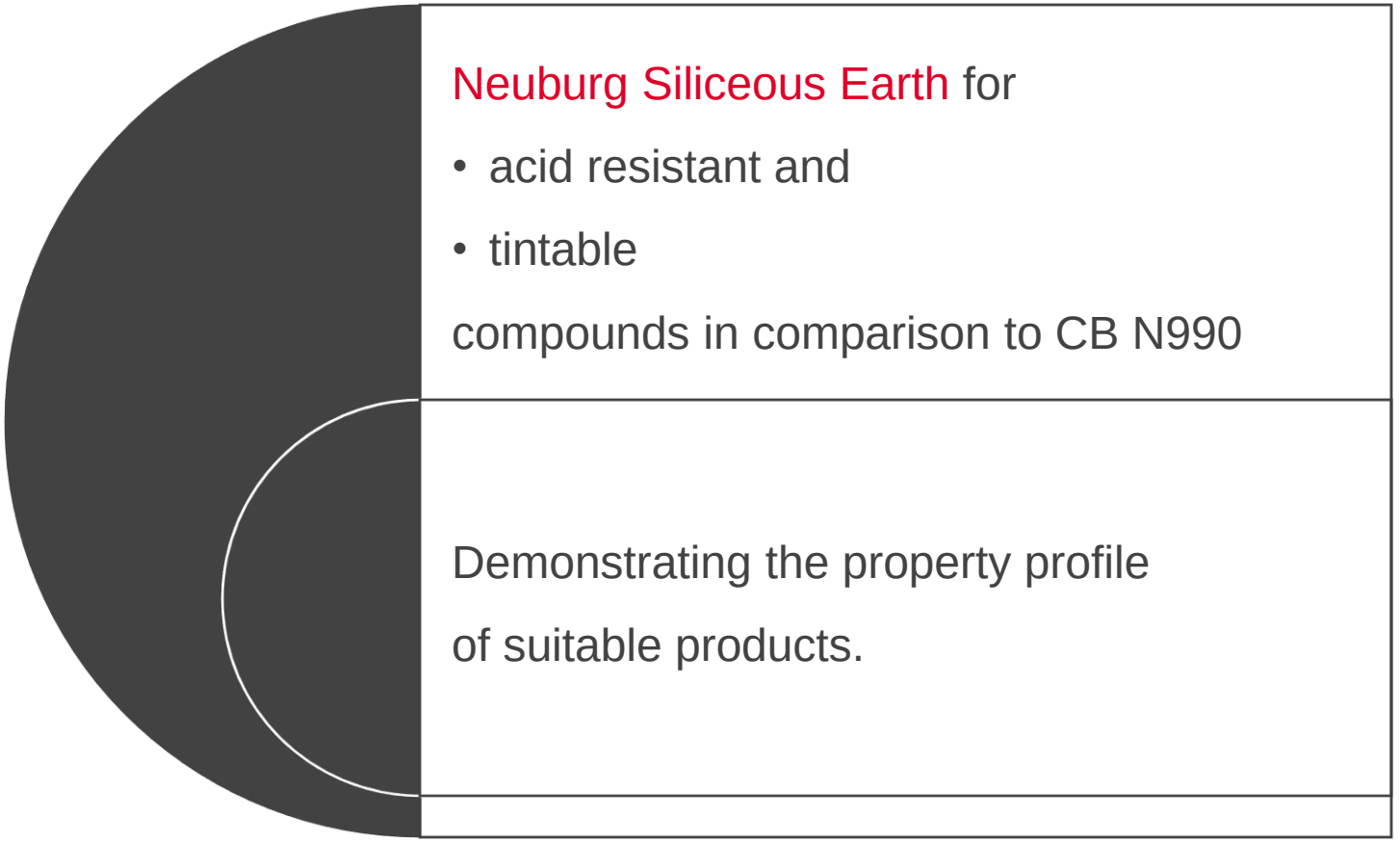
Volume: +120 %
Hardness: -32 Sh.A
Tensile Str.: -37 %



Status Quo
Acid Resistance



Objective



Formulation

		N 990	NSE
Viton GAL-200S	66 % fluorine, 25 MU (ML1+10, 121 °C) terpolymer (HFP+VFD+TFE)	**100**	**100**
Zinkoxyd aktiv	ZnO	**3**	**3**
Diak No. 7	co-activator TAIC	**3**	**3**
Varox DBPH-50	2,5-dimethyl-2,5-di(tertbutylperoxy)-hexane	**2**	**2**
N990	Carbon black	**30**	**-**
NSE	Neuburg Siliceous Earth	**-**	**30**

Fillers, Characteristics

Filler	Description	Functionalization
N990	Carbon black, MT	-
Aktifit VM	Calcined Neuburg Siliceous Earth, d_{50}: 2 µm	Vinyl
Aktifit PF 111	Calcined Neuburg Siliceous Earth, d_{50}: 2 µm	Alkyl
Aktifit AM	Calcined Neuburg Siliceous Earth, d_{50}: 2 µm	Amino
Aktifit PF 115	Calcined Neuburg Siliceous Earth, d_{50}: 2 µm	Special Amino
Aktisil AM	Neuburg Siliceous Earth, d_{50}: 2 µm	Amino
Aktisil Q	Neuburg Siliceous Earth, d_{50}: 4 µm	Methacrylic

Preparation and Curing of the Compound

Mixing	
Open mill	Ø 150 x 300 mm
Batch volume	approx. 1 kg
Temperature	50 °C 30 °C for removing the sheet off the mill
Mixing time	approx. 15 min.

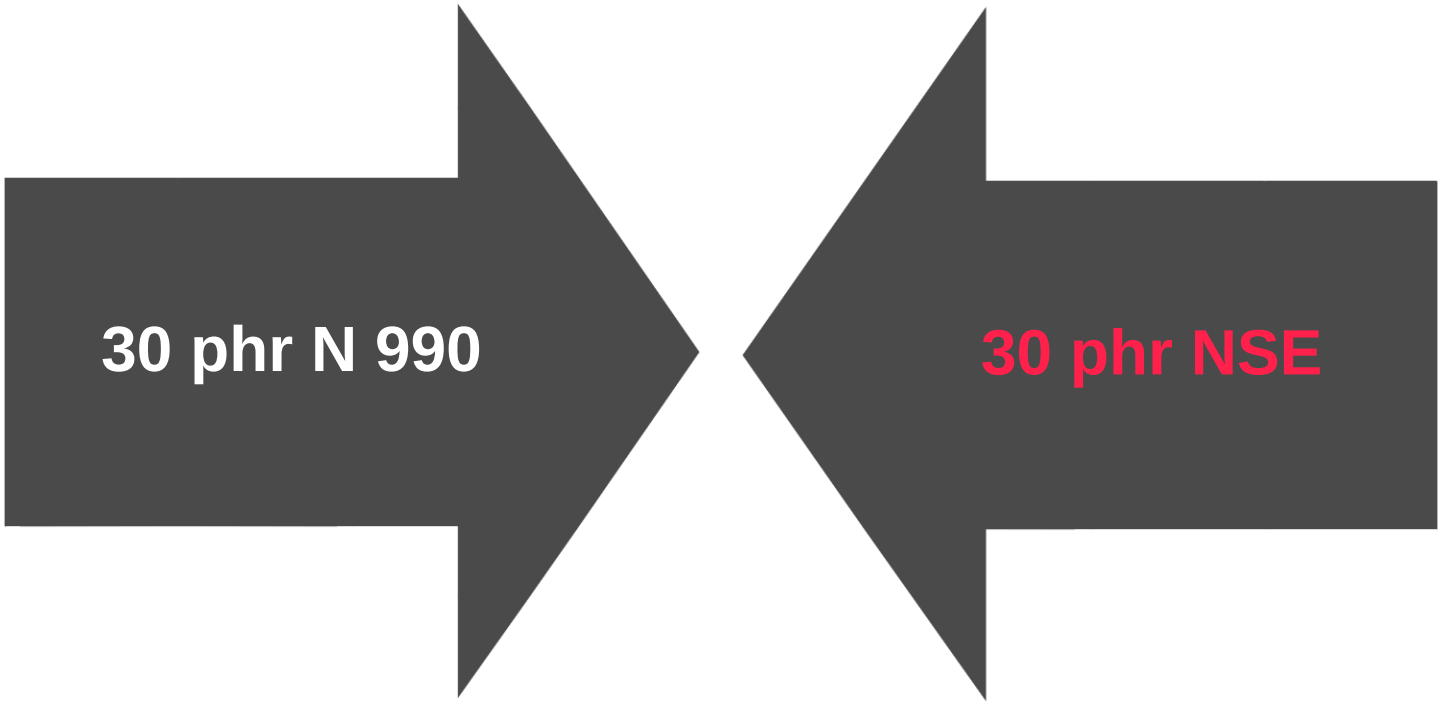
Curing and post-cure	
Cure	7 min. / 177 °C
Post-cure	2 h / 232 °C

Tests

Standard mechanical tests with post-cured specimens
Hardness, tensile tests, compression set, abrasion resistance

Resistance tests with post-cured specimens	
Hot air	94 h / 230 °C
	504 h / 210 °C
Engine Oil OS206304	168 h / 150 °C
Fuel FAM B (DIN 51604)	70 h / 23 °C
Acetic acid (1M, pH 3)	168 h / 100 °C

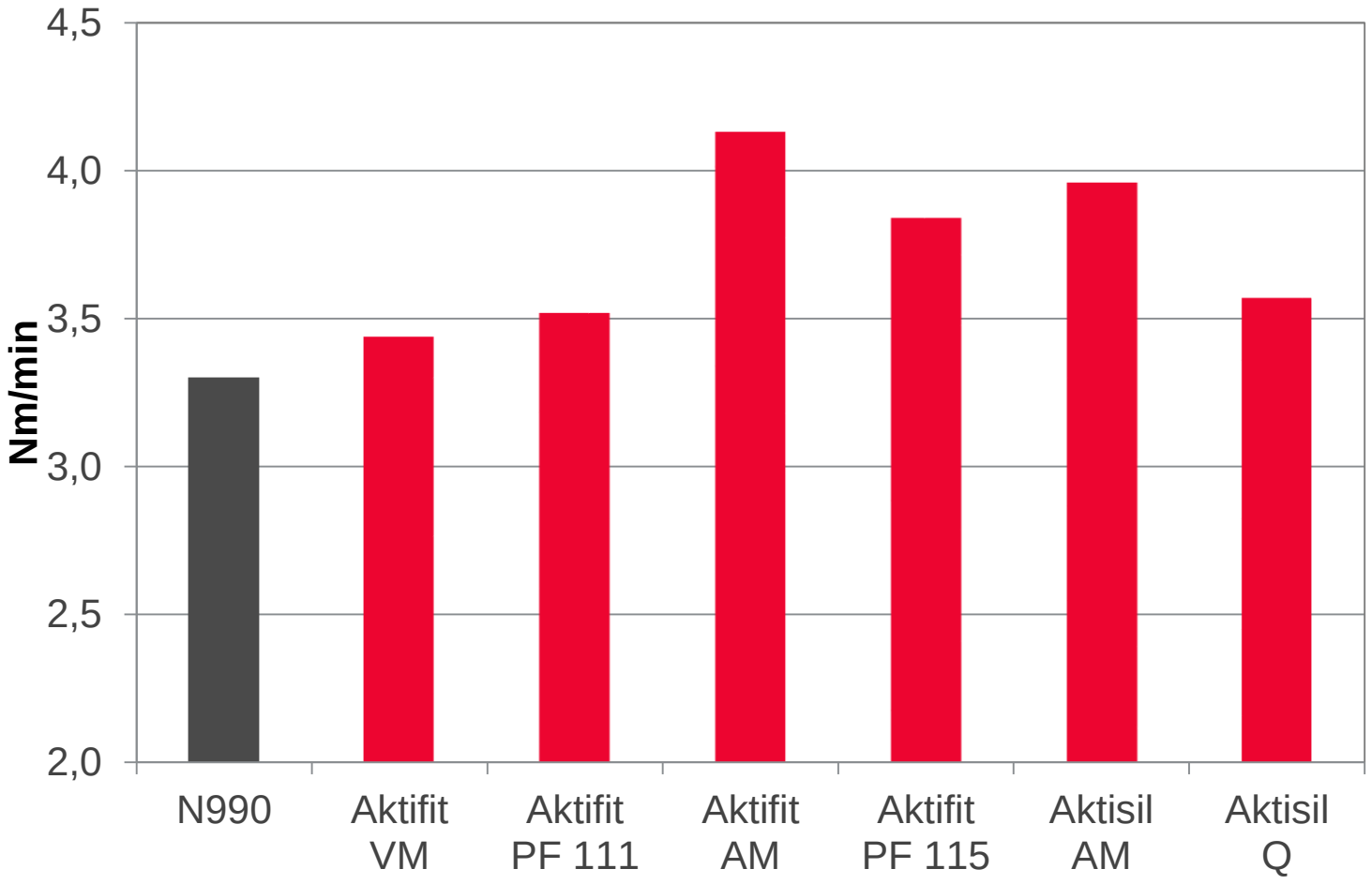
Neuburg Siliceous Earth vs. N 990



Hardness range
65 - 70 Shore A

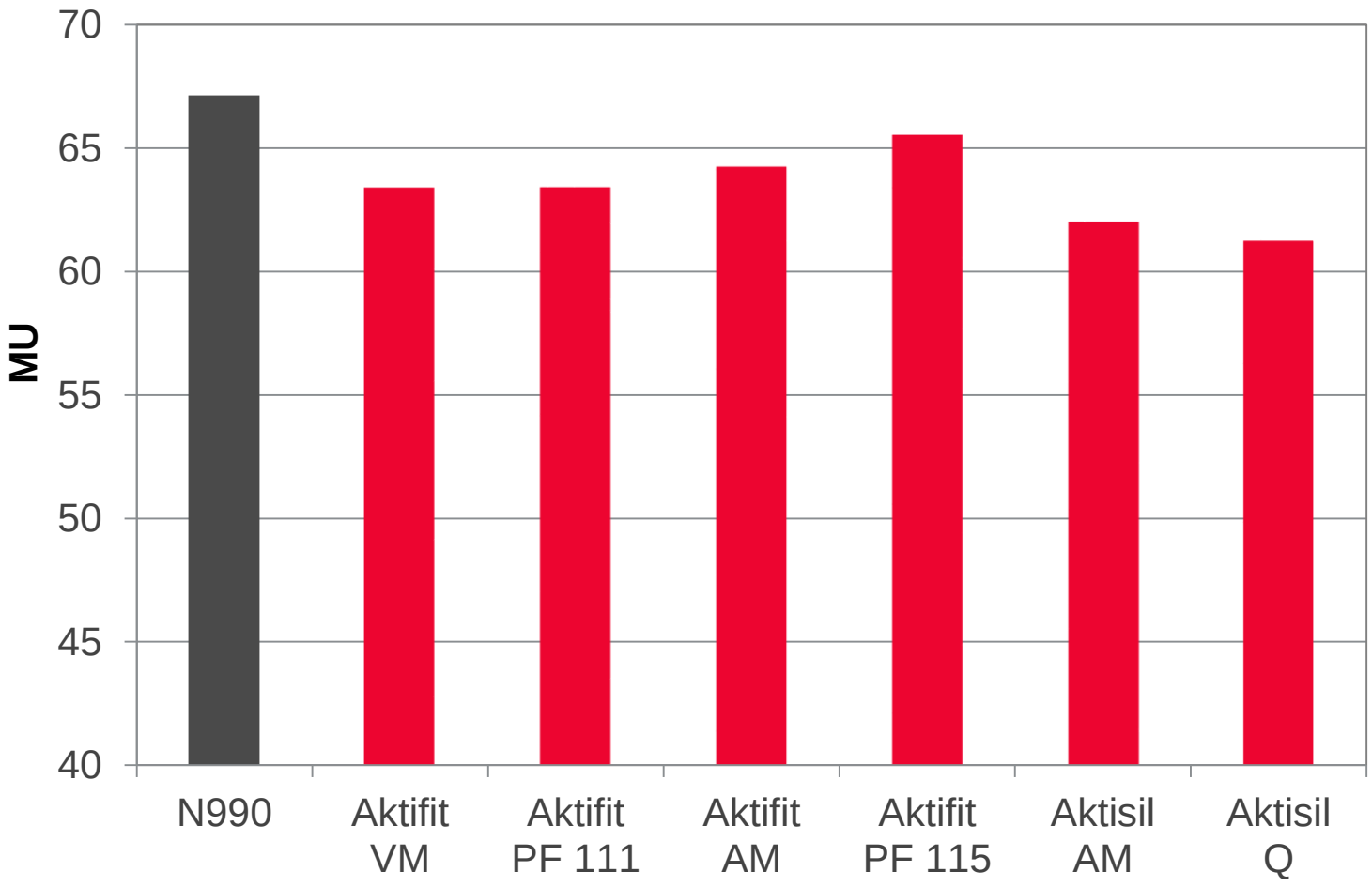
Max. Cure Speed

DIN 53 529, T3 – Göttfert Elastograph, 180 °C, amplitude 0.2°



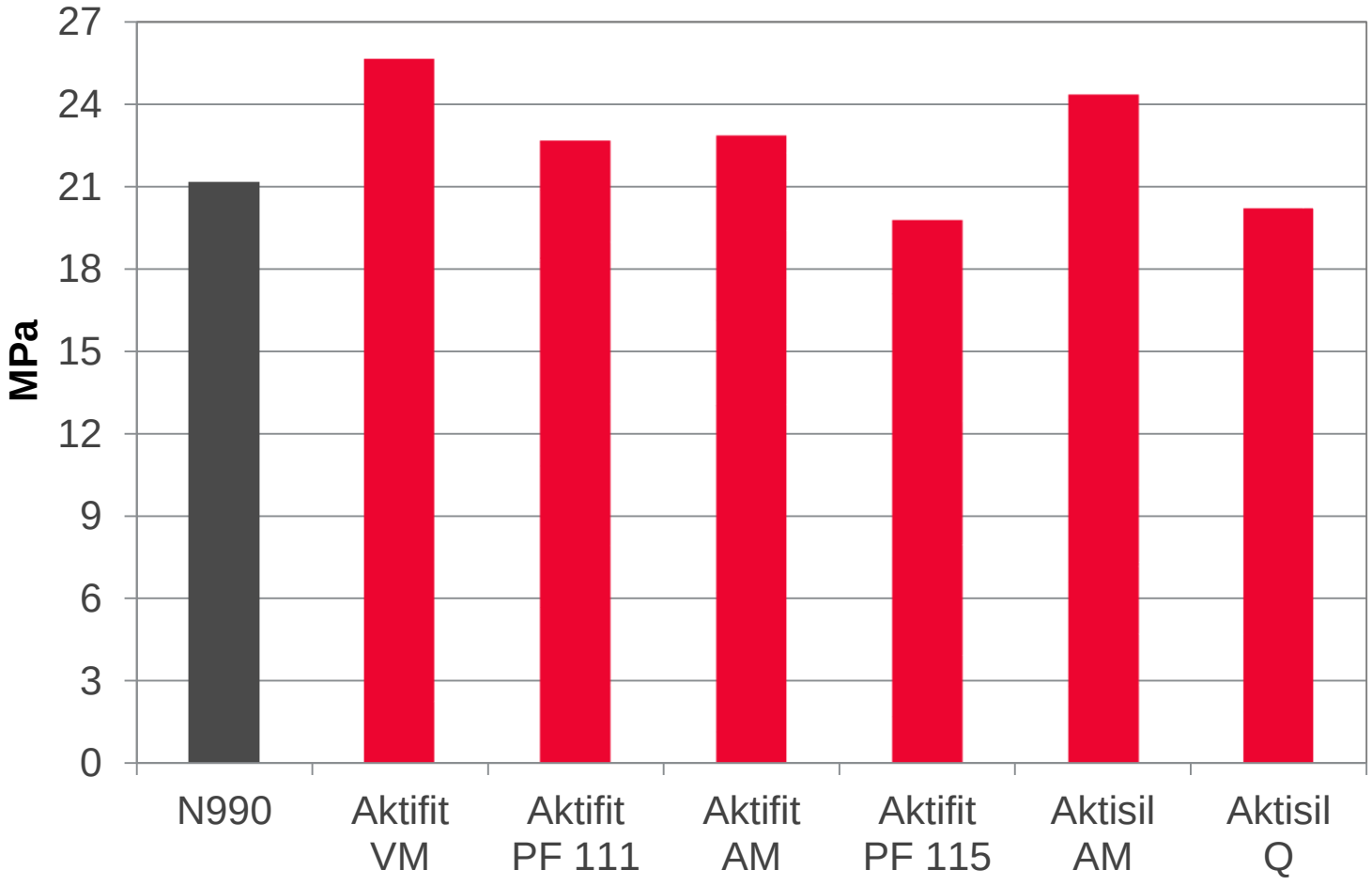
Mooney-Viscosity

DIN 53 523 T3, ML 1+4, 100 °C



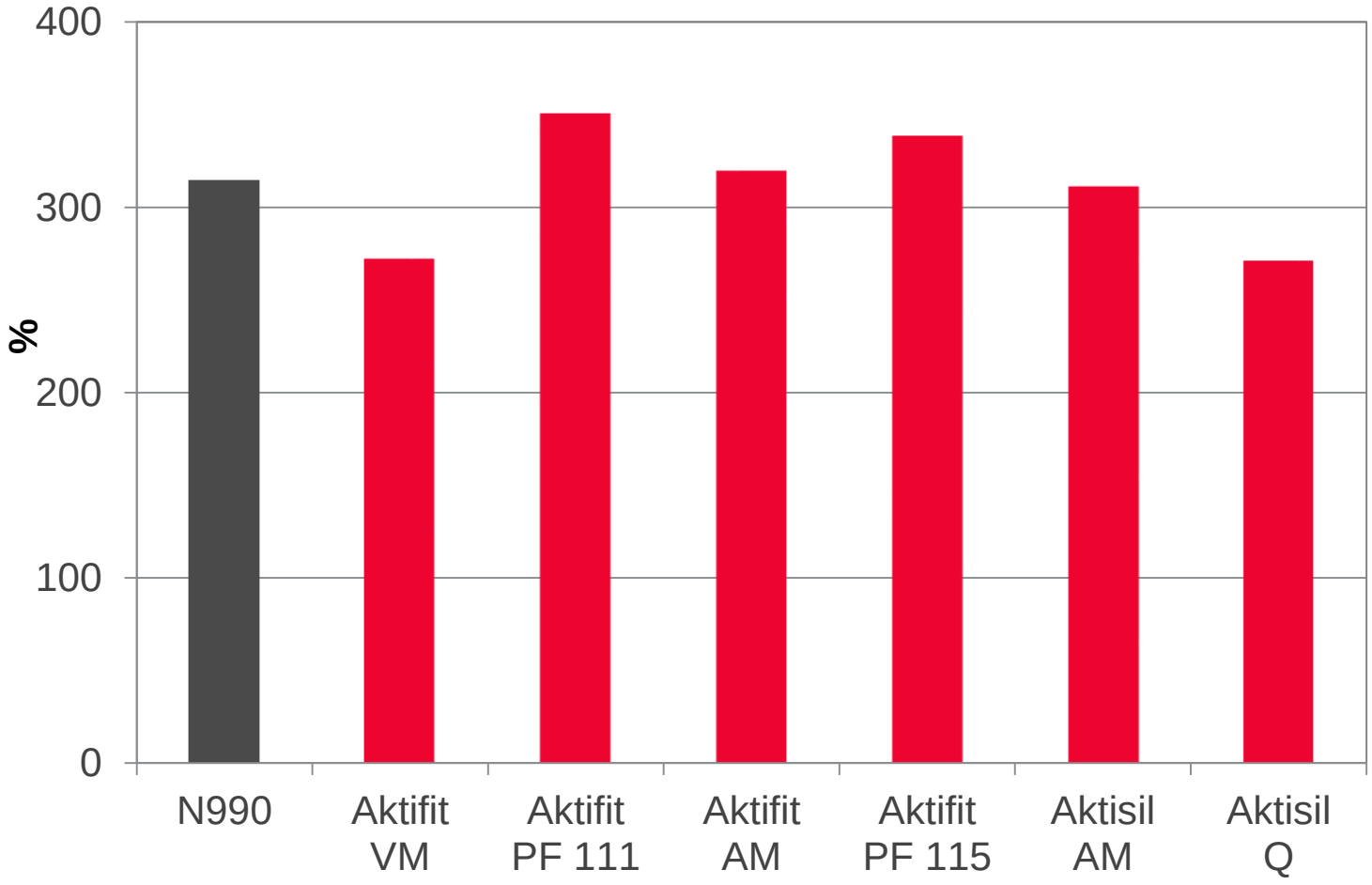
Tensile Strength

DIN 53 504, S2



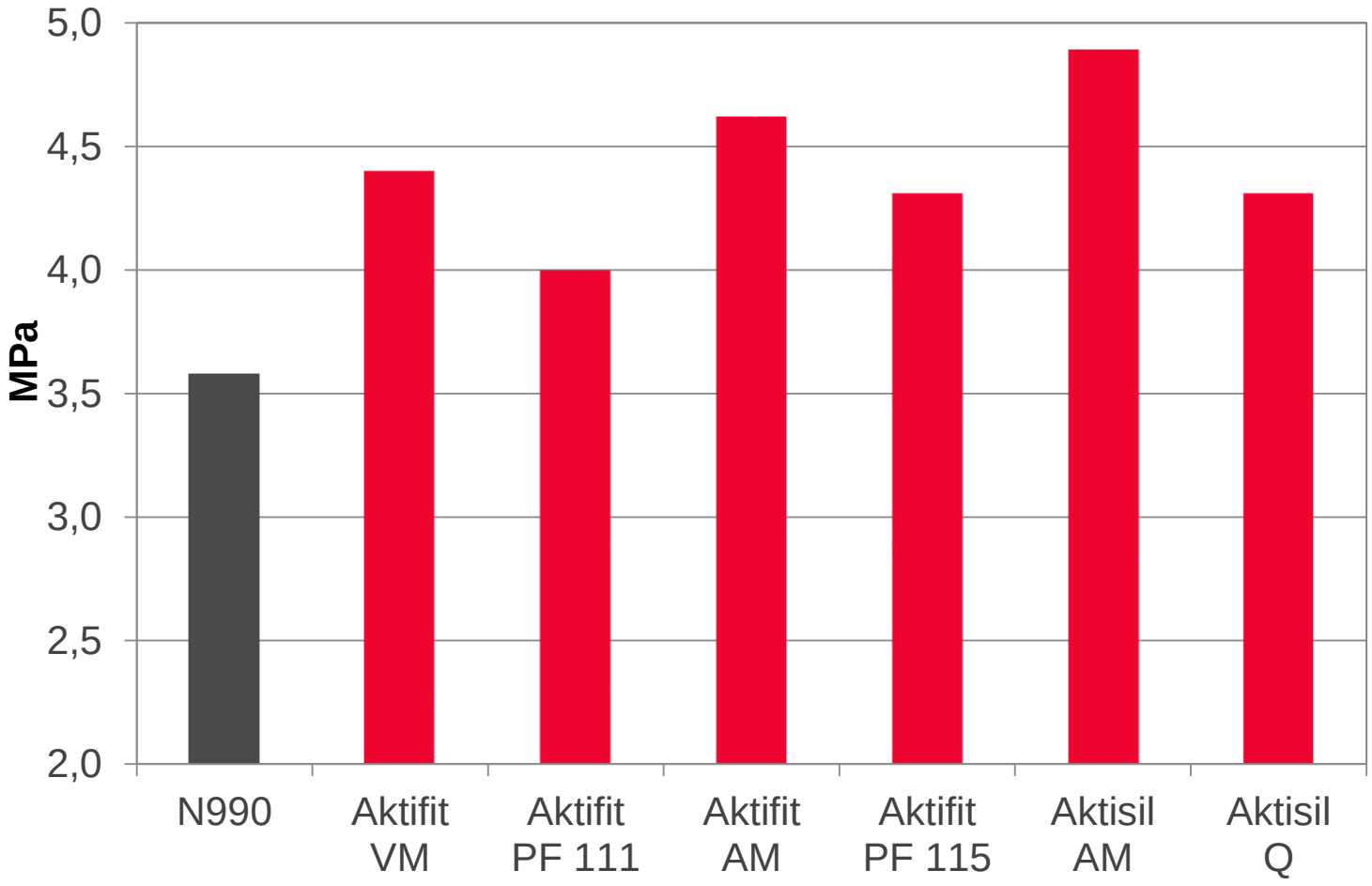
Elongation at Break

DIN 53 504, S2



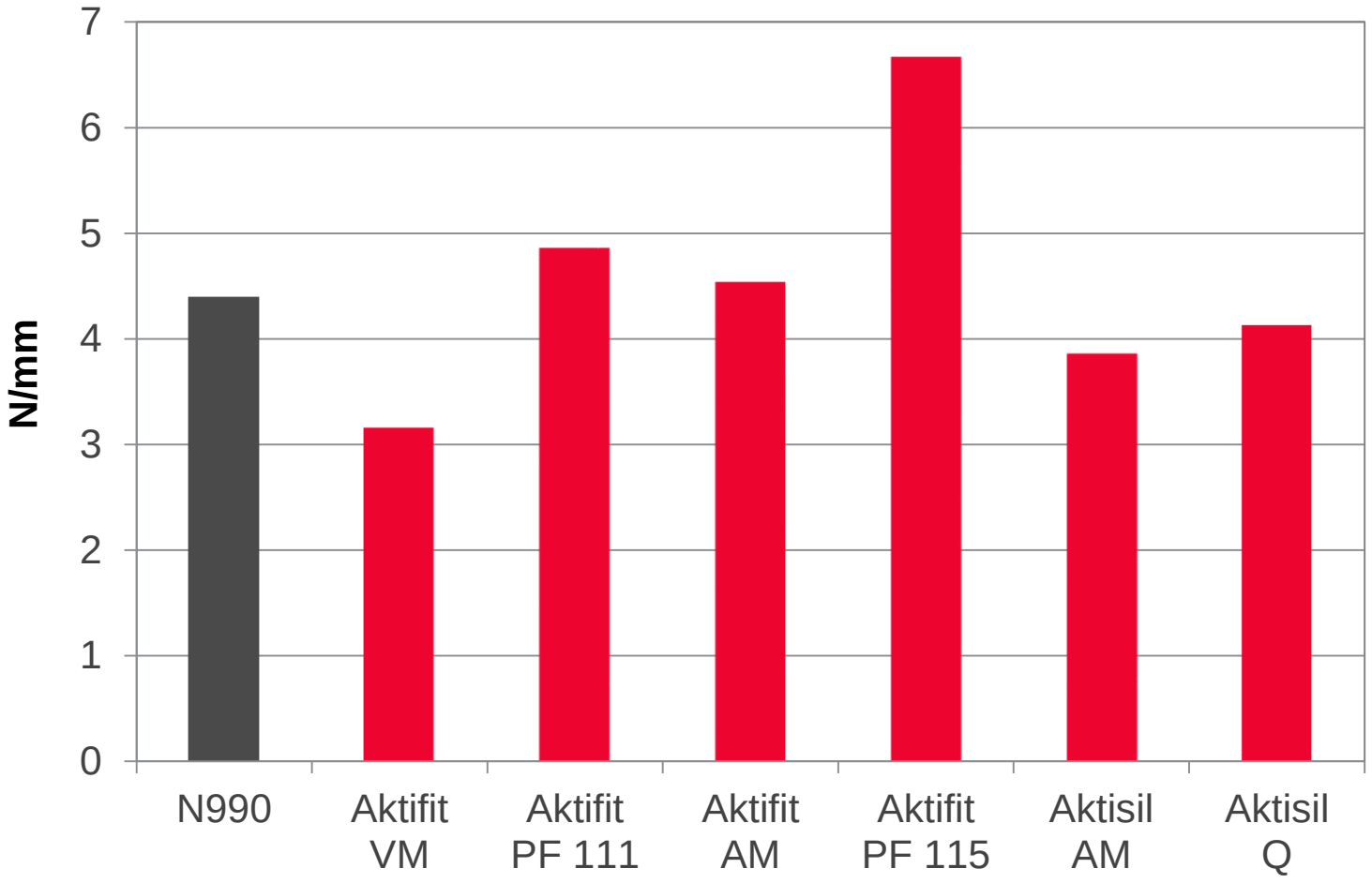
Modulus 100 %

DIN 53 504, S2



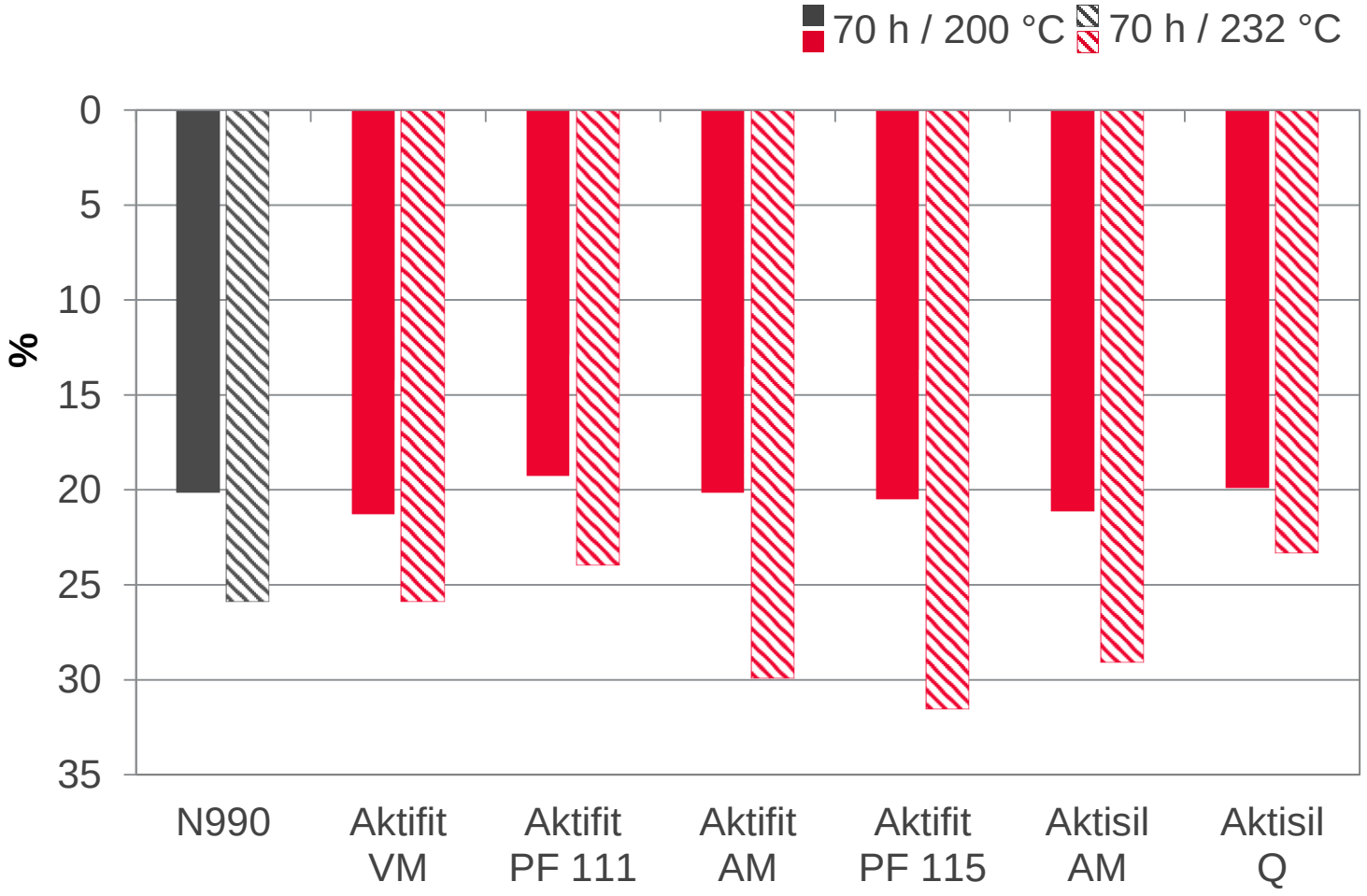
Tear Resistance

DIN ISO 34-1 A, trouser tear



Compression Set ISO

DIN ISO 815-1 B, 25 % defl.



Compression Set ISO Specimens Without Post-Cure

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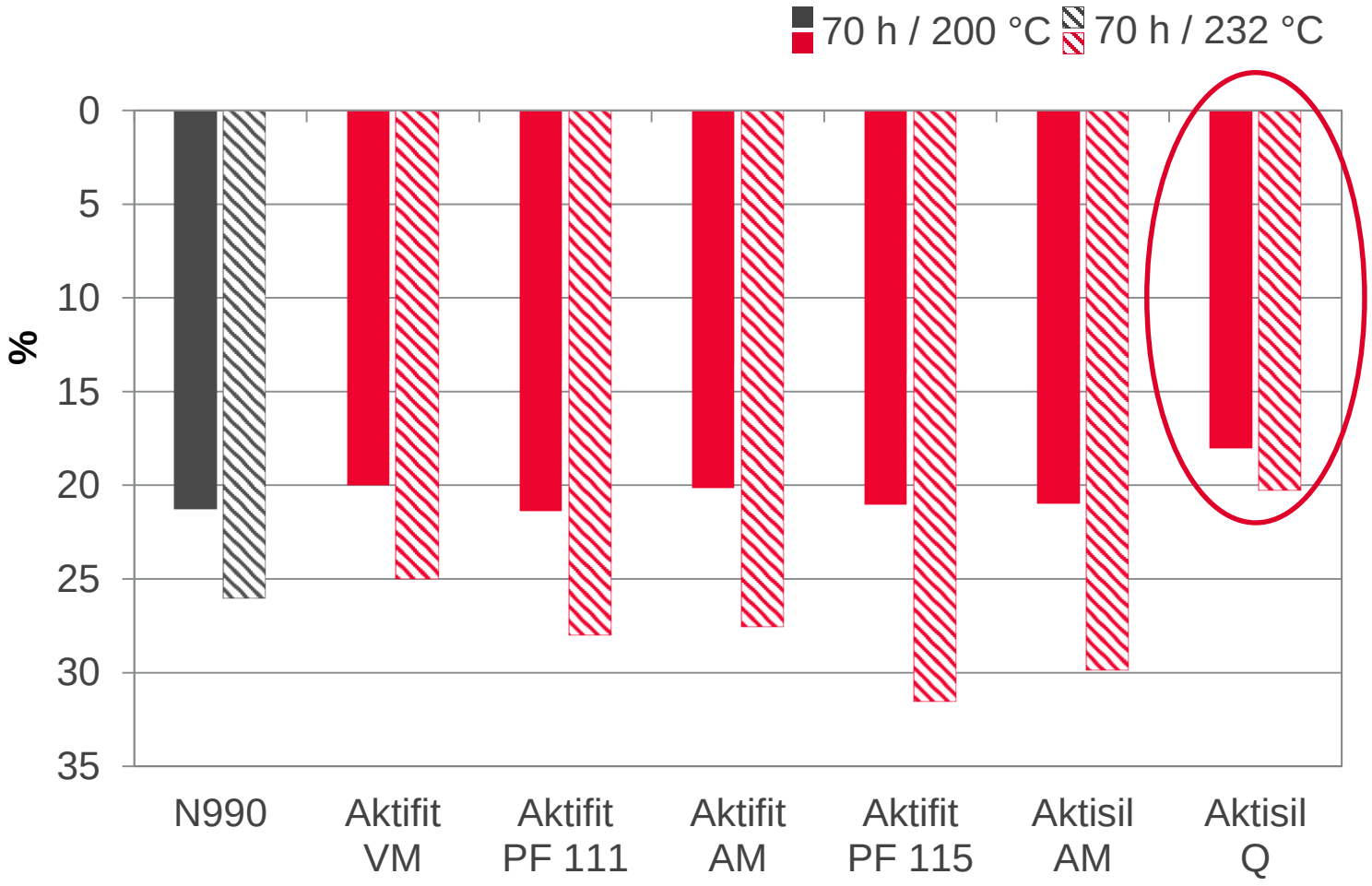
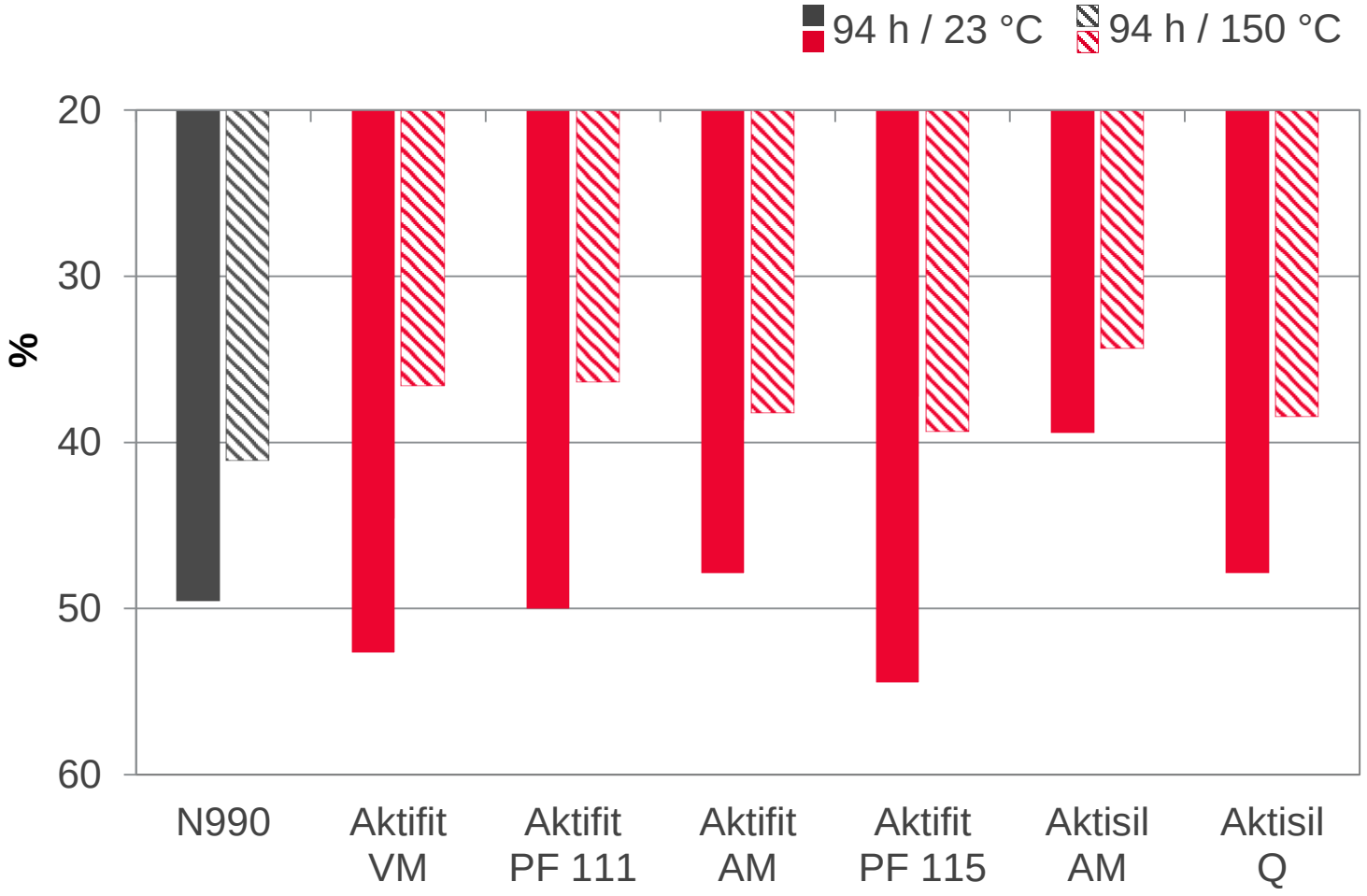
DIN ISO 815-1 B, 25 % defl.



Compression Set VW

VW PV 3307, 50 % defl., 5 s



Resistance to Hot Air
504 h / 210 °C

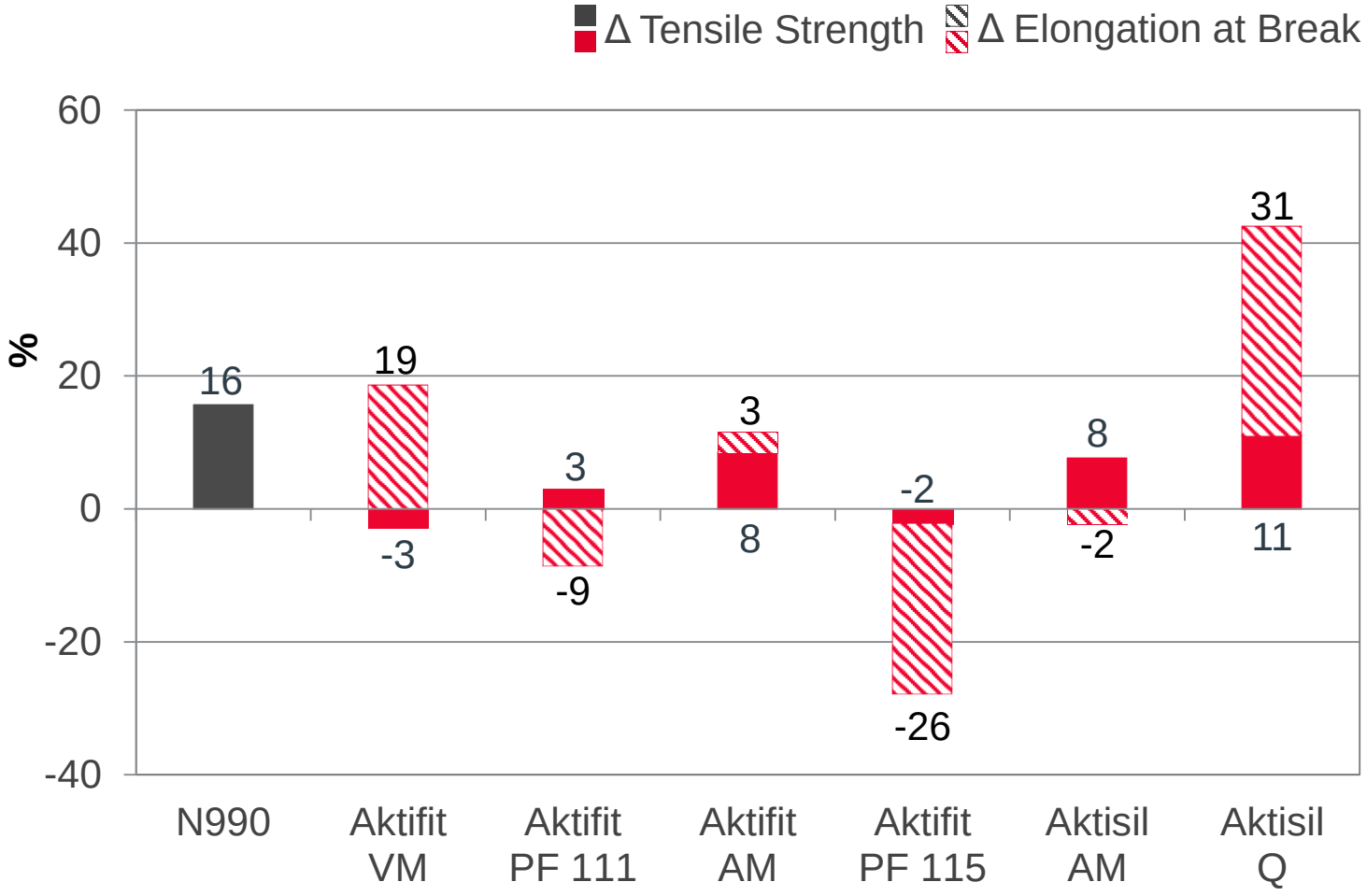
INTRODUCTION

EXPERIMENTAL

RESULTS

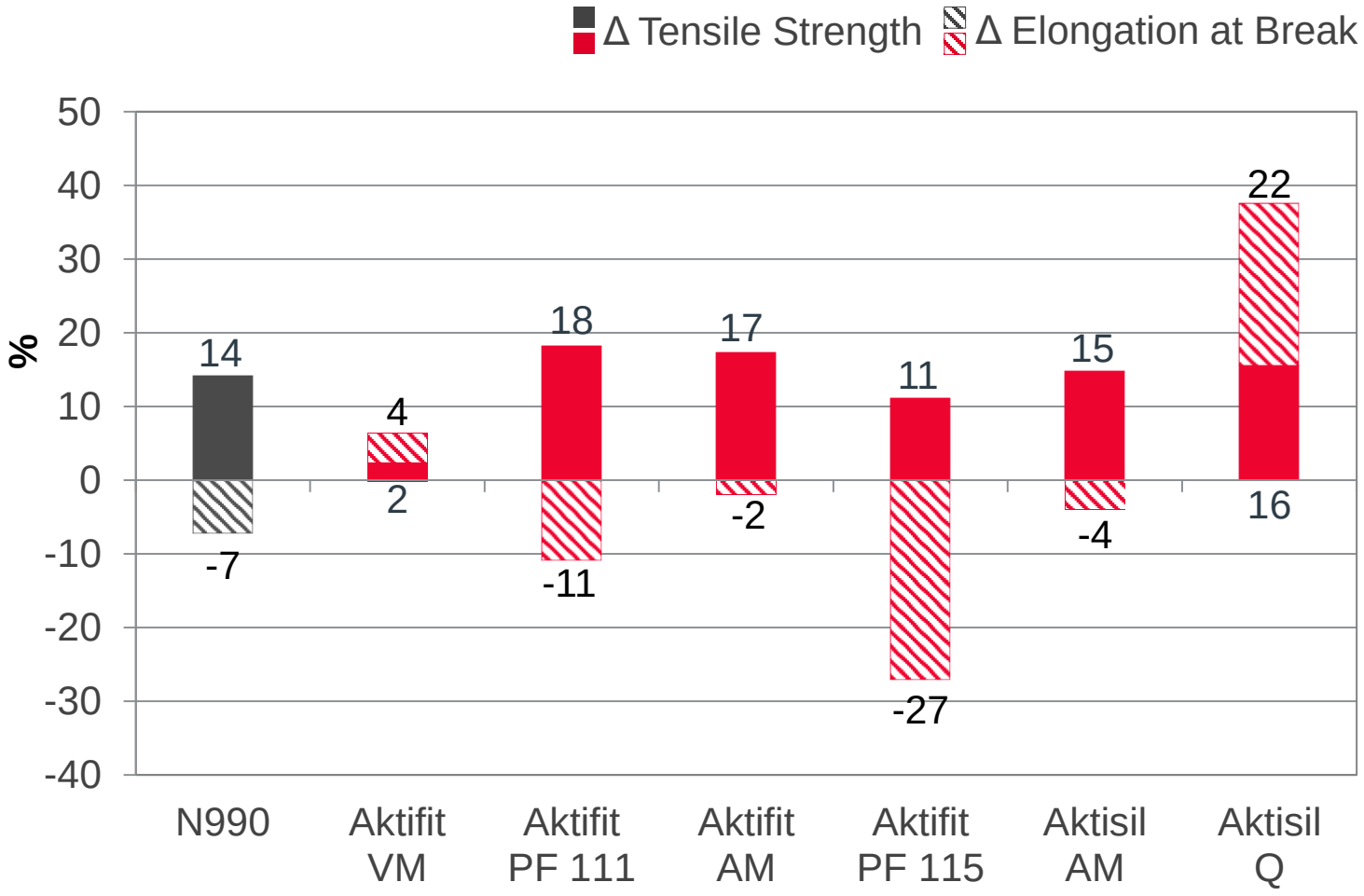
SUMMARY

DIN 53508, measured 30 min. after exposure



Resistance to Hot Air
94 h / 230 °C

DIN 53508, measured 30 min. after exposure



Resistance to Hot Air
Δ Modulus 100 %

DIN 53508, measured 30 min. after exposure

Resistance to Fuel

70 h / 23 °C, FAM B

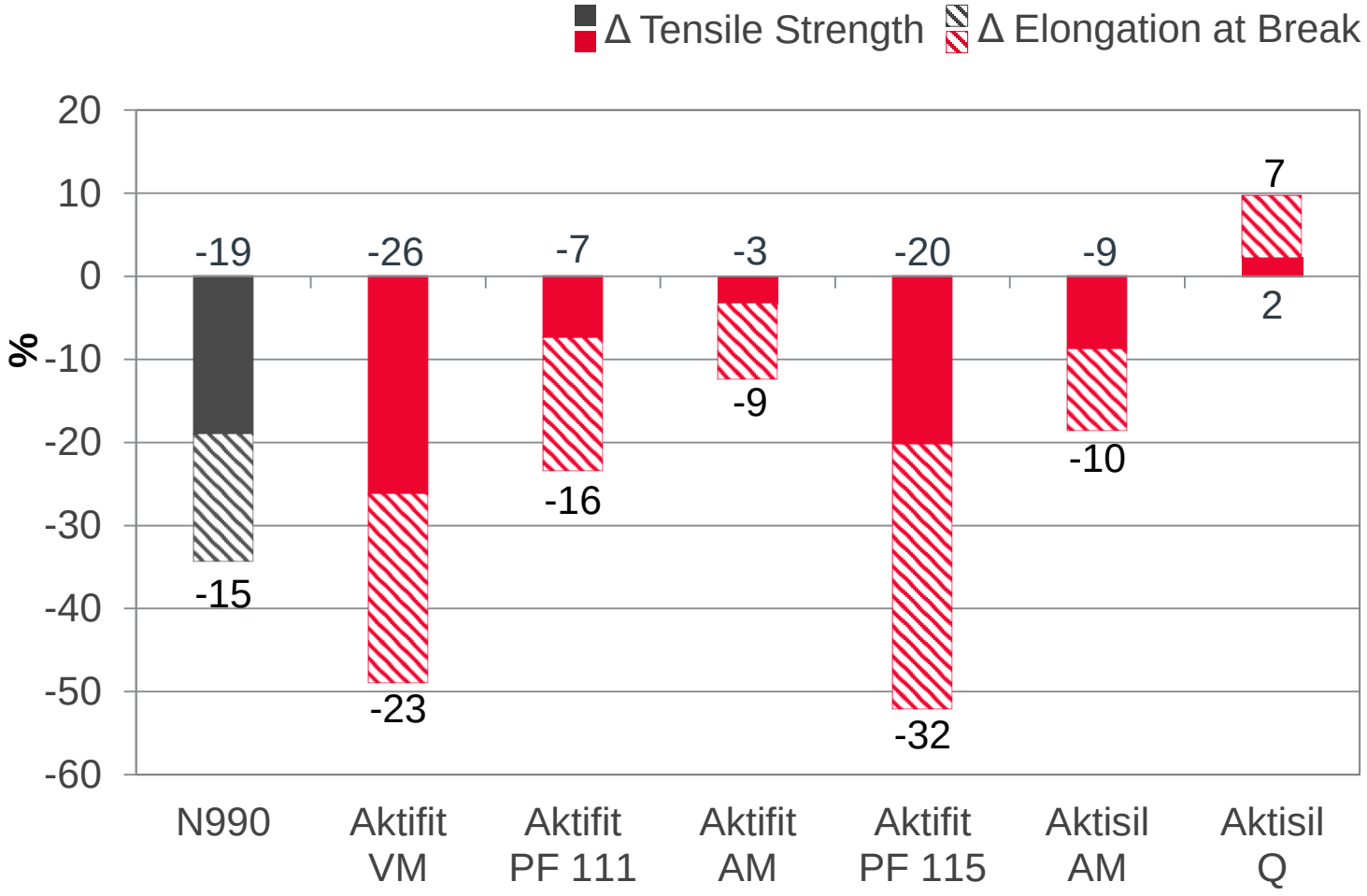
Resistance to fuel of compounds filled with Neuburg Siliceous Earth is comparable to N990

Value ranges:

Δ Hardness	-7 Shore A
Δ Tensile Strength	-50 ± 5 %
Δ Elongation at Break	-25 ± 5 rel.%
Δ Weight	6,5 - 8,0 %
Δ Volume	15 – 20 %

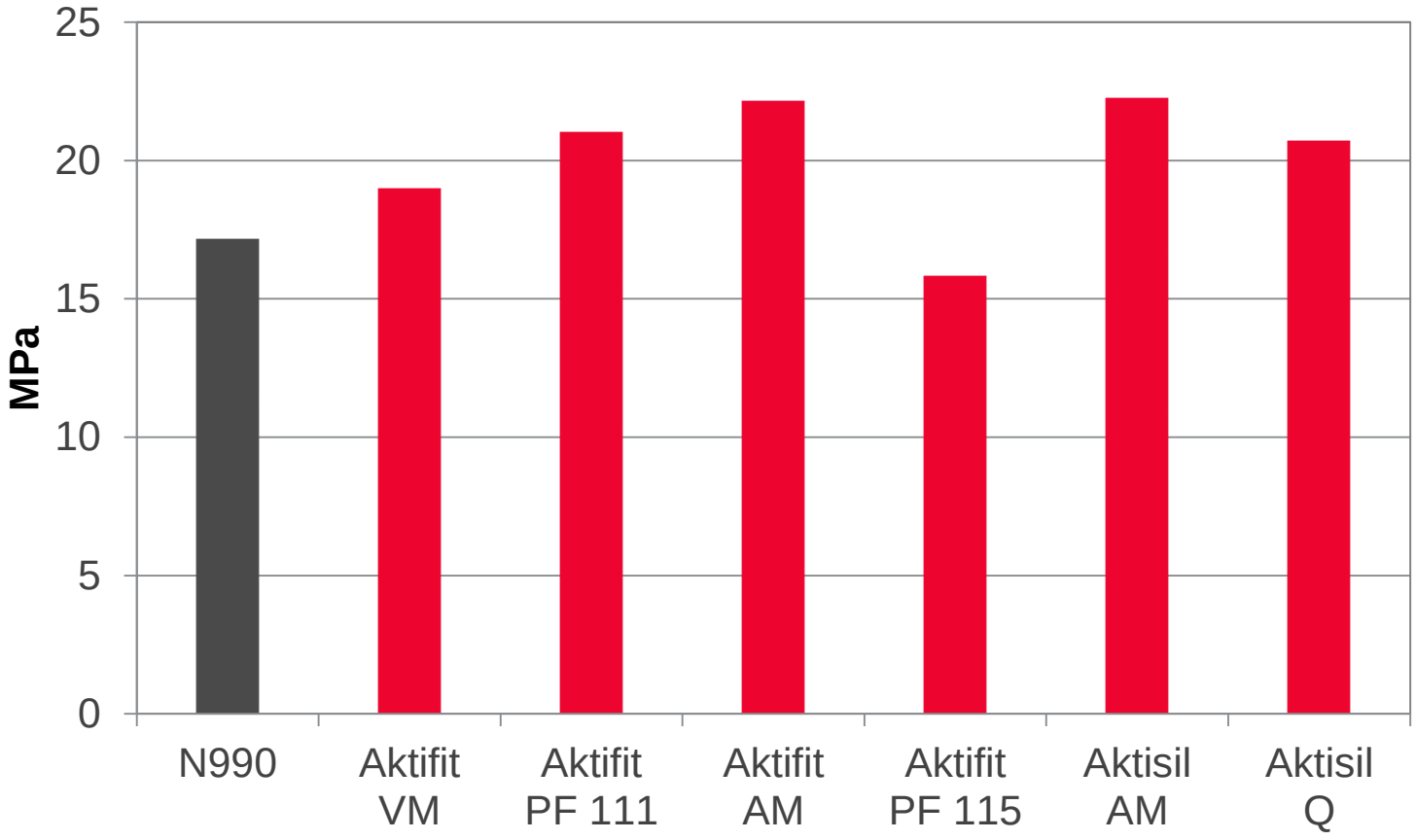
Resistance to Oil OS206304
Δ TS and Δ EB

168 h / 150 °C



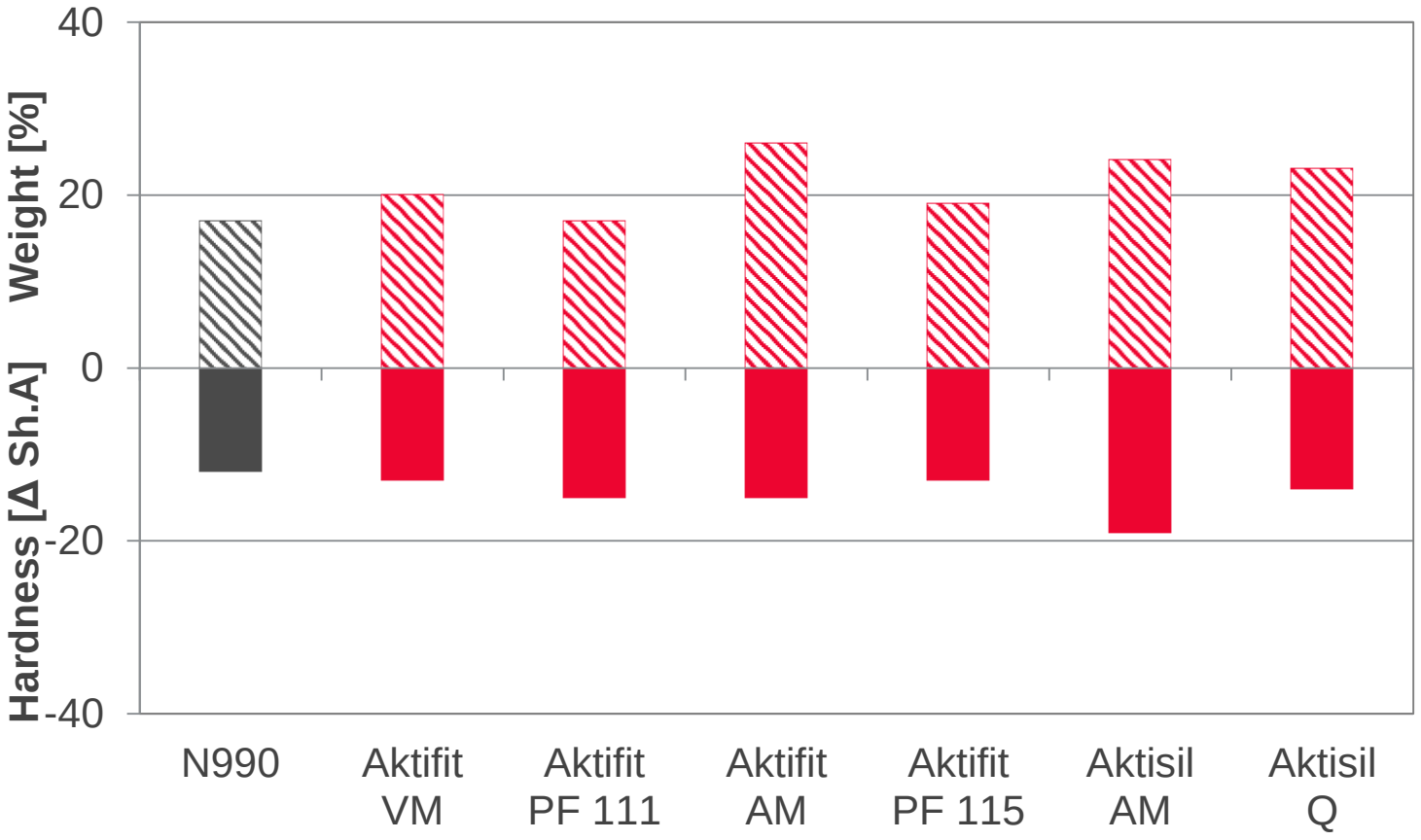
Resistance to Oil OS206304
Tensile Strength

168 h / 150 °C



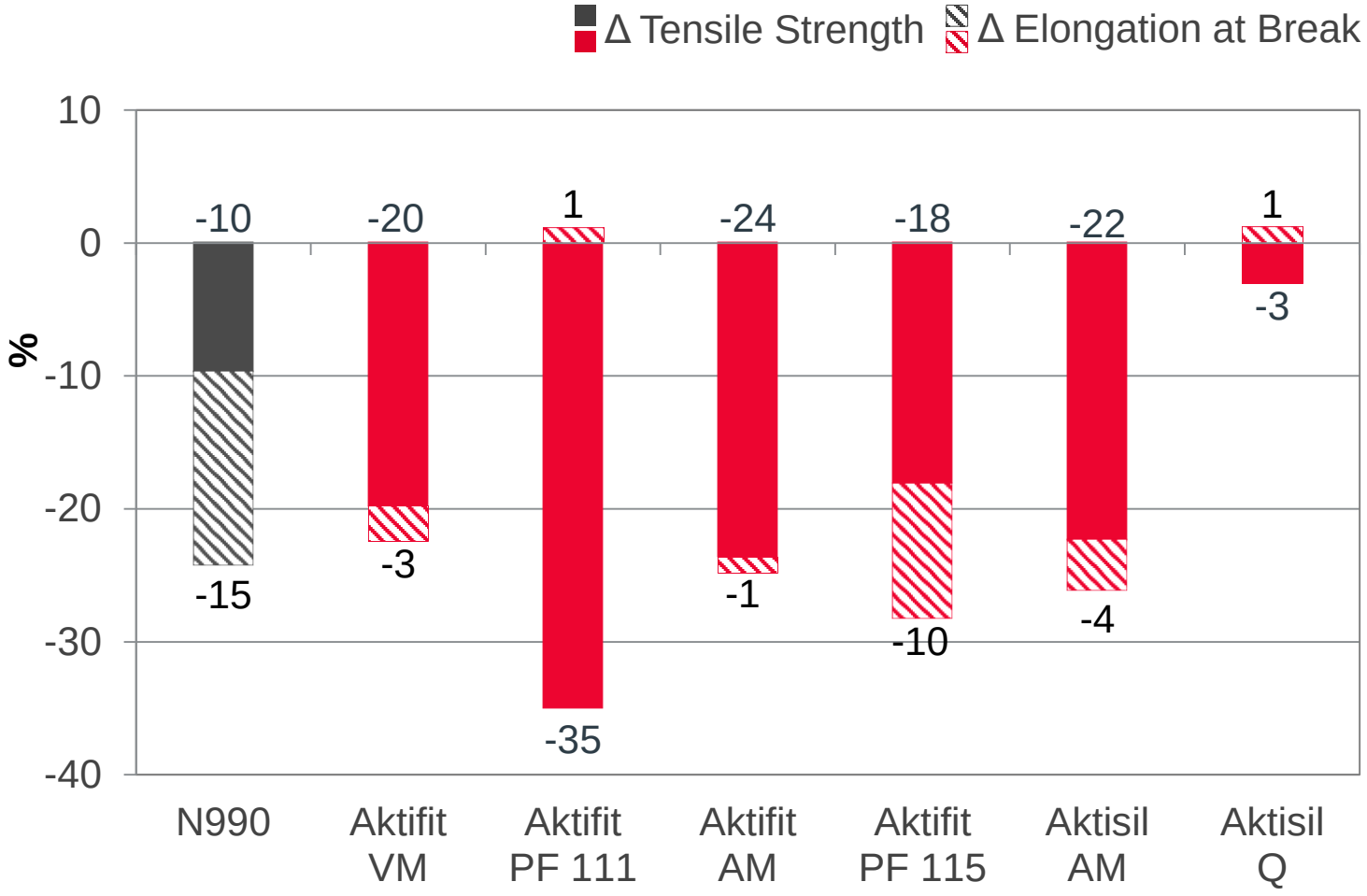
Resistance to Acetic Acid pH3
Δ Hardness and Δ Weight

168 h / 100 °C



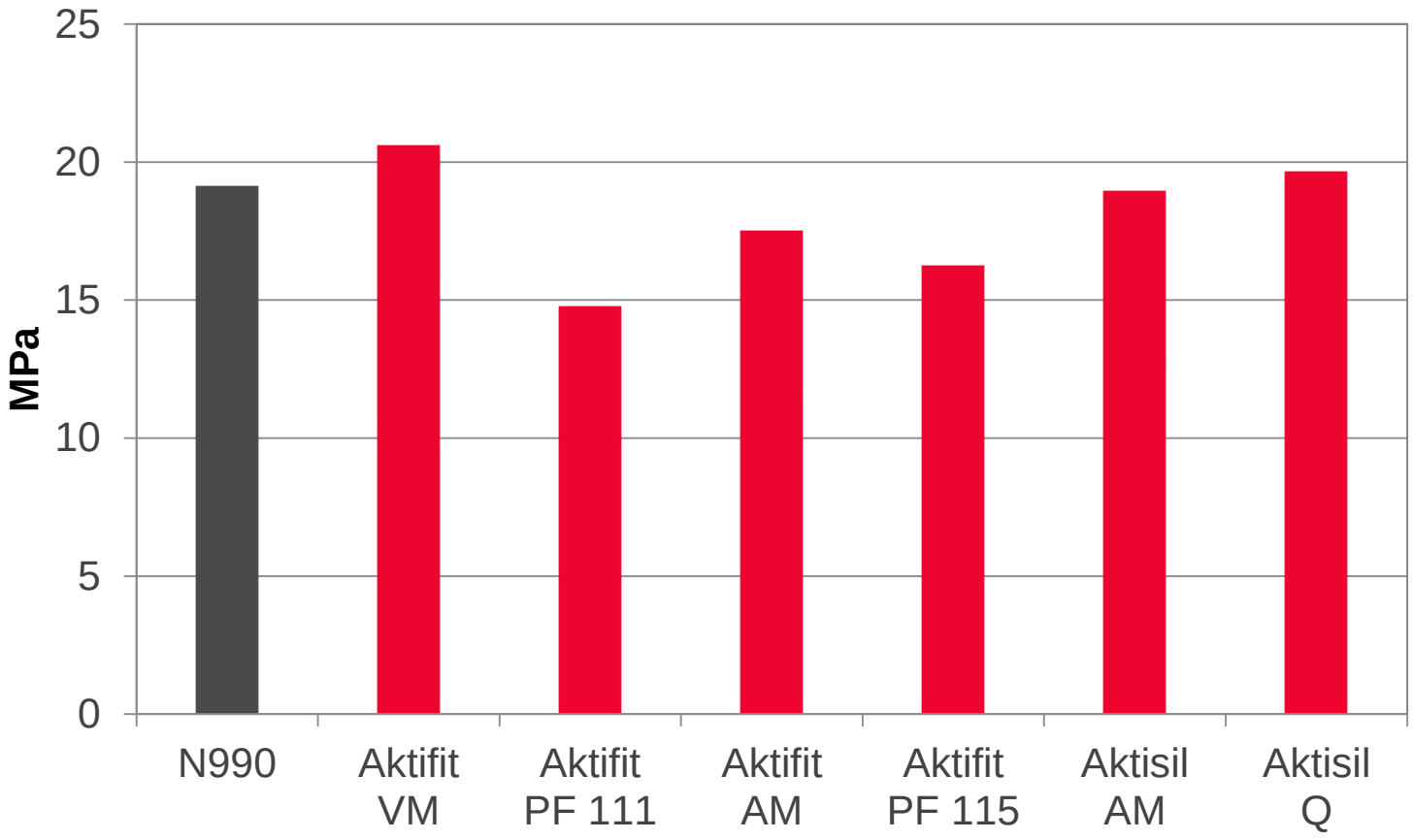
Resistance to Acetic Acid pH3
Δ TS and Δ EB

168 h / 100 °C



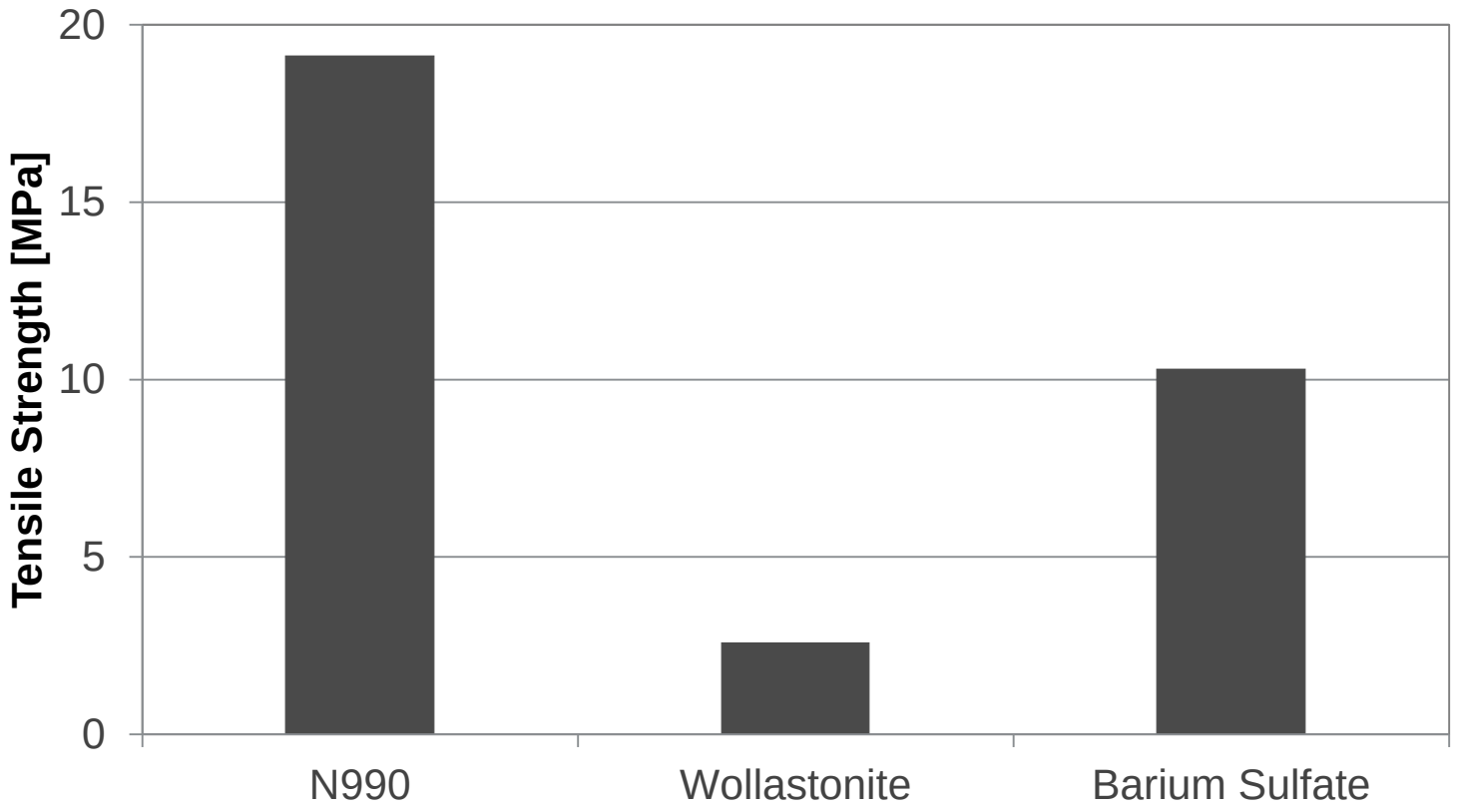
Resistance to Acetic Acid pH3
Tensile Strength

168 h / 100 °C



Resistance to Acetic Acid pH3 Competitors

168 h / 100 °C



Evaluation
NSE vs. N990

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N 990 65 - 70 Shore A	Aktifit VM	Aktifit PF 111	Aktifit AM	Aktifit PF 115	Aktisil AM	Aktisil Q
Cure speed	=	=	+	+	+	=
Viscosity	+	+	+	+	+	+
Tensile strength	+	=	=	=	+	=
Elongation at break		+	=	=	=	
Modulus100 %	+	+	+	+	+	+
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	+	+	=	=	+	=
Hot air resistance 210 °C	=	=	=		=	+
Hot air resistance 230 °C	+	=	=		=	+
Fuel resistance	=	=	=	=	=	=
Oil resistance		+	+		+	+
Resistance to acetic acid	=	=	=	=	=	+

We supply material for good ideas!

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Table of Results

		Aktifit VM	Aktifit PF 111	Aktifit AM	Aktifit PF 115	Aktisil AM	Aktisil Q	N 990
Rheology								
Mooney Viscosity, ML Min., 100 °C	MU	63	63	64	66	62	61	67
Rotorless Curemeter M_{min} 177 °C	Nm	0.04	0.04	0.04	0.05	0.04	0.04	0.04
Rotorless Curemeter V_{max} 177 °C	Nm/min.	3.4	3.5	4.1	3.8	4.0	3.6	3.3
Rotorless Curemeter t_{90} 177 °C	min.	0.8	0.9	0.8	0.8	0.8	0.8	0.8
Mechanical properties – Cure conditions 7 min. / 177 °C, no post-cure								
Hardness	Sh. A	64	65	65	65	64	63	65
Tensile Strength	MPa	22	16	18	17	19	16	17
Modulus 50 %	MPa	1.70	1.68	1.68	1.72	1.83	1.60	1.58
Modulus100 %	MPa	3.9	3.5	3.7	3.6	4.2	3.6	3.2
Elongation at Break	%	278	336	364	395	312	257	330
Tear Resistance	N/mm	3.1	5.4	4.7	6.0	4.5	4.0	4.6
CS ISO 70 h / 200 °C, 25 % defl.	%	20	21	20	21	21	18	21
CS ISO 70 h / 232 °C, 25 % defl.	%	25	28	28	32	30	20	26

Table of Results

		Aktifit VM	Aktifit PF 111	Aktifit AM	Aktifit PF 115	Aktisil AM	Aktisil Q	N990
Mechanical properties – Cure conditions 7 min. / 177 °C, post-cure 2 h / 232 °C								
Hardness	Sh. A	65	66	66	65	66	65	66
Tensile Strength	MPa	26	23	23	20	24	20	21
Modulus 50 %	MPa	1.75	1.76	1.83	1.84	1.92	1.72	1.66
Modulus100 %	MPa	4.4	4.0	4.6	4.3	4.9	4.3	3.6
Elongation at Break	%	272	351	320	339	311	271	314
Tear Resistance	N/mm	3.2	4.9	4.5	6.7	3.9	4.1	4.4
CS ISO 70 h / 200 °C, 25 % defl.	%	21	19	20	20	21	20	20
CS ISO 70 h / 232 °C, 25 % defl.	%	26	24	30	32	29	23	26
CS VW PV3307 94 h / 23 °C, 50 % defl.	%	53	50	48	54	39	48	50
CS VW PV3307 94 h / 150 °C, 50 % defl.	%	37	36	38	39	34	38	41
Abrasion Loss	mm^3	60	72	67	74	71	73	53

Table of Results

		Aktifit VM	Aktifit PF 111	Aktifit AM	Aktifit PF 115	Aktisil AM	Aktisil Q	N 990
Hot air aging, 504 h / 210 °C, measured 30 min. after exposure								
Hardness	Sh. A	68	68	68	69	69	67	69
Tensile Strength	MPa	25	23	25	19	26	22	24
Elongation at Break	%	323	320	330	252	304	356	314
Δ Hardness	Sh. A	+3	+2	+2	+4	+3	+2	+3
Δ Tensile Strength	%	-3	+3	+8	-2	+8	+11	+16
Δ Elongation at Break	rel.%	+19	-9	+3	-26	-2	+31	0
Hot air aging, 94 h / 230 °C, measured 30 min. after exposure								
Hardness	Sh. A	67	68	67	68	68	65	69
Tensile Strength	MPa	26	27	27	22	28	23	24
Elongation at Break	%	283	313	314	247	299	331	292
Δ Hardness	Sh. A	+2	+2	+1	+3	+2	0	+3
Δ Tensile Strength	%	+2	+18	+17	+11	+15	+16	+14
Δ Elongation at Break	rel.%	+4	-11	-2	-27	-4	+22	-7

Table of Results

		Aktifit VM	Aktifit PF 111	Aktifit AM	Aktifit PF 115	Aktisil AM	Aktisil Q	N 990
Exposure to fuel FAM B, 70 h / 23 °C								
Hardness	Sh. A	58	59	58	58	58	58	59
Tensile Strength	MPa	14	11	12	10	11	10	12
Elongation at Break	%	220	255	246	268	238	206	231
Δ Hardness	Sh. A	-7	-7	-8	-7	-8	-7	-7
Δ Tensile Strength	%	-46	-51	-48	-50	-53	-49	-44
Δ Elongation at Break	rel.%	-19	-27	-23	-21	-24	-24	-26
Δ Weight	%	+7.3	+7.8	+8.0	+8.0	+6.8	+8.0	+6.7
Δ Volume	%	+18	+19	+19	+19	+17	+19	+15
Exposure to engine oil OS206304, 168 h / 150 °C								
Hardness	Sh. A	65	65	65	66	65	64	65
Tensile Strength	MPa	19	21	22	16	22	21	17
Elongation at Break	%	210	295	291	231	281	291	266
Δ Hardness	Sh. A	0	-1	-1	+1	-1	-1	-1
Δ Tensile Strength	%	-26	-7	-3	-20	-9	+2	-19
Δ Elongation at Break	rel.%	-23	-16	-9	-32	-10	+7	-15
Δ Weight	%	+0.8	+0.7	+0.6	+0.6	+0.7	+0.6	+0.8
Δ Volume	%	+1.4	+1.2	+0.9	+1.4	+1.2	+0.7	+1.4

Table of Results

		Aktifit VM	Aktifit PF 111	Aktifit AM	Aktifit PF 115	Aktisil AM	Aktisil Q	N 990
Exposure to acetic acid pH3, 168 h / 100 °C								
Hardness	Sh. A	52	51	51	52	47	51	54
Tensile Strength	MPa	21	15	17	16	19	20	19
Elongation at Break	%	265	355	316	304	300	274	268
Δ Hardness	Sh. A	-13	-15	-15	-13	-19	-14	-12
Δ Tensile Strength	%	-20	-35	-24	-18	-22	-3	-10
Δ Elongation at Break	rel.%	-3	+1	-1	-10	-4	+1	-15
Δ Weight	%	+20	+17	+26	+19	+24	+23	+17
Δ Volume	%	+37	+34	+50	+37	+47	+43	+30

Table of Results only Competitors

Loading 30 phr (49 phr for $BaSO_4$)		Wollastonite AST	Wollastonite EST	Barium Sulfate	N 990
Rheology					
Mooney Viscosity, ML Min., 100 °C	MU	63	59	66	67
Rotorless Curemeter M_{min} 177 °C	Nm	0.03	0.03	0.04	0.04
Rotorless Curemeter V_{max} 177 °C	Nm/min.	3.4	3.1	3.4	3.3
Rotorless Curemeter t_{90} 177 °C	min.	0.9	0.9	0.9	0.8
Mechanical properties – Cure conditions 7 min. / 177 °C, no post-cure					
Hardness	Sh. A	61	63	61	65
Tensile Strength	MPa	18	16	15	17
Modulus 50 %	MPa	1.9	1.6	1.4	1.58
Modulus100 %	MPa	4.2	3.2	2.1	3.2
Elongation at Break	%	397	393	421	330
Tear Resistance	N/mm	6.0	5.9	4.7	4.6
CS ISO 70 h / 200 °C, 25 % defl.	%	24	21	22	21
CS ISO 70 h / 232 °C, 25 % defl.	%	35	28	31	26

Table of Results only Competitors

Loading 30 phr (49 phr for $BaSO_4$)		Wollastonite AST	Wollastonite EST	Barium Sulfate	N 990
Mechanical properties – Cure conditions 7 min. / 177 °C, post-cure 2 h / 232 °C					
Hardness	Sh. A	67	64	67	66
Tensile Strength	MPa	19	20	16	21
Modulus 50 %	MPa	1.7	1.7	1.4	1.7
Modulus100 %	MPa	3.9	3.5	2.4	3.6
Elongation at Break	%	337	399	407	314
Tear Resistance	N/mm	6.2	6.9	6.1	4.4
CS ISO 70 h / 200 °C, 25 % defl.	%	22	18	22	20
CS ISO 70 h / 232 °C, 25 % defl.	%	29	24	28	26
CS VW PV3307 94 h / 23 °C, 50 % defl.	%	51	51	49	50
CS VW PV3307 94 h / 150 °C, 50 % defl.	%	35	36	36	41
Abrasion Loss	mm^3	104	114	124	53

Table of Results only Competitors

Loading 30 phr (49 phr for $BaSO_4$)		Wollastonite AST	Wollastonite EST	Barium Sulfate	N 990
Hot air aging, 504 h / 210 °C, measured 30 min. after exposure					
Hardness	Sh. A	64	64	65	69
Tensile Strength	MPa	20	21	24	24
Elongation at Break	%	331	390	372	314
Δ Hardness	Sh. A	-3	0	-2	+3
Δ Tensile Strength	%	+6	+3	+43	+16
Δ Elongation at Break	rel.%	-2	-2	-9	0
Hot air aging, 94 h / 230 °C, measured 30 min. after exposure					
Hardness	Sh. A	65	65	65	69
Tensile Strength	MPa	22	22	25	24
Elongation at Break	%	325	335	353	292
Δ Hardness	Sh. A	-2	1	-2	+3
Δ Tensile Strength	%	+18	+8	+51	+14
Δ Elongation at Break	rel.%	-4	-16	-13	-7

Table of Results only Competitors

Loading 30 phr (49 phr for $BaSO_4$)		Wollastonite AST	Wollastonite EST	Barium Sulfate	N 990
Exposure to fuel FAM B, 70 h / 23 °C					
Hardness	Sh. A	56	55	52	59
Tensile Strength	MPa	8.6	7.0	7.7	12
Elongation at Break	%	241	261	329	231
Δ Hardness	Sh. A	-11	-9	-15	-7
Δ Tensile Strength	%	-53	-66	-53	-44
Δ Elongation at Break	rel.%	-28	-35	-19	-26
Δ Weight	%	+7,6	+7,2	+7,4	+6,7
Δ Volume	%	+19	+18	+20	+15
Exposure to engine oil OS206304, 168 h / 150 °C					
Hardness	Sh. A	62	62	62	65
Tensile Strength	MPa	17	13	11	17
Elongation at Break	%	286	297	340	266
Δ Hardness	Sh. A	-5	-2	-5	-1
Δ Tensile Strength	%	-7	-35	-34	-19
Δ Elongation at Break	rel.%	-15	-26	-17	-15
Δ Weight	%	+0.6	+0.6	+0.5	+0.8
Δ Volume	%	+1.2	+1.1	+1.3	+1.4

Table of Results only Competitors

Loading 30 phr (49 phr for $BaSO_4$)		Wollastonite AST	Wollastonite EST	Barium Sulfate	N 990
Exposure to acetic acid pH3, 168 h / 100 °C					
Hardness	Sh. A	37	non-determinable	35	54
Tensile Strength	MPa	2.6	2.8	10	19
Elongation at Break	%	54	84	252	268
Δ Hardness	Sh. A	-30	non-determinable	-32	-12
Δ Tensile Strength	%	-86	-86	-37	-10
Δ Elongation at Break	rel.%	-84	-79	-38	-15
Δ Weight	%	+288	+227	+55	+17
Δ Volume	%	+593	+499	+121	+30