Peroxide cured silicone rubber – Optimization of property combinations with Aktisil Q

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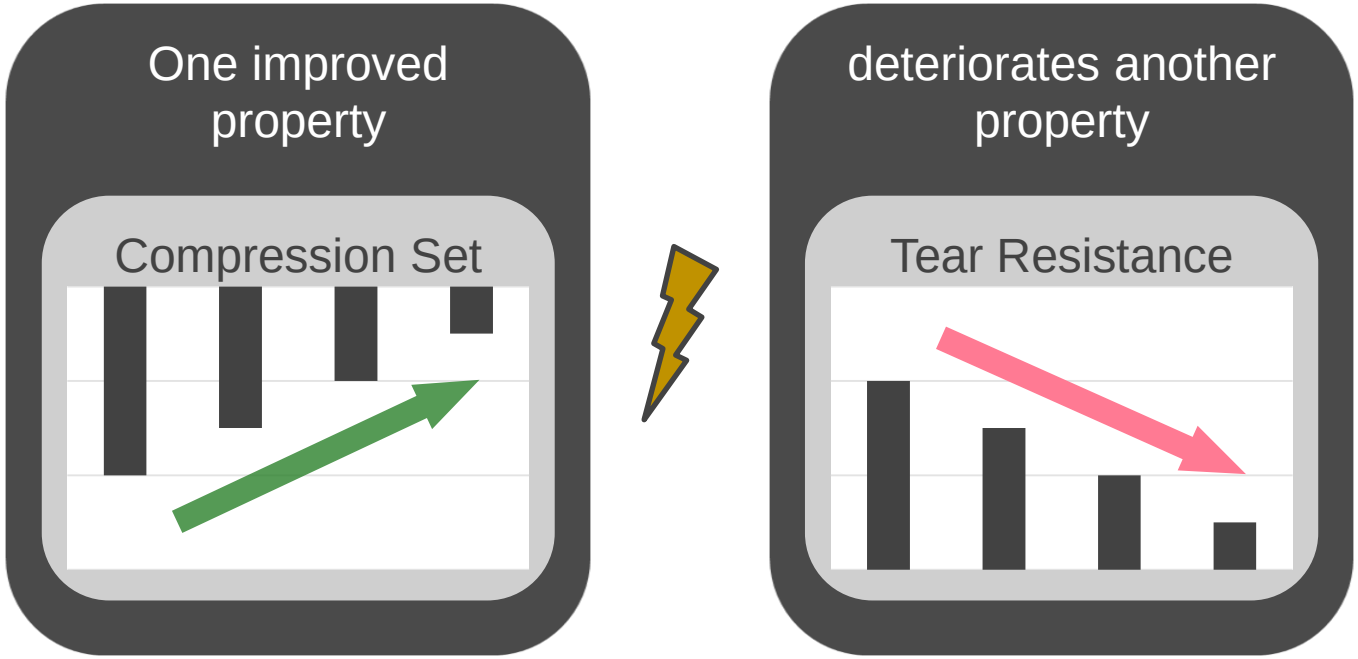
Status Quo

Addition of mineral fillers to silicone rubber

- Cost reduction
- Improved processing
- Optimized mechanical properties

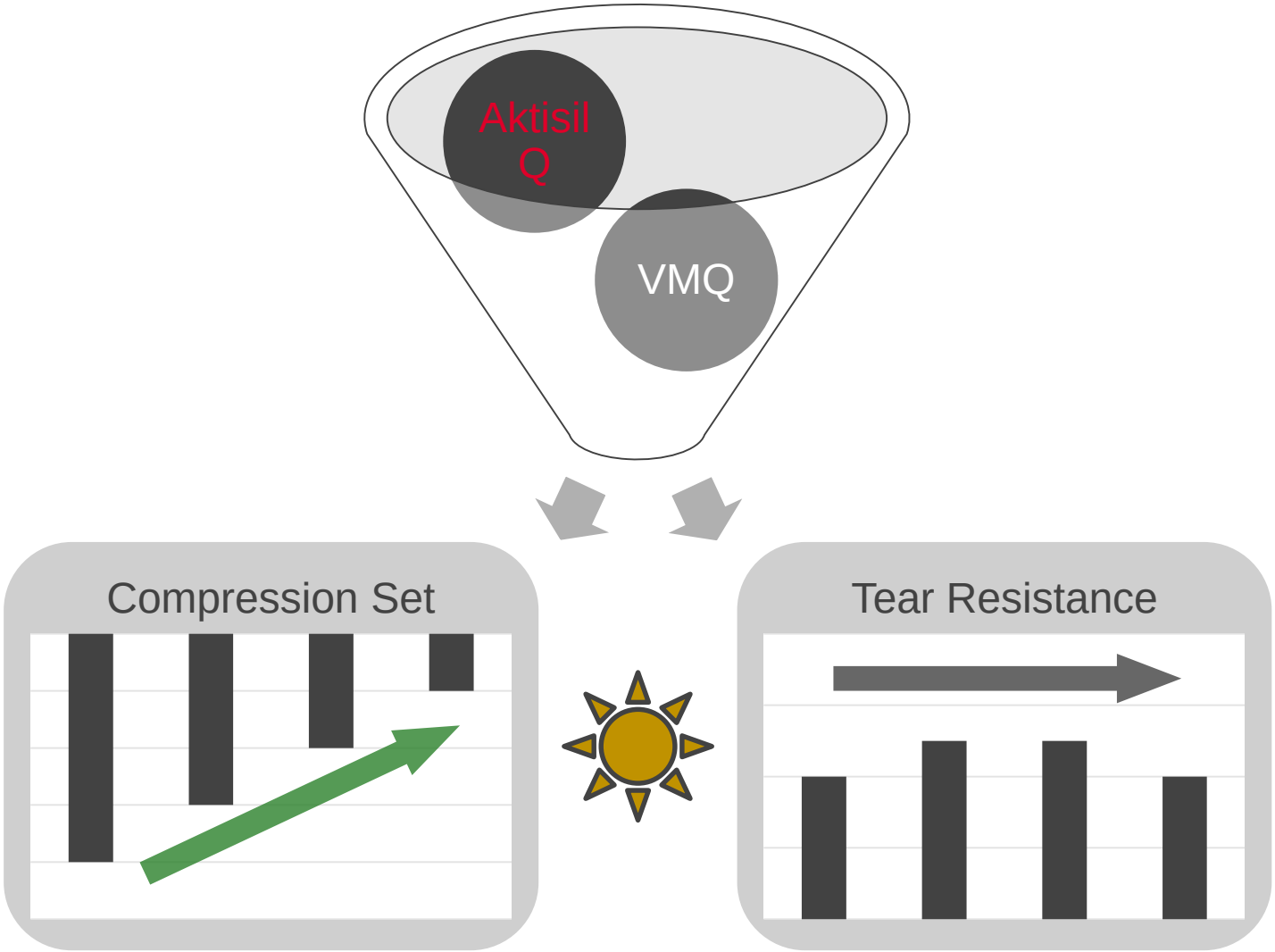
Opposing Properties

For example

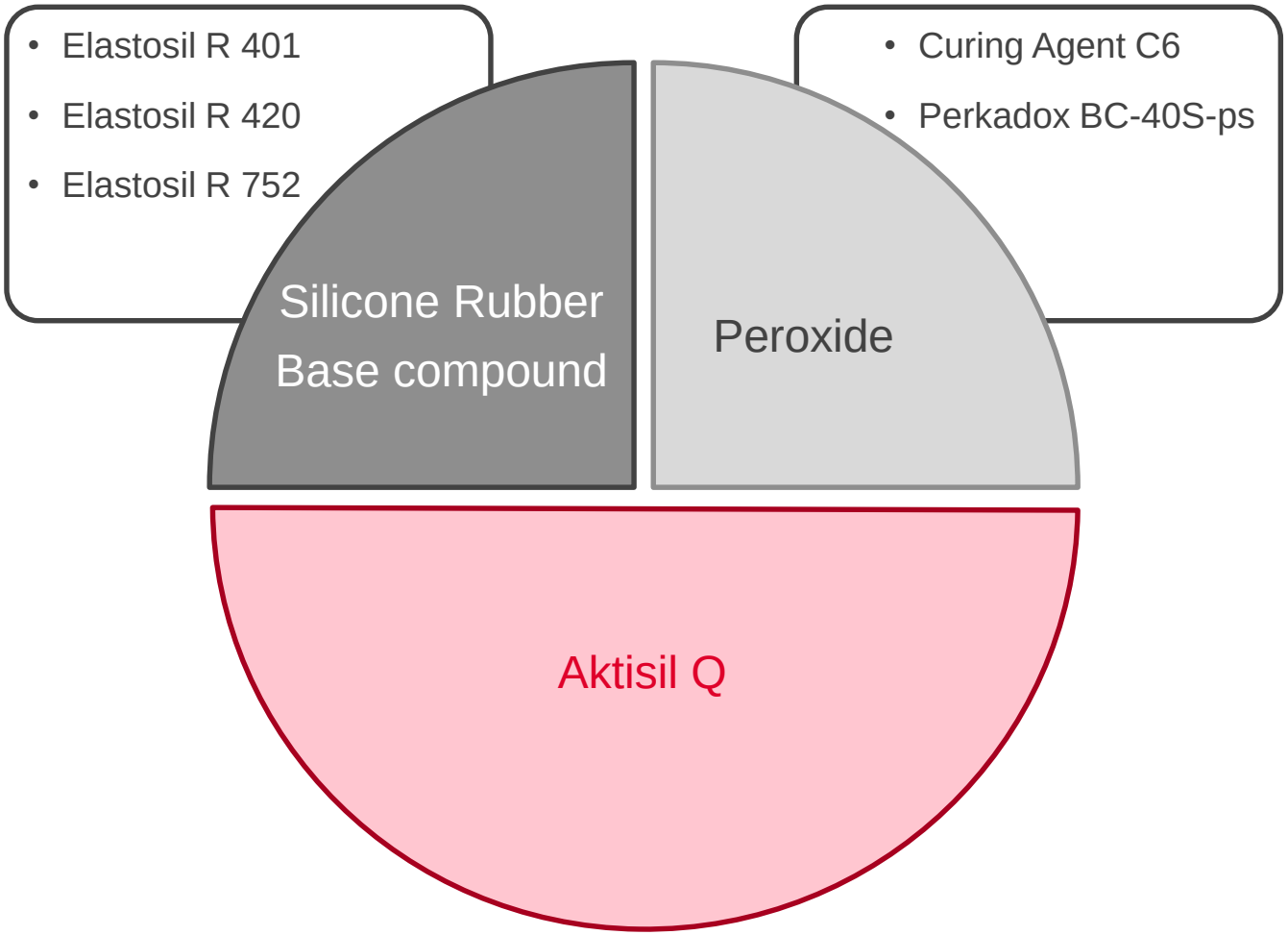


Objective

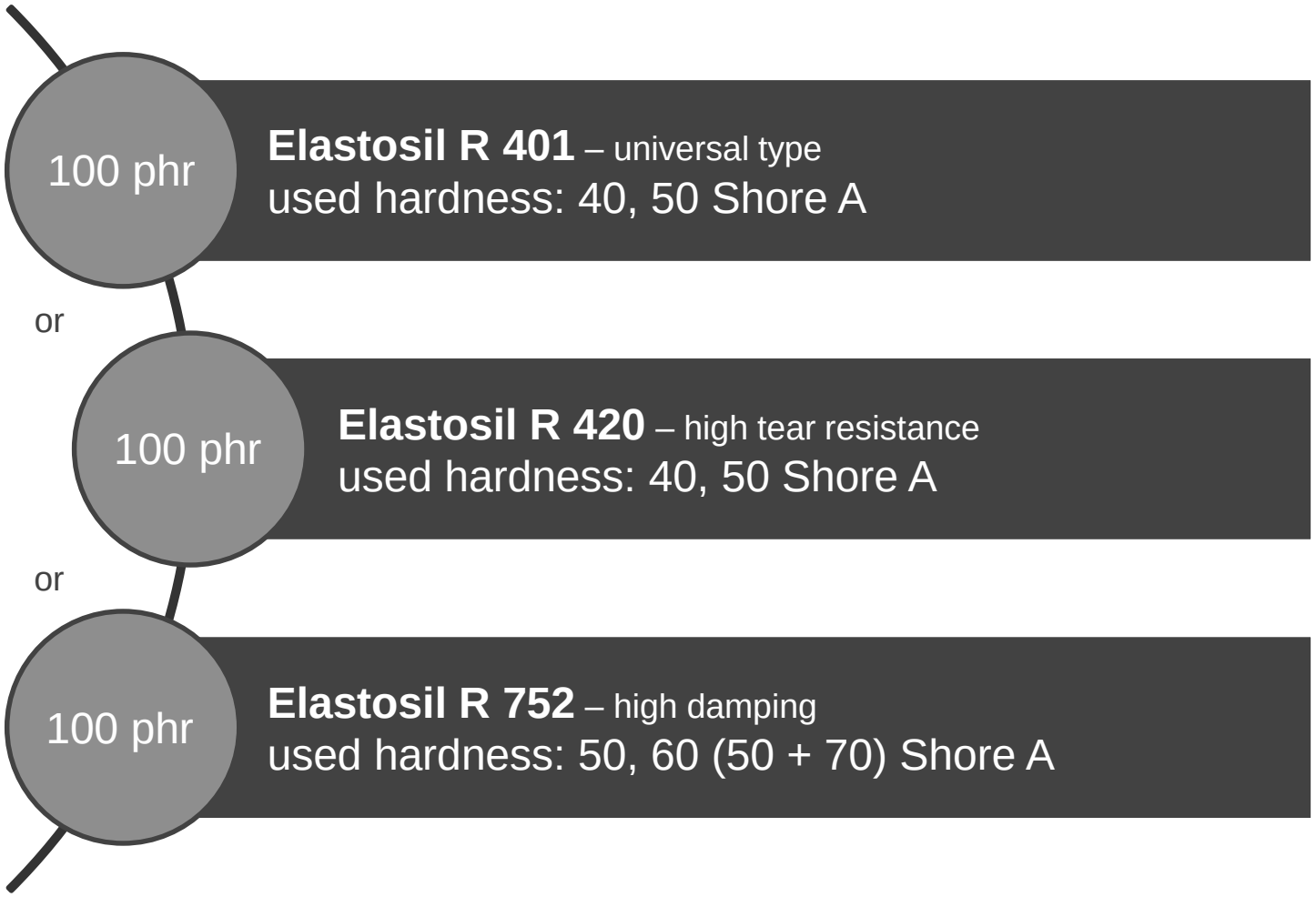
Optimization of Silicone Rubber



Formulation Components



Formulation Components
Selection of Polymer Types



Formulation Components
Selection of Peroxide Type

1.2 phr

Curing Agent C6 - 2,5-bis-(t-butylperoxy)-2,5-dimethylhexane, 45 %
mainly for moldings
curing conditions: 5' / 165 °C

or

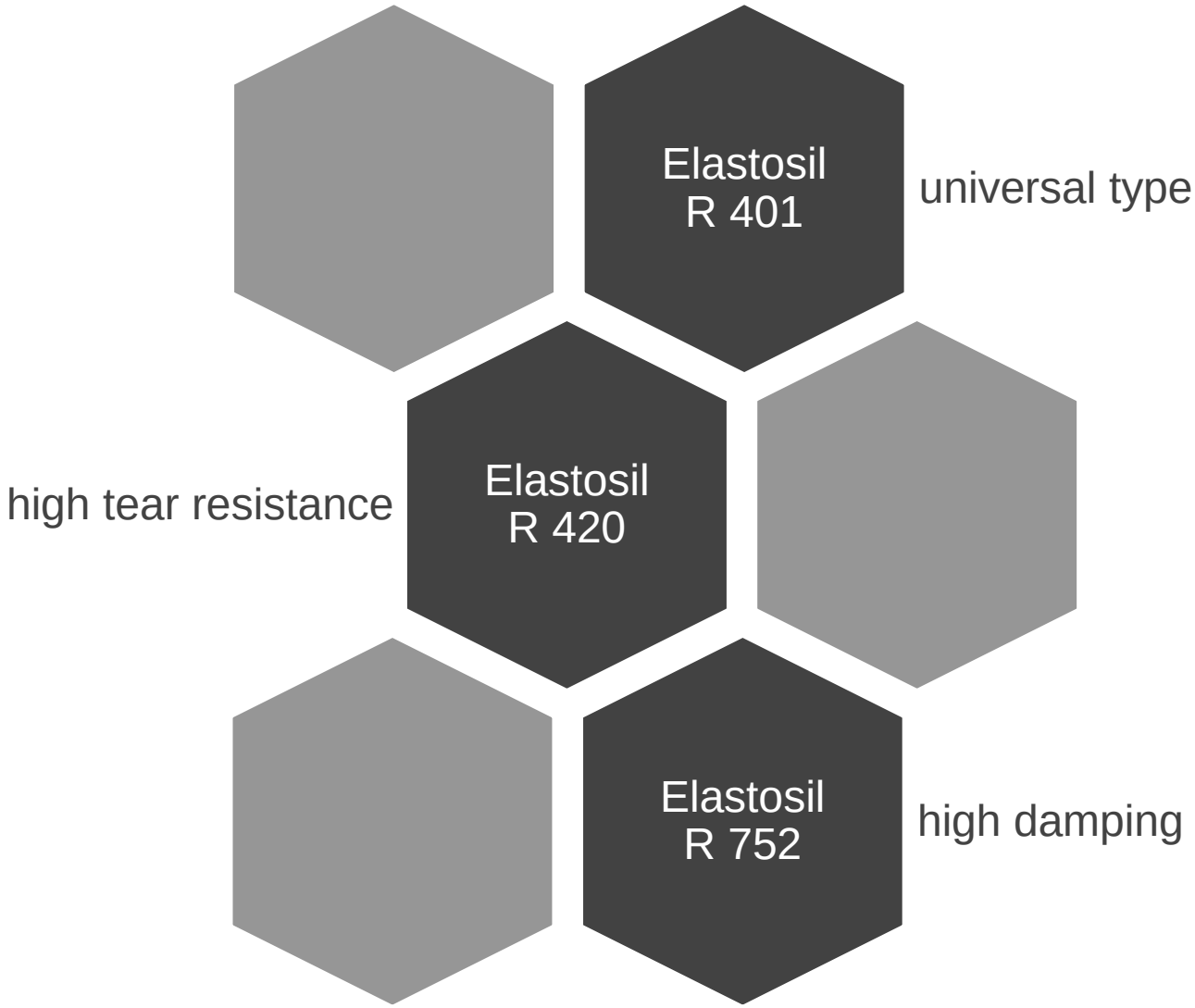
0.99 phr

Perkadox BC-40S-ps - dicumyl peroxide, 40 %
mainly for moldings
curing conditions: 5' / 180 °C

All results are based on specimens that have been post-cured 4 hours at 200 °C.

Formulation Components
Filler: Aktisil Q

Selection of Results



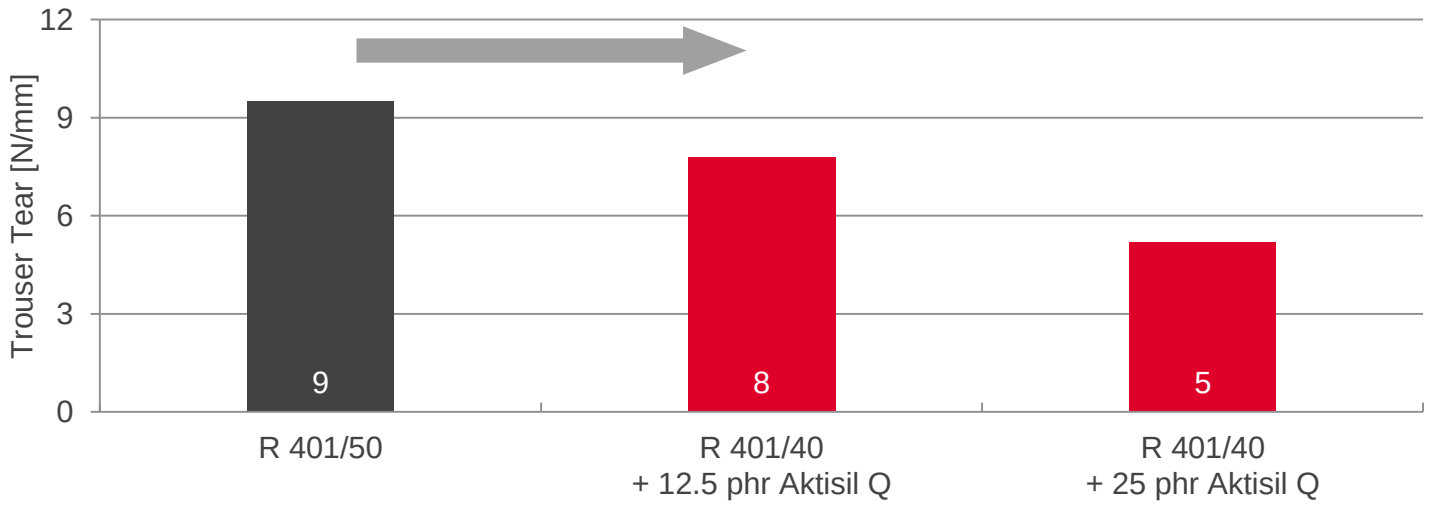
Results

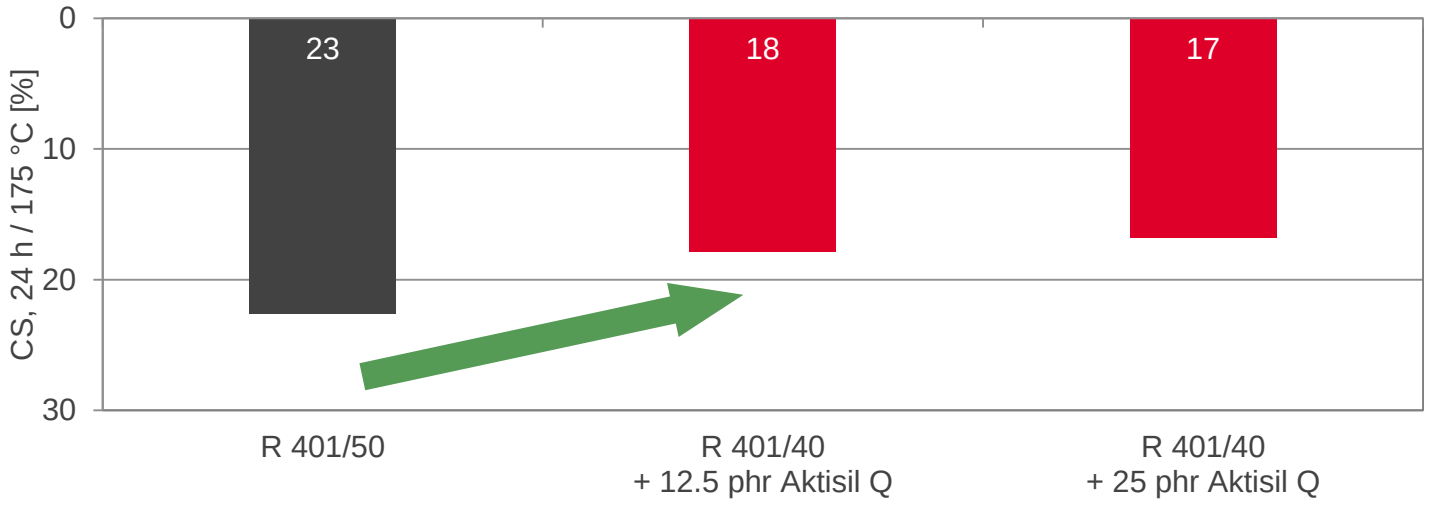
Elastosil R 401

Hardness With and Without Filler Addition

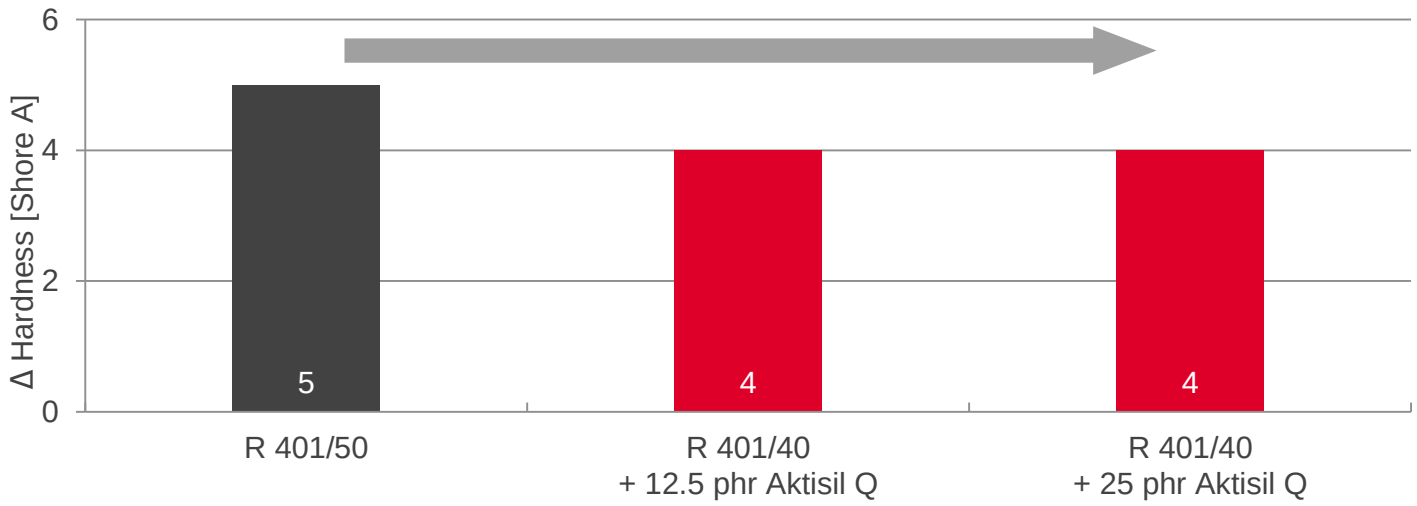
		Curing Agent C6	Perkadox BC-40S-ps
100 phr Elastosil R 401/50		46 Shore A	44 Shore A
100 phr Elastosil R 401/40	+ 12.5 phr Aktisil Q	39 Shore A	39 Shore A
100 phr Elastosil R 401/40	+ 25 phr Aktisil Q	44 Shore A	43 Shore A

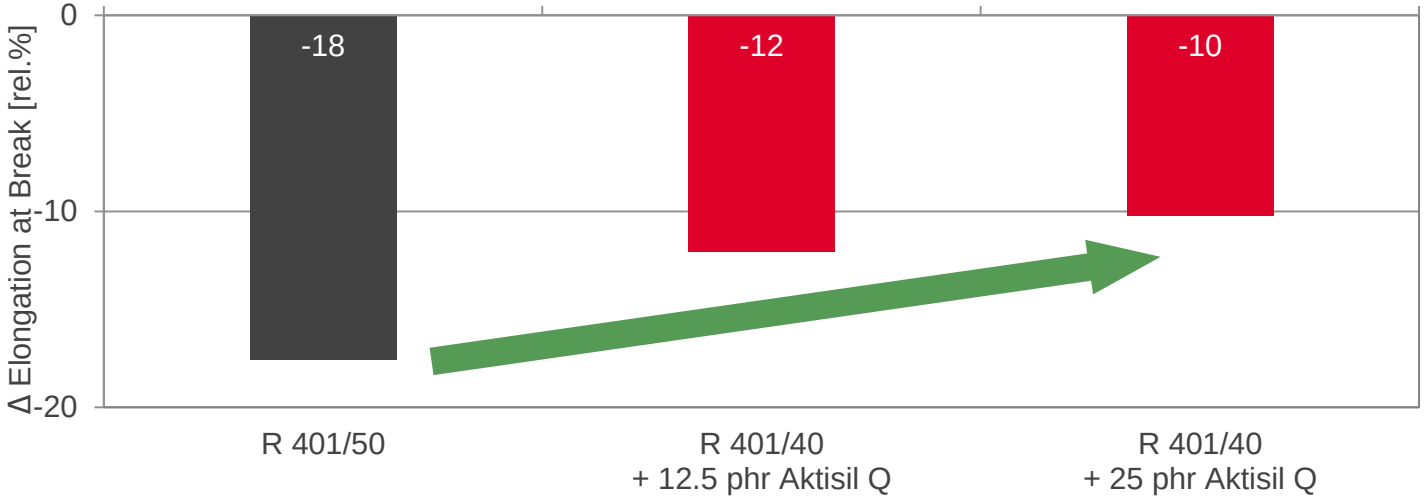
Tear Resistance (Trouser Tear) and Compression Set



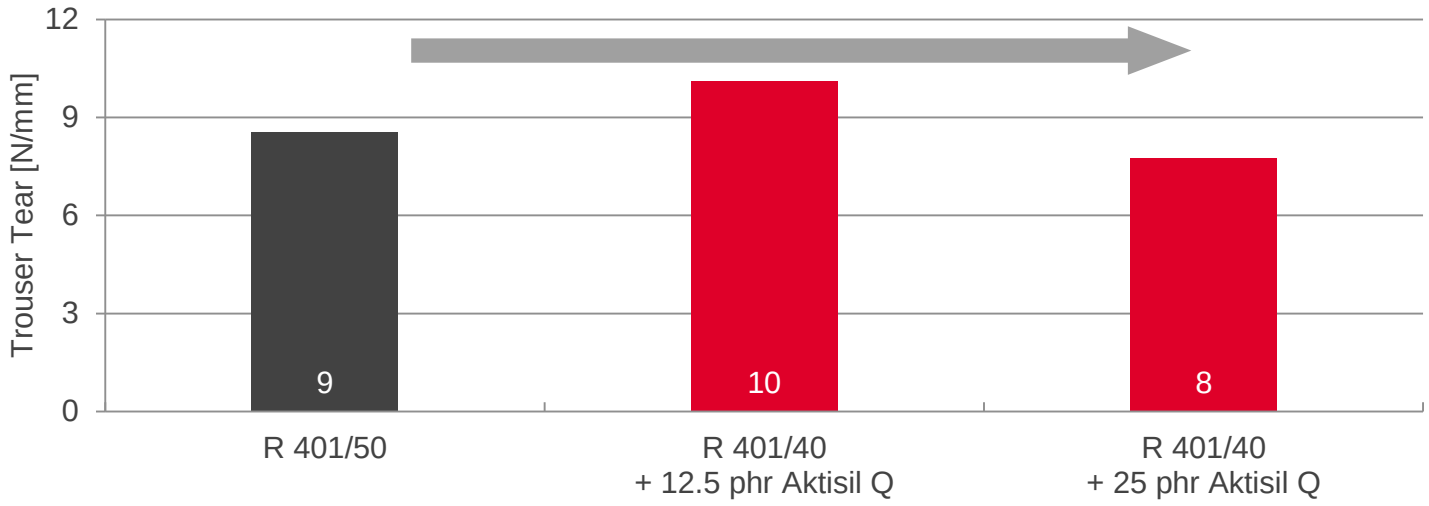


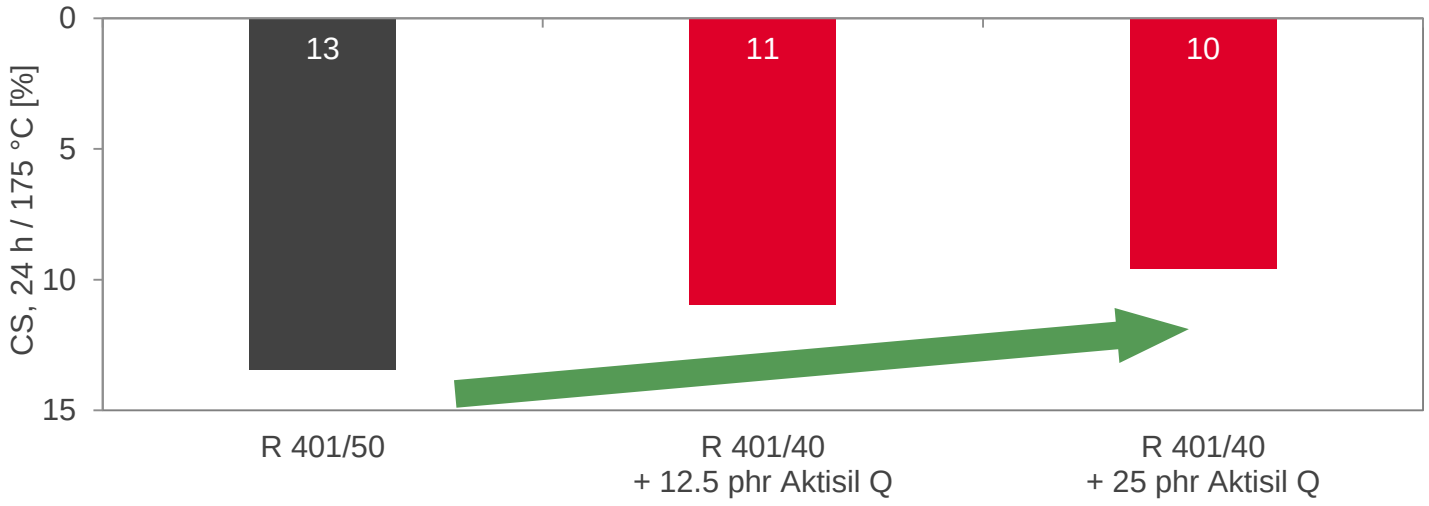
Storage in Hot Air, 168 h / 200 °C
Δ Hardness und Δ Elong. at Break





Tear Resistance (Trouser Tear) and Compression Set





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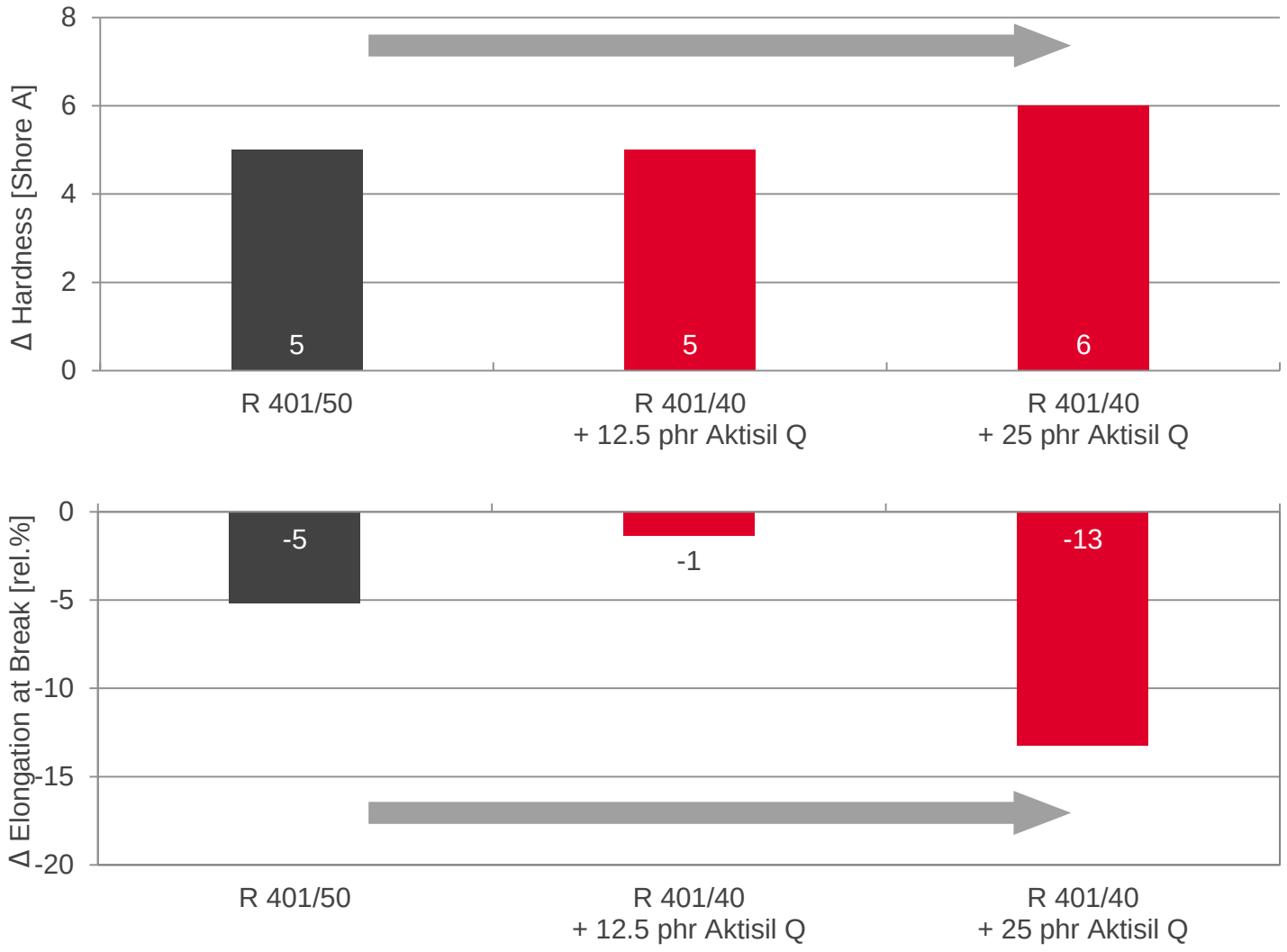
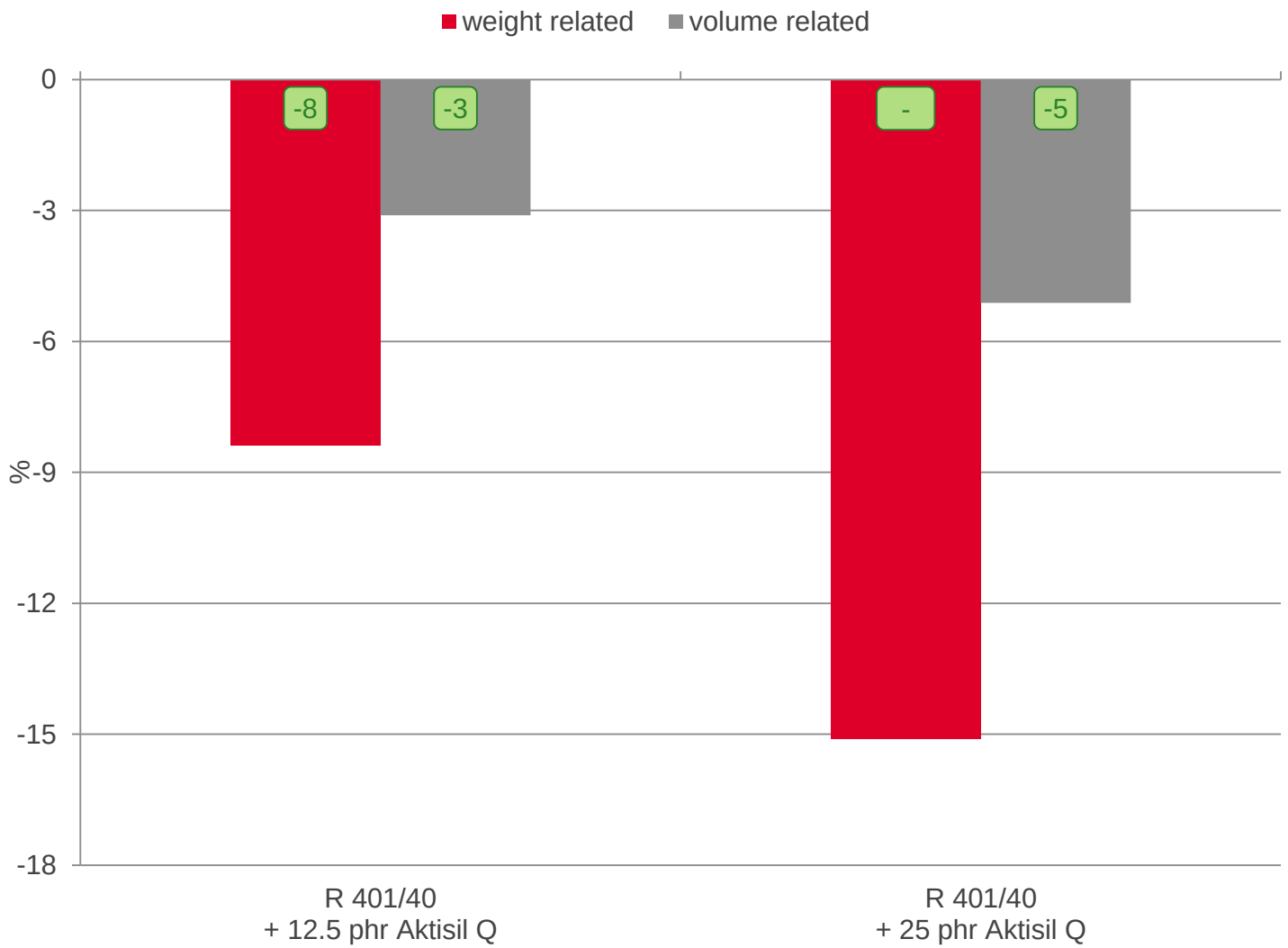
Δ Hardness und Δ Elong. at Break



Reduced Compound Costs by Using Aktisil Q in Elastosil R 401



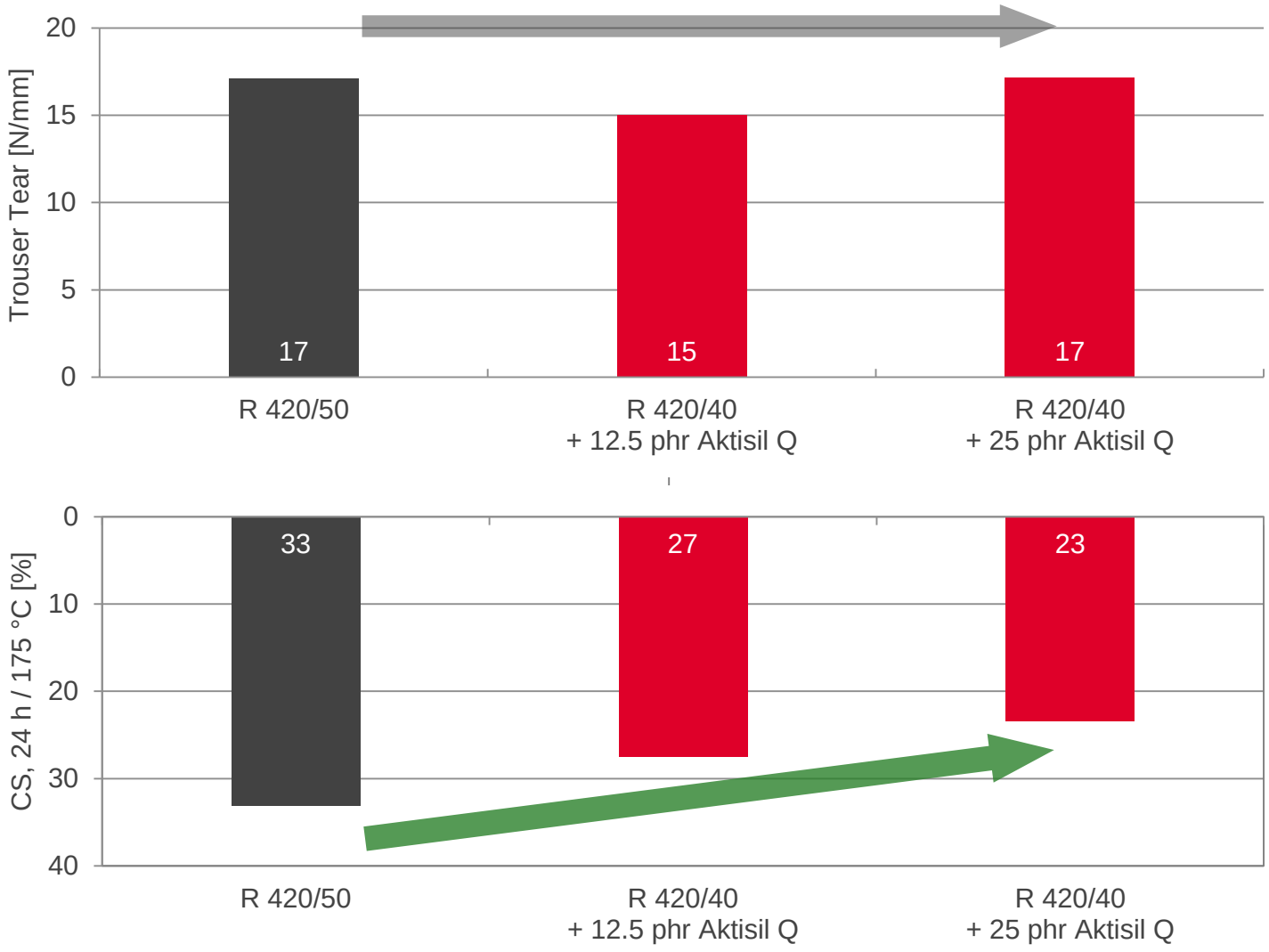
Results

Elastosil R 420

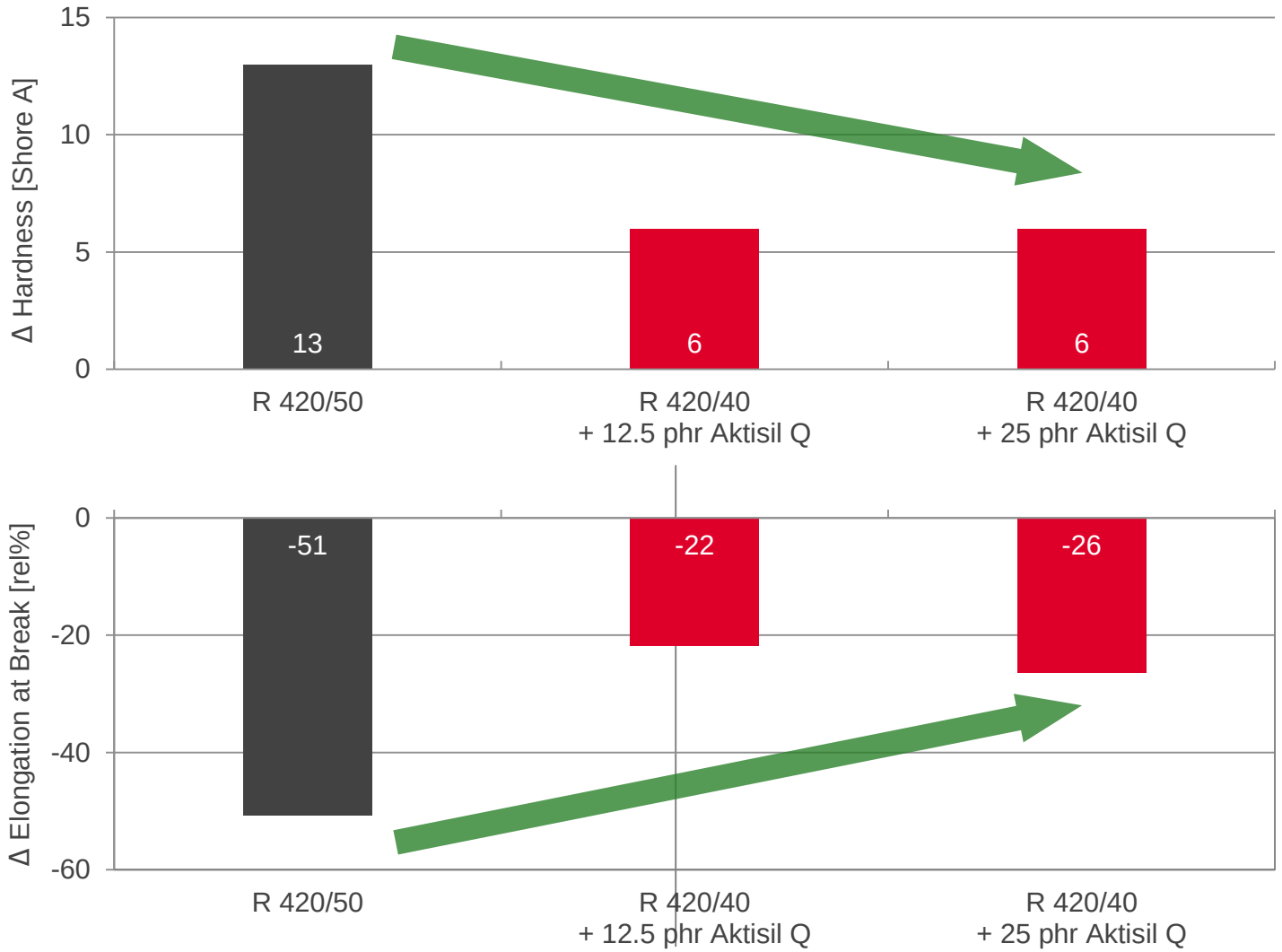
Hardness With and Without Filler Addition

		Curing Agent C6	Perkadox BC-40S-ps
100 phr Elastosil R 420/50		50 Shore A	50 Shore A
100 phr Elastosil R 420/40	+ 12.5 phr Aktisil Q	41 Shore A	38 Shore A
100 phr Elastosil R 420/40	+ 25 phr Aktisil Q	46 Shore A	44 Shore A

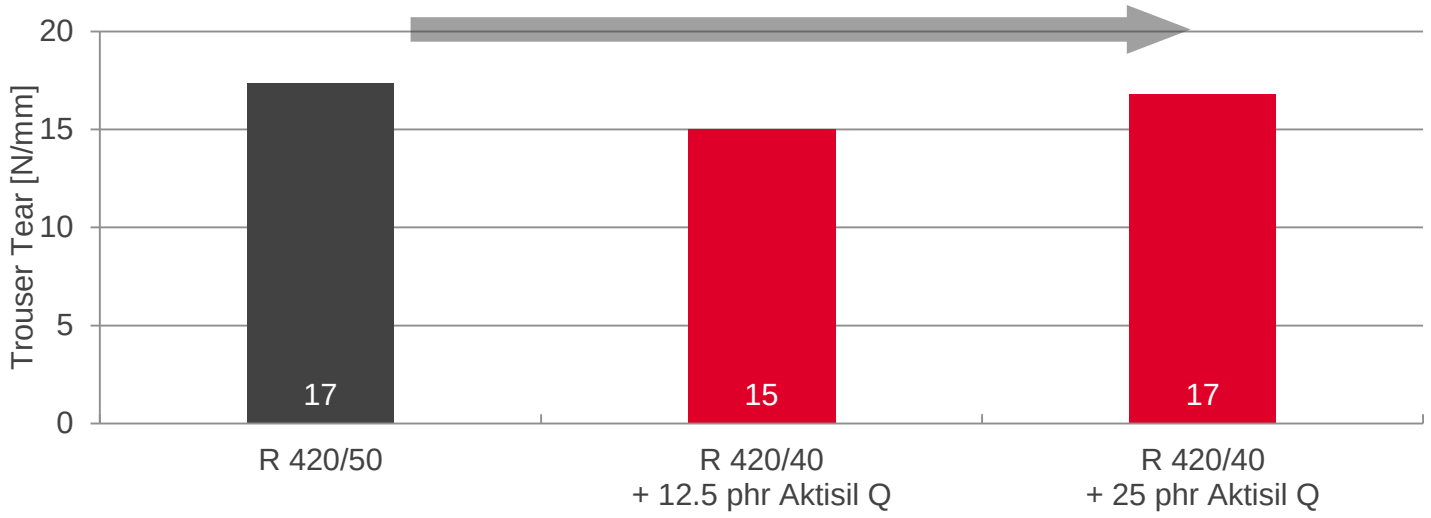
Tear Resistance (Trouser Tear) and Compression Set

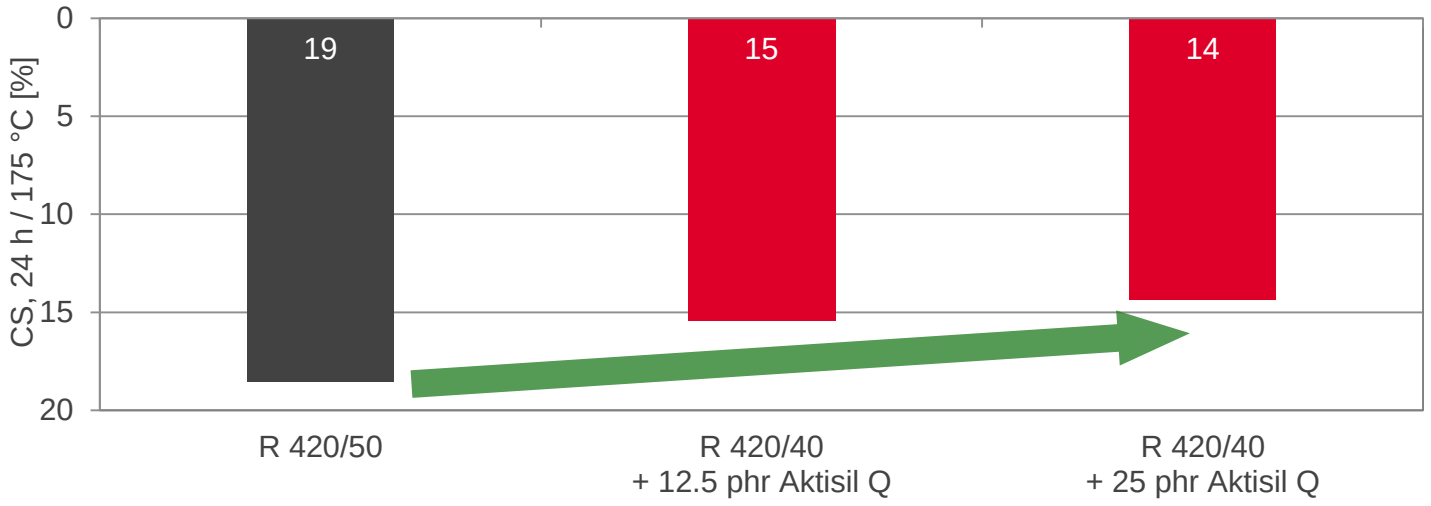


Storage in Hot Air, 168 h / 200 °C
Δ Hardness und Δ Elong. at Break

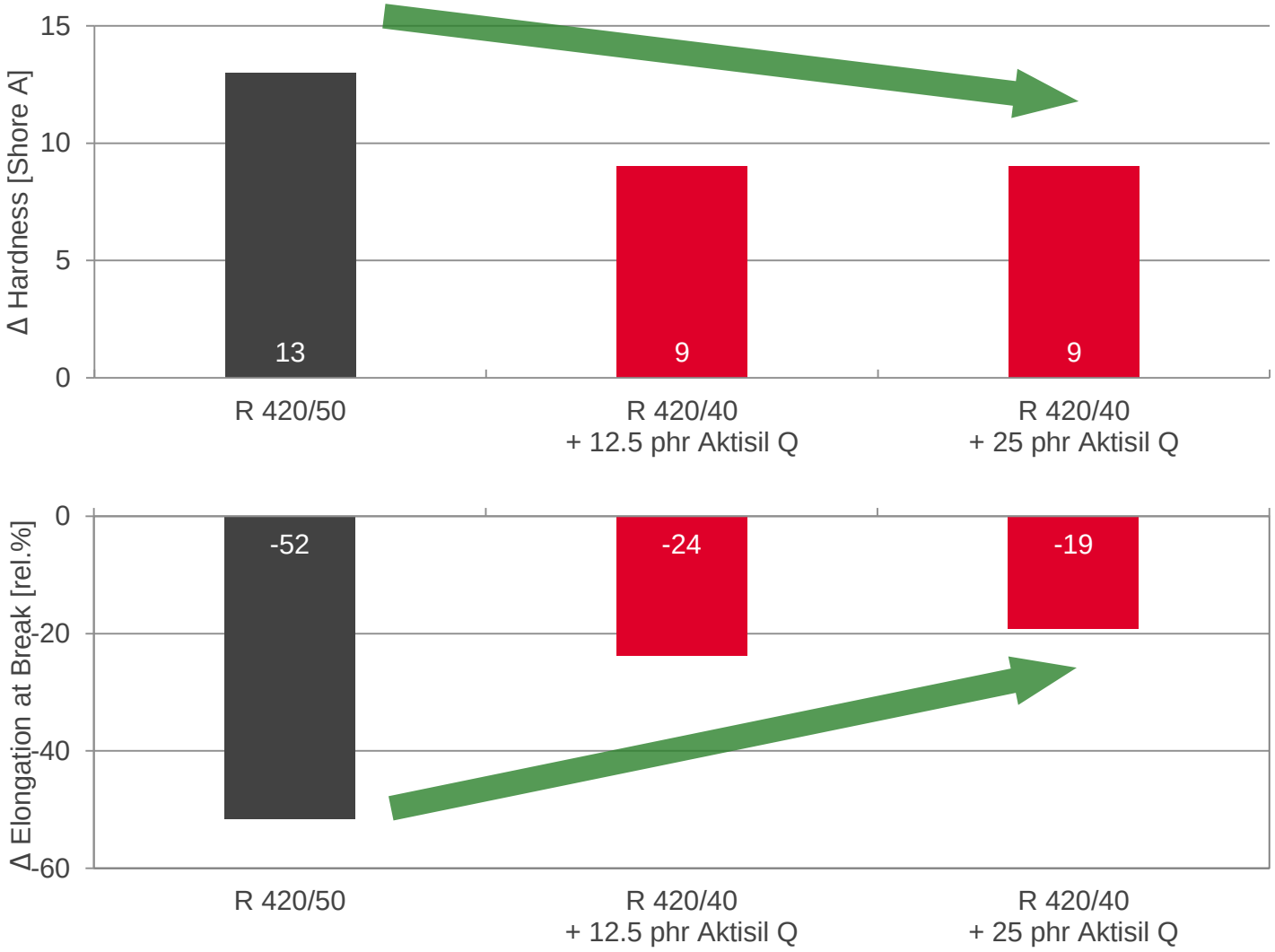


Tear Resistance (Trouser Tear) and Compression Set

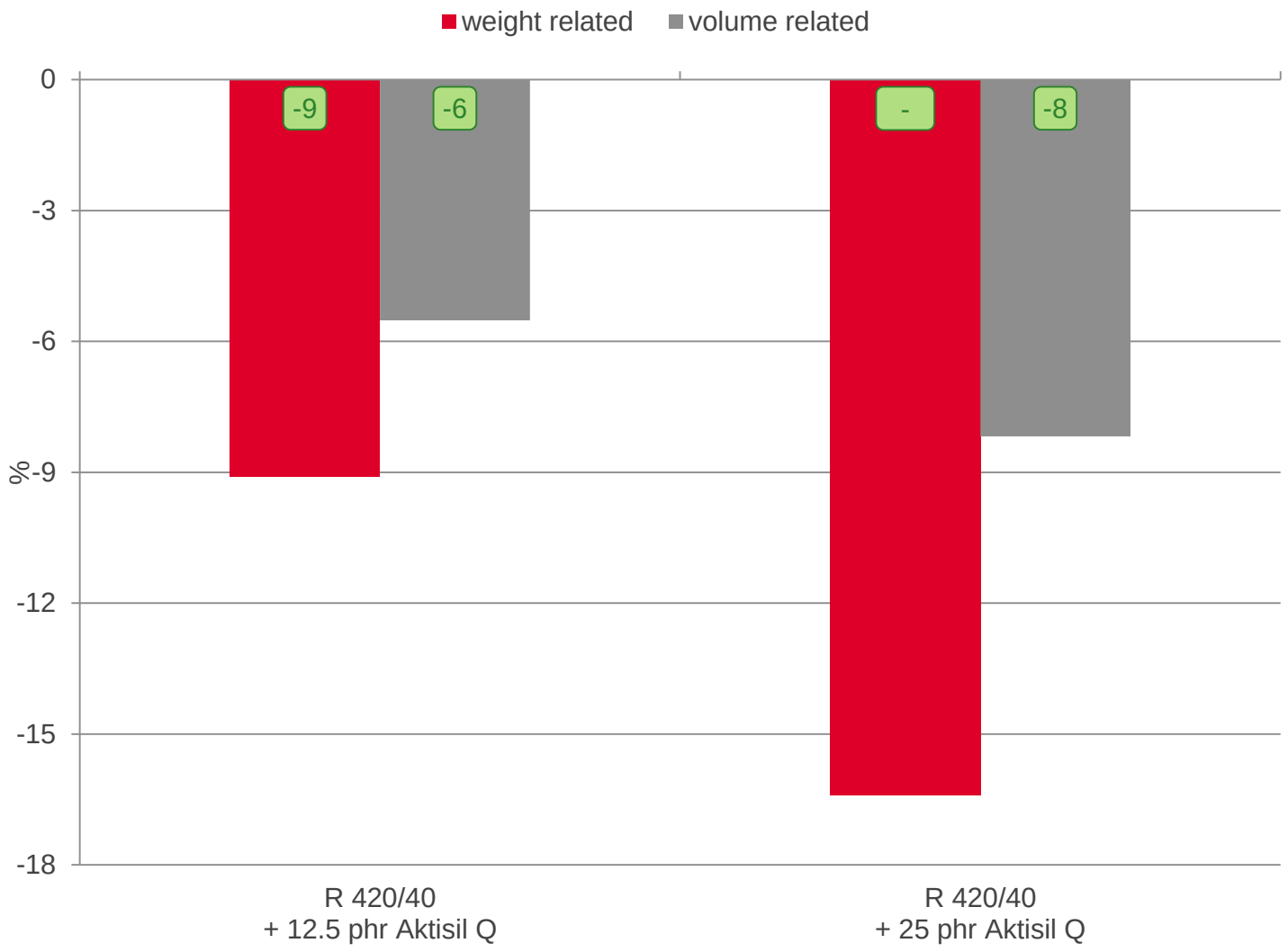




Storage in Hot Air, 168 h / 200 °C
Δ Hardness und Δ Elong. at Break



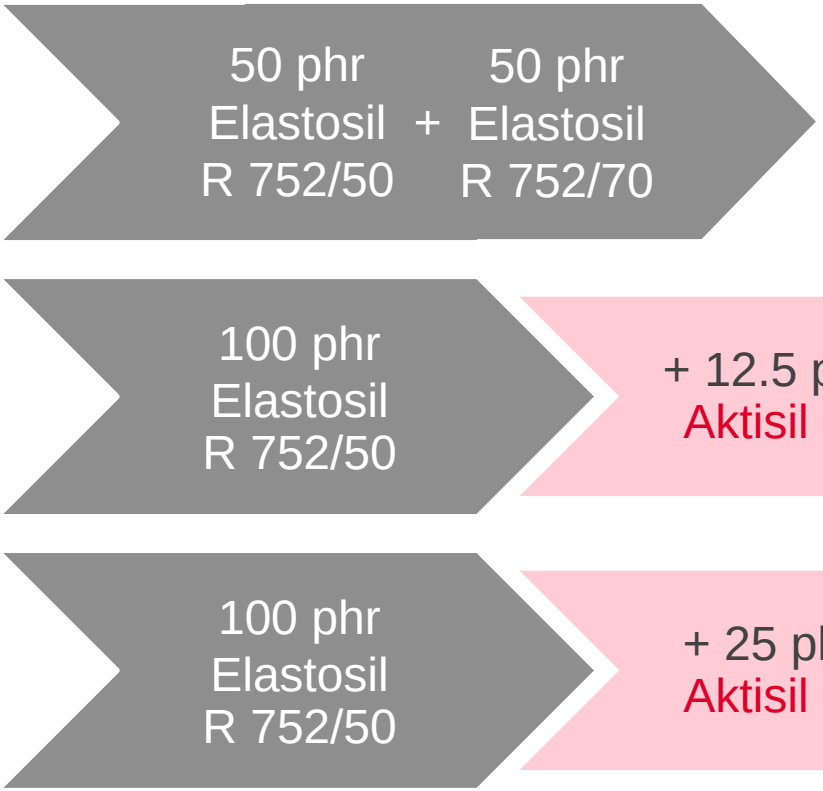
Reduced Compound Costs by Using Aktisil Q in Elastosil R 420



Results

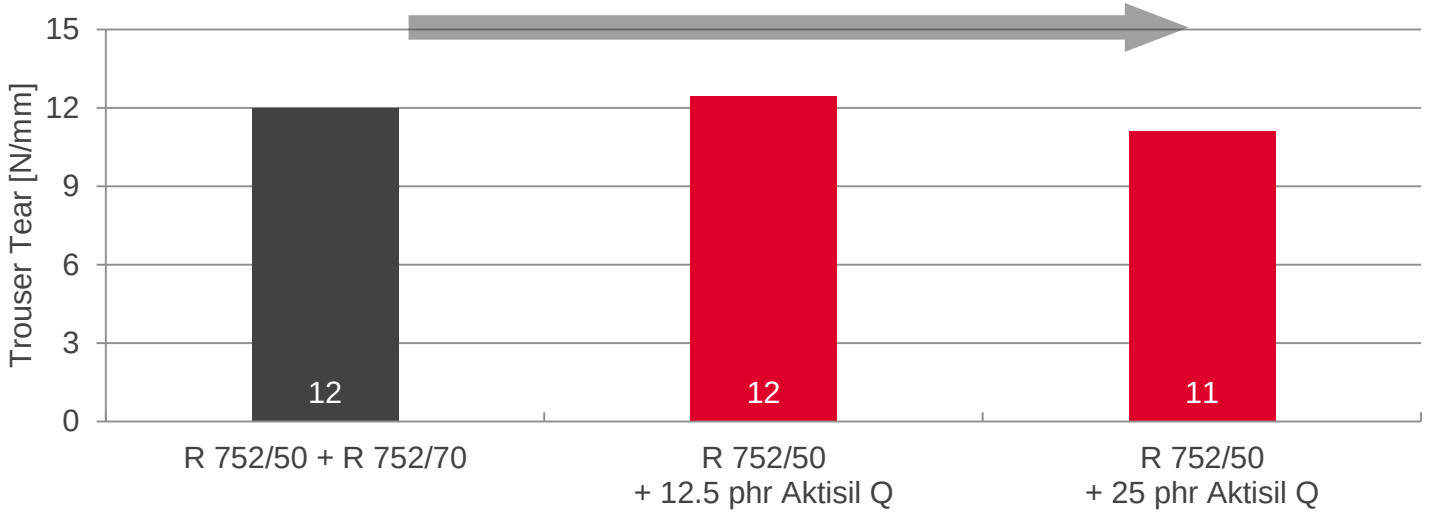
Elastosil R 752

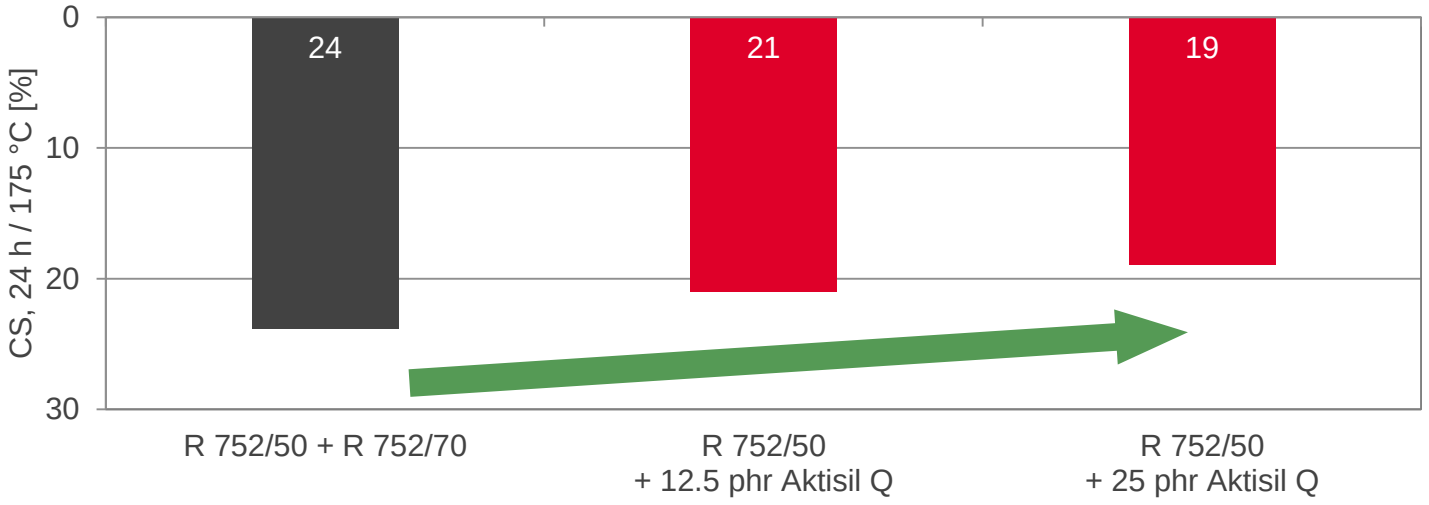
Hardness With and Without Filler Addition



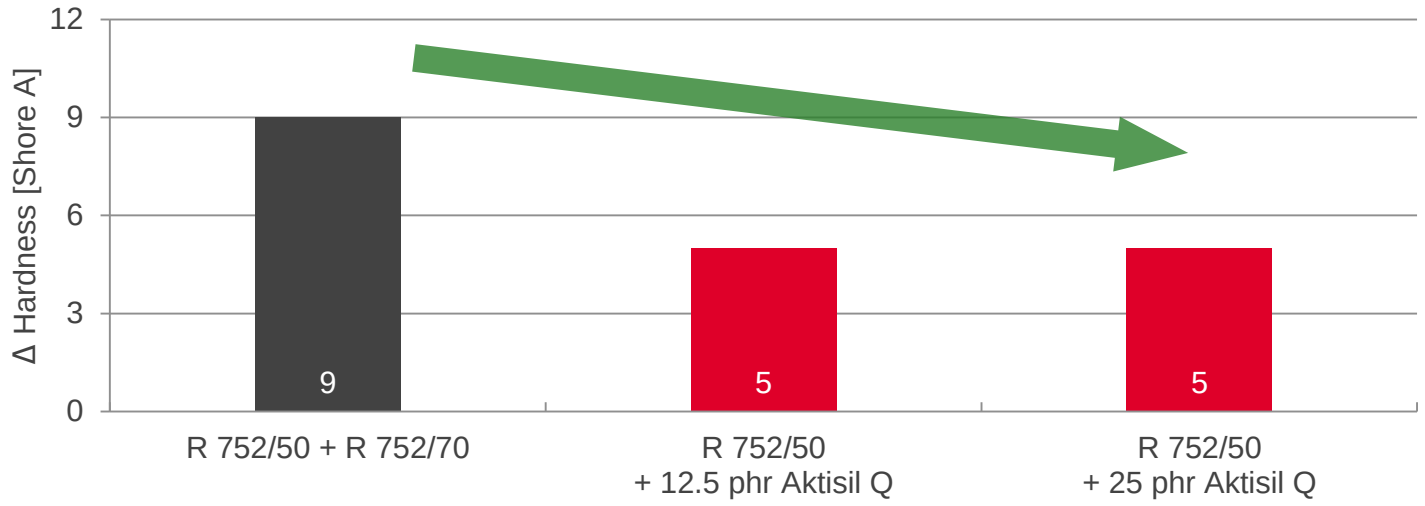
Curing Agent C6	Perkadox BC-40S-ps
55 Shore A	56 Shore A
52 Shore A	51 Shore A
59 Shore A	59 Shore A

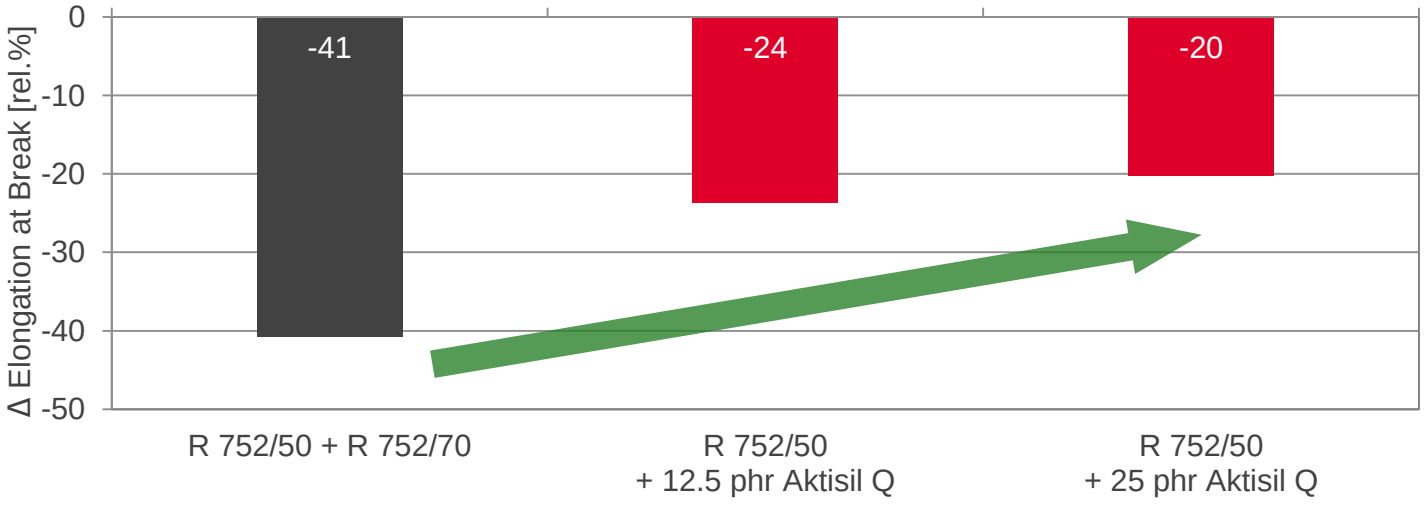
Tear Resistance (Trouser Tear) and Compression Set



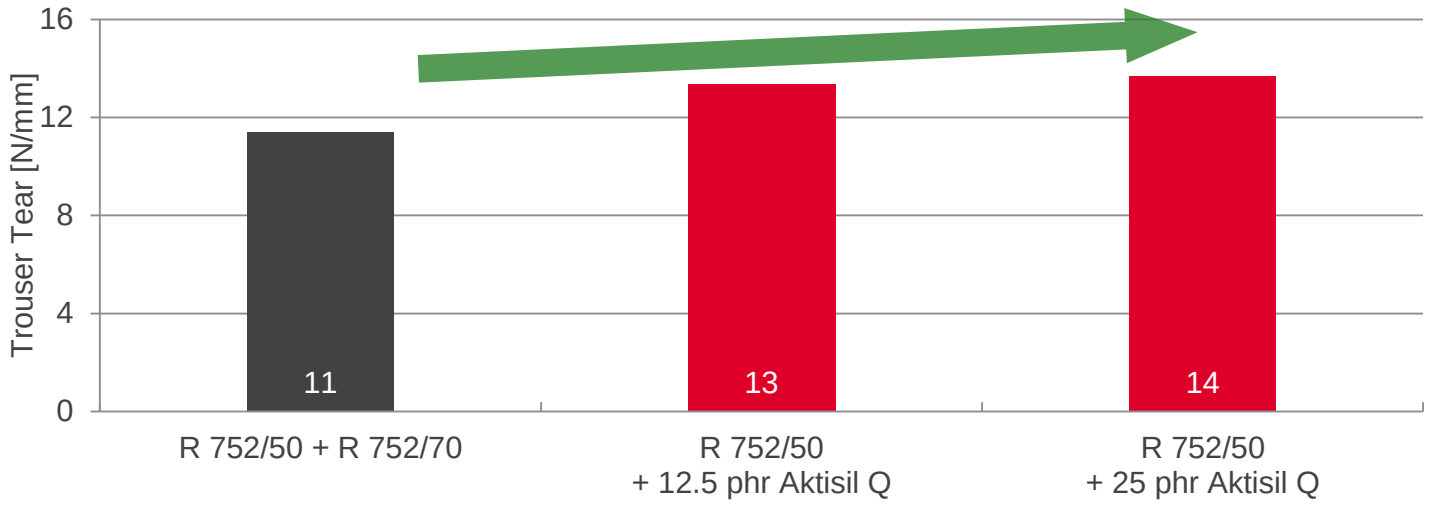


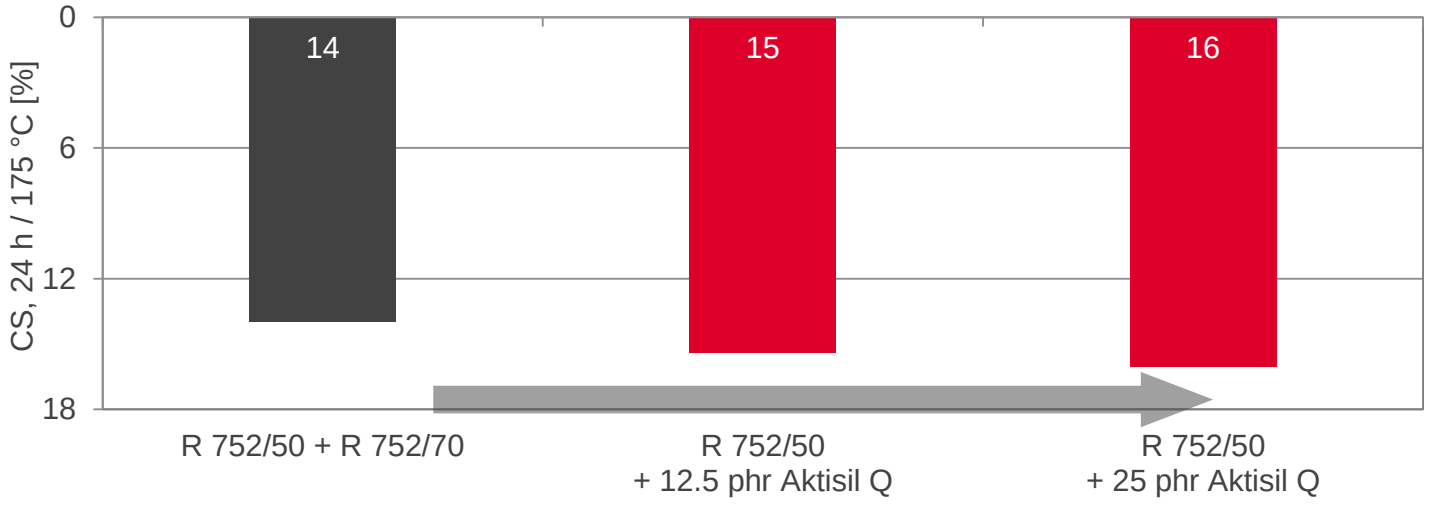
Storage in Hot Air, 168 h / 200 °C
Δ Hardness und Δ Elong. at Break



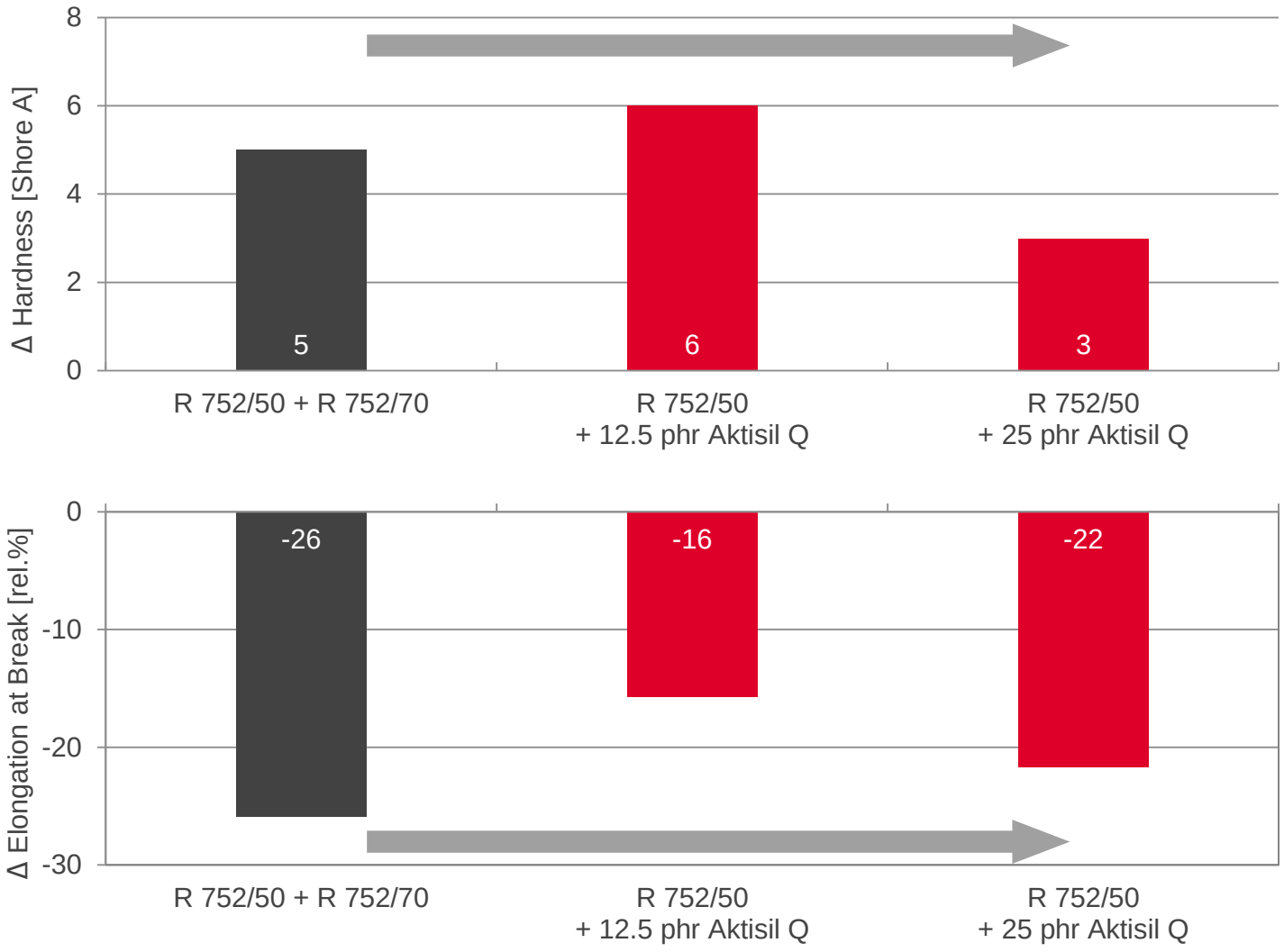


Tear Resistance (Trouser Tear) and Compression Set



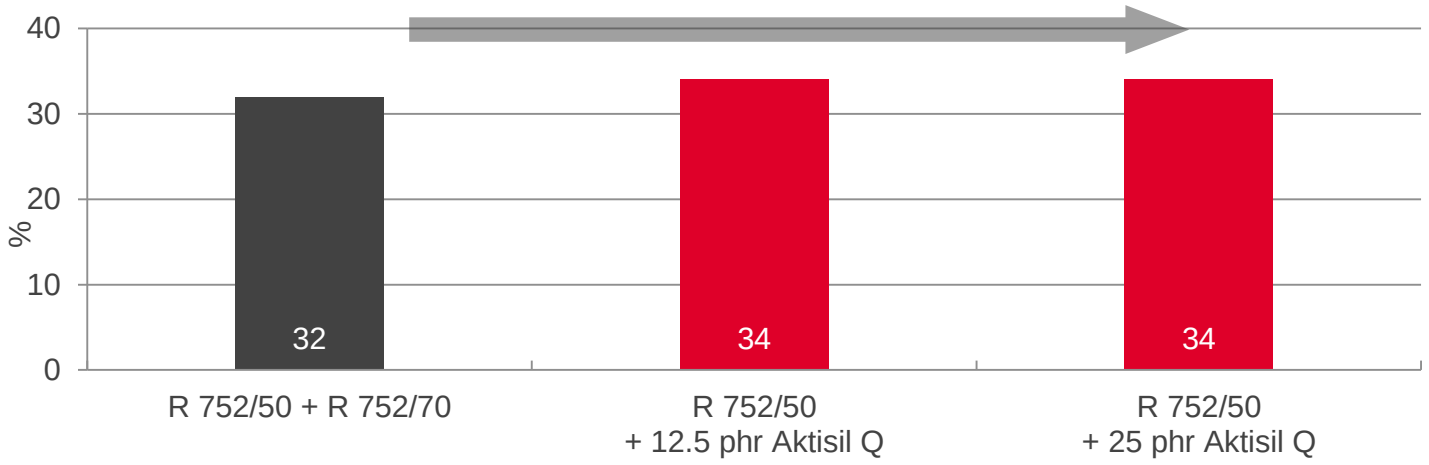


Storage in Hot Air, 168 h / 200 °C
Δ Hardness und Δ Elong. at Break

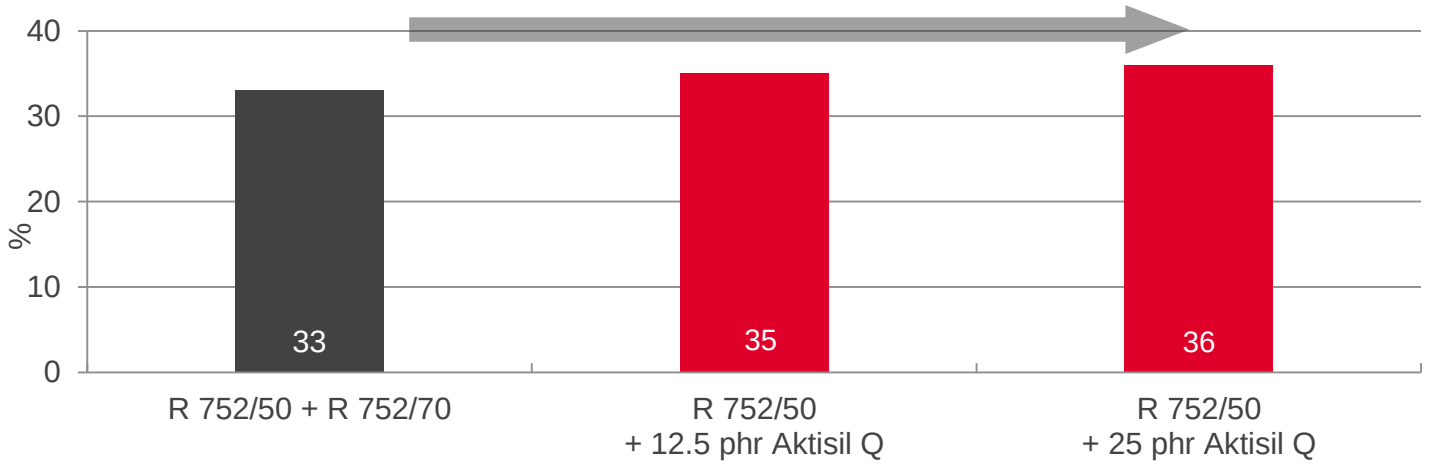


Rebound Elasticity

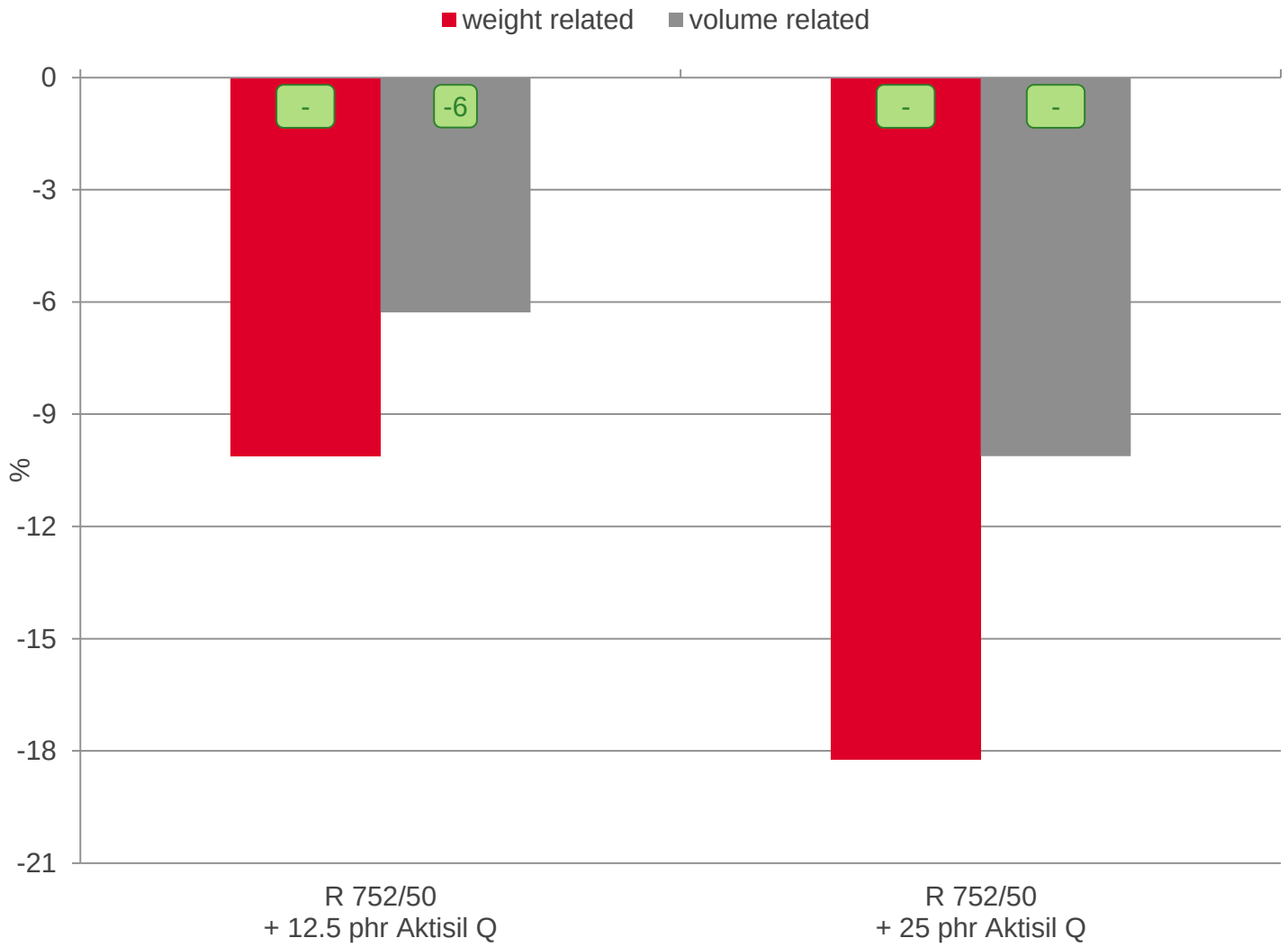
Peroxide: Curing Agent C6



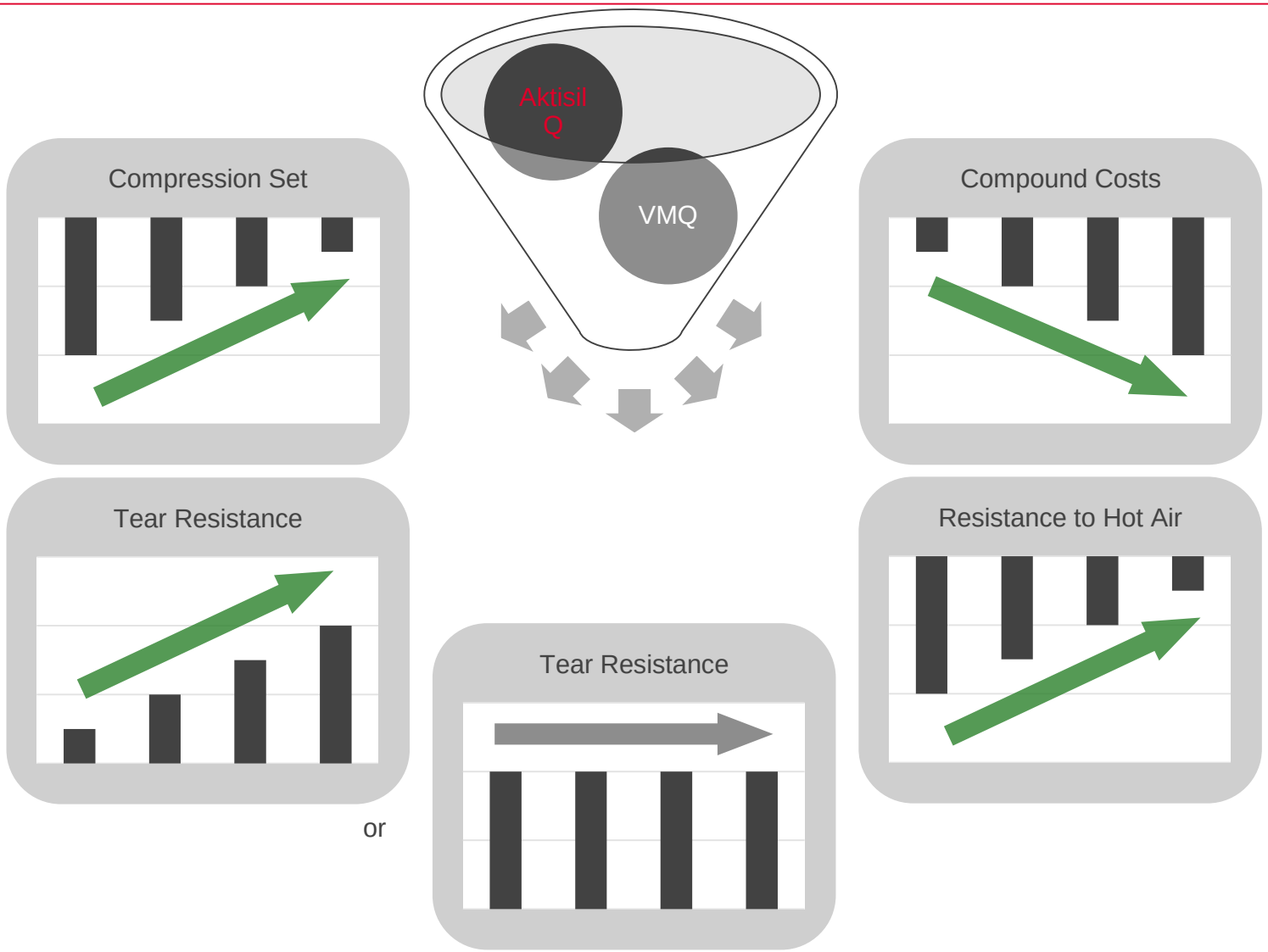
Peroxide: Perk. BC-40S-ps



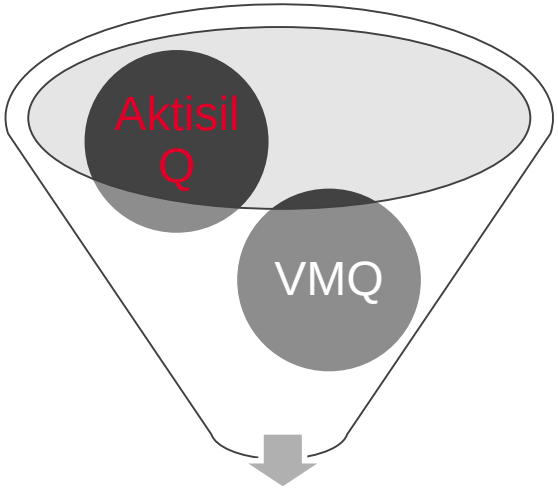
Reduced Compound Costs by Using Aktisil Q in Elastosil R 752



Conclusion



Conclusion



- Improved processing behavior due to reduced stickiness
- Optimized mechanical properties
- Reduction of compound costs

We supply material for good ideas!

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Test Standards

Test	Standard
Mooney Viscosity, ML 1+4	DIN ISO 289-1
Mooney Scorch, ML +5	DIN ISO 289-2
Rotorless Curemeter	DIN 53 529 Part 3
Hardness	DIN ISO 7619-1
Tensile strength	DIN 53 504, S2
Modulus 100 %	DIN 53 504, S2
Elongation at Break	DIN 53 504, S2
Rebound Elasticity	DIN 53 512
Tear resistance	DIN ISO 34-1, A
Compression Set	DIN ISO 815-1, B

Table of Results
Elastosil R 401

		Curing Agent C6			Perkadox BC-40S-ps		
		R 401/50	R 401/40 + 12.5 phr Aktisil Q	R 401/40 + 25 phr Aktisil Q	R 401/50	R 401/40 + 12.5 phr Aktisil Q	R 401/40 + 25 phr Aktisil Q
Rheology							
Mooney Viscosity, ML 1+4, 120 °C	MU	14	11	13	14	11	13
Mooney Scorch, ML +5, 120 °C	min.	72	20	12	64	17	10
Temperature Curemeter	°C		165			180	
Rotorless Curemeter M_{min}	Nm	0.04	0.03	0.03	0.04	0.03	0.03
Rotorless Curemeter V_{max}	Nm/min.	0.26	0.23	0.26	0.76	0.64	0.76
Rotorless Curemeter t_{90}	min.	2.7	2.5	2.3	1.0	0.9	0.9
Mechanical properties – post-cured, 4 h / 200 °C							
Hardness	Sh. A	46	39	44	44	39	43
Tensile strength	MPa	13	10	10	12	9.2	9.6
Modulus 100 %	MPa	0.9	0.7	1.0	0.9	0.8	1.0
Elongation at Break	%	679	702	631	647	624	616
Tear resistance	N/mm	9.5	7.8	5.2	8.6	10	7.8
Compression Set, 24 h / 175 °C, 25 % Def.	%	23	18	17	13	11	9,6

Table of Results
Elastosil R 401

		Curing Agent C6			Perkadox BC-40S-ps		
		R 401/50	R 401/40 + 12.5 phr Aktisil Q	R 401/40 + 25 phr Aktisil Q	R 401/50	R 401/40 + 12.5 phr Aktisil Q	R 401/40 + 25 phr Aktisil Q
Mechanical properties after storage in hot air (post-cured specimens), 168 h / 200 °C							
Hardness	Sh. A	51	43	48	49	44	49
Tensile strength	MPa	11	8.9	8.5	11	9.5	8.5
Modulus 100 %	MPa	1.3	09	1.3	1.1	1,0	1.2
Elongation at Break	%	560	617	567	614	616	535
Δ Hardness	Sh. A	+5	+4	+4	+5	+5	+6
Δ Tensile strength	%	-17	-15	-16	-9	+4	-12
Δ Modulus 100 %	%	+40	+25	+26	+16	+23	+19
Δ Elongation at break	%	-18	-12	-10	-5	-1	-13

Table of Results
Elastosil R 420

		Curing Agent C6			Perkadox BC-40S-ps		
		R 420/50	R 420/40 + 12.5 phr Aktisil Q	R 420/40 + 25 phr Aktisil Q	R 420/50	R 420/40 + 12.5 phr Aktisil Q	R 420/40 + 25 phr Aktisil Q
Rheology							
Mooney Viscosity, ML 1+4, 120 °C	MU	17	14	15	17	14	16
Mooney Scorch, ML +5, 120 °C	min.	57	20	11	55	16	8,4
Temperature Curemeter	°C		165			180	
Rotorless Curemeter M_{min}	Nm	0.04	0.03	0.04	0.04	0.03	0.03
Rotorless Curemeter V_{max}	Nm/min.	0.11	0.12	0.18	0.41	0.38	0.51
Rotorless Curemeter t_{90}	min.	4.4	4.1	3.6	1.5	1.3	1.1
Mechanical properties – post-cured, 4 h / 200 °C							
Hardness	Sh. A	50	41	46	50	38	44
Tensile strength	MPa	10	8.8	8.2	9.5	8.9	7.9
Modulus 100 %	MPa	1.5	1.0	1.3	1.5	1.0	1.3
Elongation at Break	%	651	705	630	642	725	614
Tear resistance	N/mm	17	15	17	17	15	17
Compression Set, 24 h / 175 °C, 25 % Def.	%	33	27	23	19	15	14

Table of Results
Elastosil R 420

		Curing Agent C6			Perkadox BC-40S-ps		
		R 420/50	R 420/40 + 12.5 phr Aktisil Q	R 420/40 + 25 phr Aktisil Q	R 420/50	R 420/40 + 12.5 phr Aktisil Q	R 420/40 + 25 phr Aktisil Q
Mechanical properties after storage in hot air (post-cured specimens), 168 h / 200 °C							
Hardness	Sh. A	63	47	52	63	47	53
Tensile strength	MPa	9,5	7,8	6,8	8,5	7,5	7,0
Modulus 100 %	MPa	3,2	1,4	1,8	3,1	1,3	1,7
Elongation at Break	%	320	551	464	310	553	496
Δ Hardness	Sh. A	+13	+6	+6	+13	+9	+9
Δ Tensile strength	%	-7	-11	-17	-10	-16	-11
Δ Modulus 100 %	%	+116	+38	+35	+115	+34	+29
Δ Elongation at break	%	-51	-22	-26	-52	-24	-19

Table of Results
Elastosil R 752

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		Curing Agent C6			Perkadox BC-40S-ps		
		R 752/50 + R 752/70	R 752/50 + 12.5 phr Aktisil Q	R 752/50 + 25 phr Aktisil Q	R 752/50 + R 752/70	R 752/50 + 12.5 phr Aktisil Q	R 752/50 + 25 phr Aktisil Q
Rheology							
Mooney Viscosity, ML 1+4, 120 °C	MU	24	24	27	25	25	26
Mooney Scorch, ML +5, 120 °C	min.	64	23	13	66	22	13
Temperature Curemeter	°C		165			180	
Rotorless Curemeter M_{min}	Nm	0.09	0.10	0.11	0.08	0.09	0.10
Rotorless Curemeter V_{max}	Nm/min.	0.32	0.33	0,50	0.79	0.77	0.96
Rotorless Curemeter t_{90}	min.	4.9	4.5	3.2	1.5	1.5	1.3
Mechanical properties – post-cured, 4 h / 200 °C							
Hardness	Sh. A	55	52	59	56	51	59
Tensile strength	MPa	9.6	8.8	7.3	9.5	8.6	7.8
Modulus 100 %	MPa	1.2	1.1	1.4	1.2	1.2	1.5
Elongation at Break	%	672	698	557	637	631	543
Tear resistance	N/mm	12	12	11	11	13	14
Rebound Elasticity	%	32	34	34	33	35	36
Compression Set, 24 h / 175 °C, 25 % Def	%	24	21	19	14	15	16

Table of Results
Elastosil R 752

		Curing Agent C6			Perkadox BC-40S-ps		
		R 752/50 + R 752/70	R 752/50 + 12.5 phr Aktisil Q	R 752/50 + 25 phr Aktisil Q	R 752/50 + R 752/70	R 752/50 + 12.5 phr Aktisil Q	R 752/50 + 25 phr Aktisil Q
Mechanical properties after storage in hot air (post-cured specimens), 168 h / 200 °C							
Hardness	Sh. A	64	57	64	61	57	62
Tensile strength	MPa	5.5	6.1	5.2	6.2	7.0	6.1
Modulus 100 %	MPa	1.6	1.3	1.6	1.5	1.3	1.8
Elongation at Break	%	398	532	445	472	532	425
Δ Hardness	Sh. A	+9	+5	+5	+5	+6	+3
Δ Tensile strength	%	-42	-30	-28	-35	-18	-22
Δ Modulus 100 %	%	+42	+17	+16	+27	+16	+16
Δ Elongation at break	%	-41	-24	-20	-26	-16	-22