

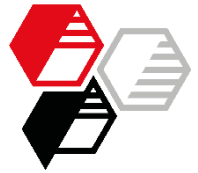
Neuburg Siliceous Earth in Water-based Corrosion Protection Primer 2C Epoxy, grey

e. g. for Trains of Deutsche Bahn AG



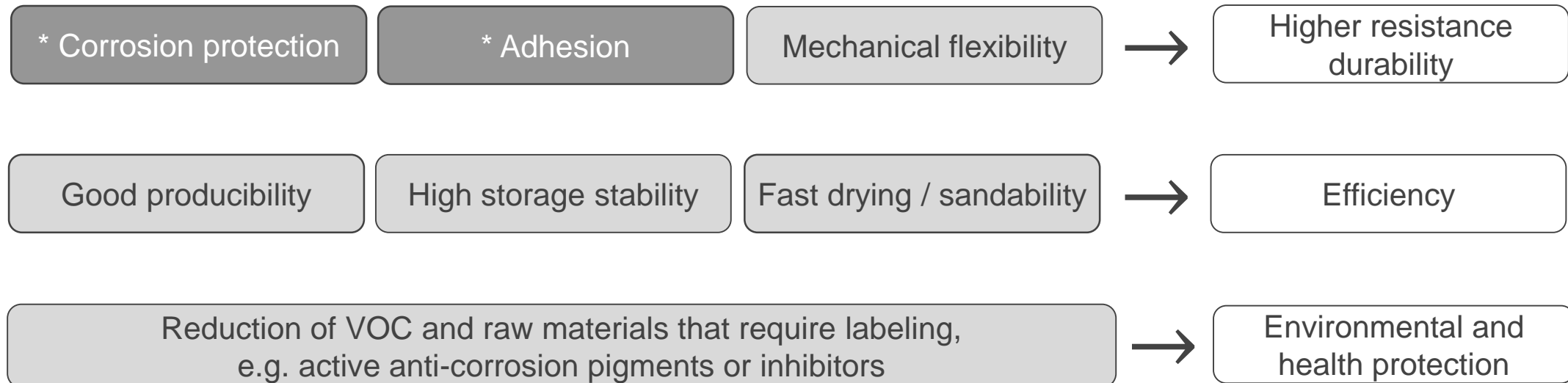
Contents

- Introduction
- Experimental
- Results
 - Findings preliminary study
 - Optimisation filler package
 - Producibility
 - Storage stability
 - Mechanical flexibility - cupping test
 - Corrosion protection
- Summary
- Appendix



Status Quo

- 2C Epoxy primers are among the highest performing anti-corrosive base coats
- Environmentally friendly water-based formulations already available on the market
- Very high requirements go beyond previous * key criteria typical for primers up to now

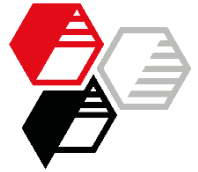




Objective

- Selection of merchantable formulation with already good properties in terms of corrosion protection
 - Systematic variation of the filler composition
 - Identification of wet / dry paint properties with strongest positive filler influence
 - Optimization approaches using functional **Neuburg Siliceous Earth** filler
- Higher performance, more durable 2C Epoxy protective coatings compliant to high requirements e.g. according to the DBS 918300 for rail vehicles of Deutsche Bahn AG.

DB
compliant
?



Base Formulation

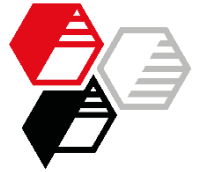
Component A		parts by weight
Pigment preparation	Water deionised	11.94
	Additol VXW 6208	Dispersing additive 3.52
	Additol VXW 6393	Defoamer 0.16
	Texanol	Solvent, coalescent agent 0.64
	Kronos 2190	Pigment white 21.85
	Bayferrox 3920	Pigment yellow 0.43
	Bayferrox 306	Pigment black 1.17
	Talc	Filler 9.06
	Barite	Filler 24.62
	Additol VXW 6388	Rheological additive 0.64
	Methoxypropanol	Solvent 1.07
	Beckocure EH 2261w/41WA	Hardener, aliphatic polyamine adduct dispersion HEW 1100 g/mol 24.90
Total		100.00
Component B		
	Beckopox EP 387/w/52WA	Binder, solid epoxy resin dispersion EEW 1000 g/mol 49.80
	Mixing ratio Amine/Epoxy	1 : 2
	Stoichiometric crosslinking ratio Amine/Epoxy	0.49
	Solids content w/w [%]	64.1
	PVC	32.0

Water-based 2C Epoxy
Anti-corrosion Coating

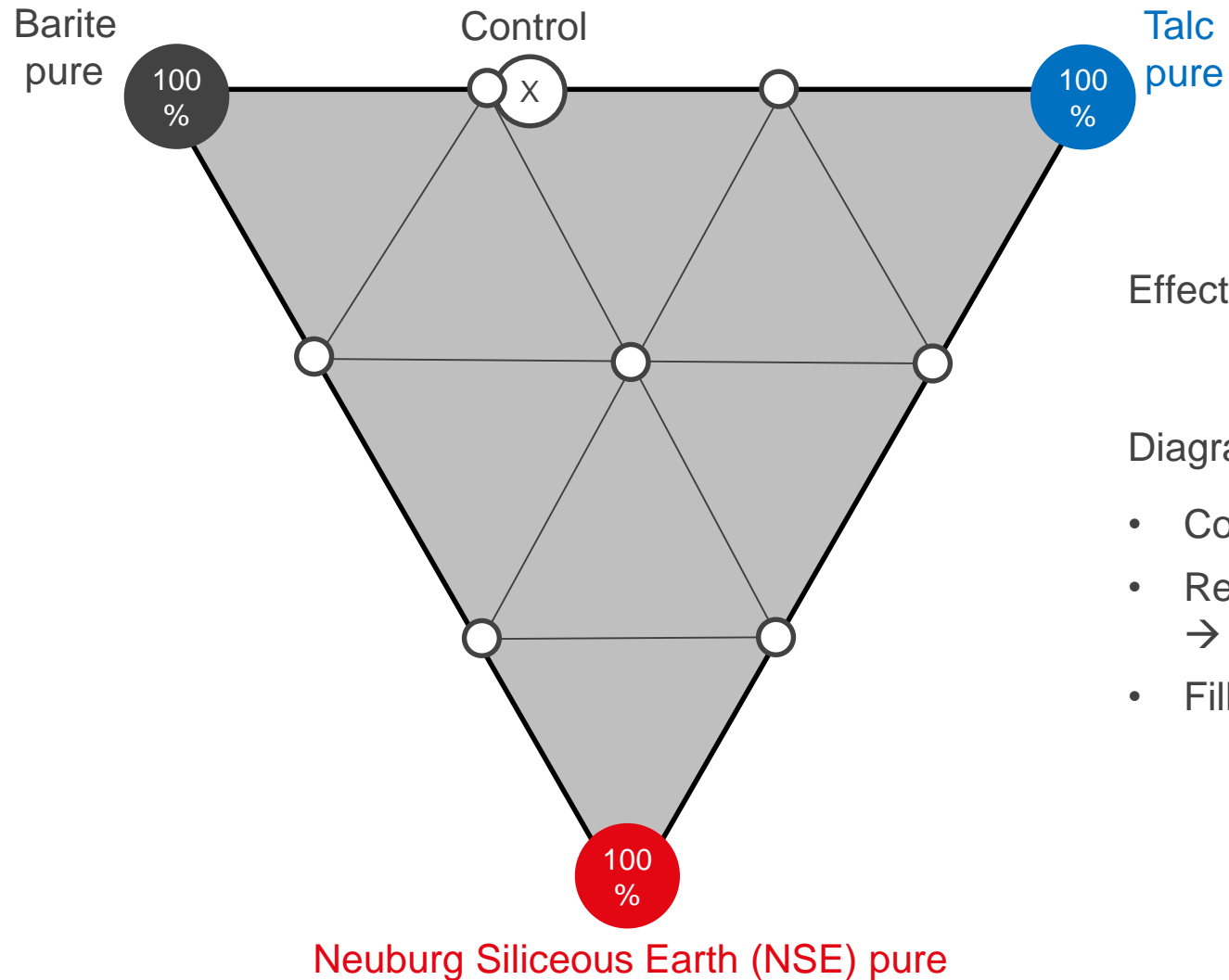
Allnex Company

Low VOC
Active pigment / Inhibitor free

Fast drying
Mechanically flexible



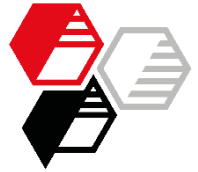
Preliminary study – Filler variation at equal PVC



Effect assessment at constant filler volume

Diagram of ternary mixture

- Corner point = Pure-Variant of the respective filler
- Replacement of 1/3 of the filler volume each
→ new variants ○
- Filler package of control formulation (X)



Preliminary study – Findings

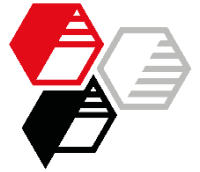
Checked Feature	Performance Control	Filler effekt at variation
Producibility	★ ★ ★ ★	large i
Storage stability	★ ★ ★	large i
Drying / Sandability	★ ★ ★ ★ ★ ✓	none i
Pendulum hardness	★ ★ ★	moderate i
Cupping	★ ★ ★	large i
Adhesion	★ ★ ★ ★ ★ ✓	none i
Corrosion protection	★ ★ ★ ★	large i

Highest
optimization potential

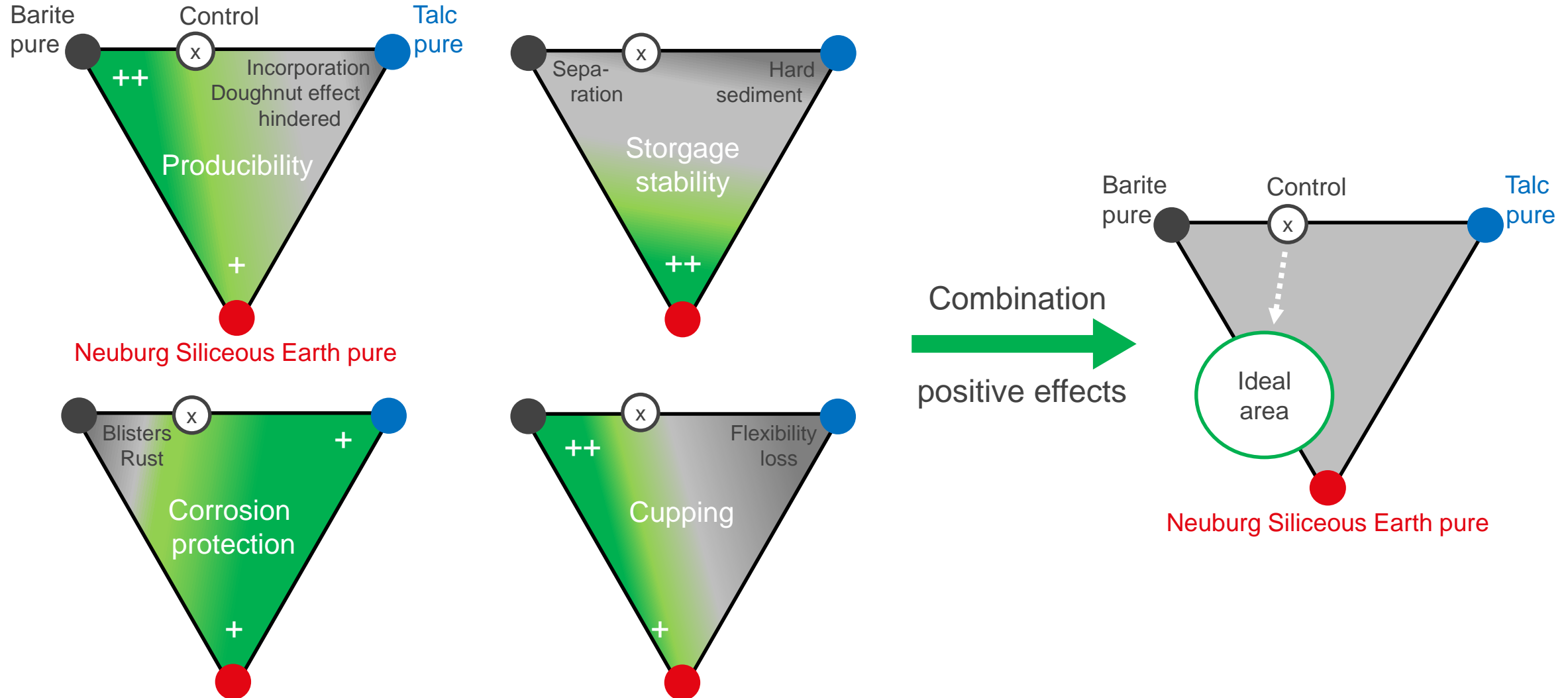
for

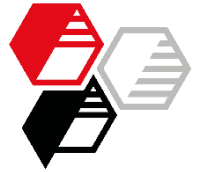
properties
with lower performance

+
highest
positive
filler effect



Preliminary study – Position of optimal filler package

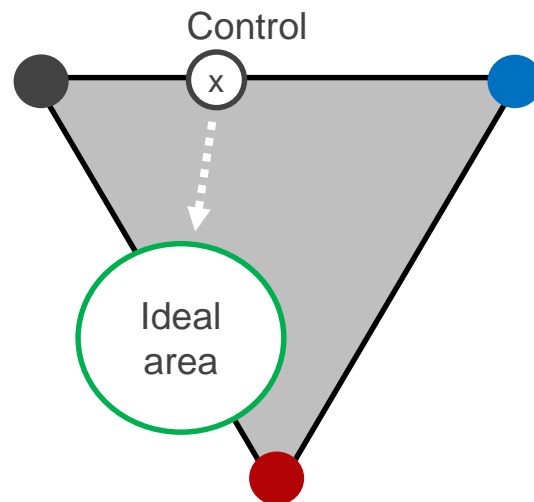




Optimisation filler package

Step 1: Reduction of barite content
→ 1/3 filler volume

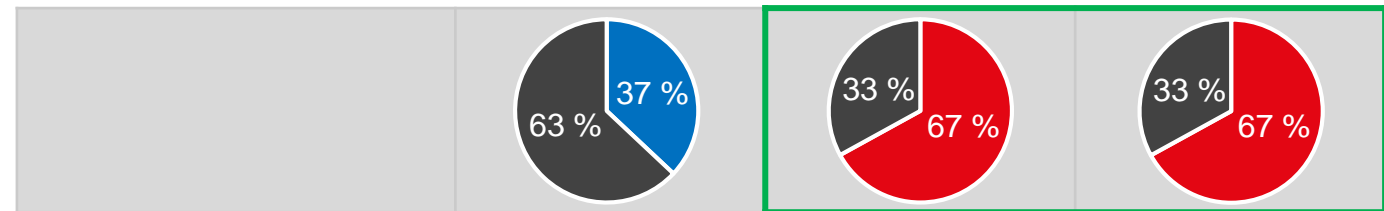
Step 2: Use of **Neuburg Siliceous Earth**
→ 2/3 filler volume



Control	Aktisil AM	Sillitin V 85
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Filler dosage

volume fraction

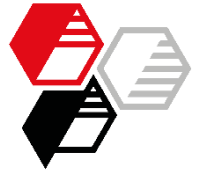


parts by weight on formulation

Talc	9.06		
Barite	24.62	13.00	13.00
Neuburg Siliceous Earth		15.37	15.37

i Filler characteristics

i Structure **Neuburg Siliceous Earth**



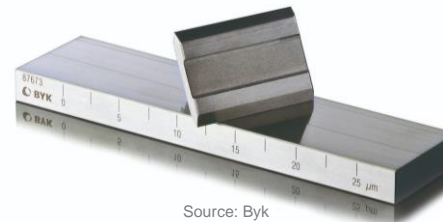
Producibility

A-Component: Laboratory dissolver with toothed disc (Cowles Blade) 30 min 8 m/s, ice water cooling



Good filler / pigment incorporation and dispersing process:

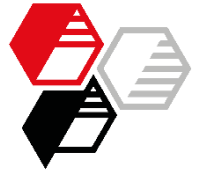
- Variant with **Sillitin V 85** 15 - 20 μm
- All other 10 - 15 μm fineness of grind



$\leq 35 \mu\text{m}$
DB compliant

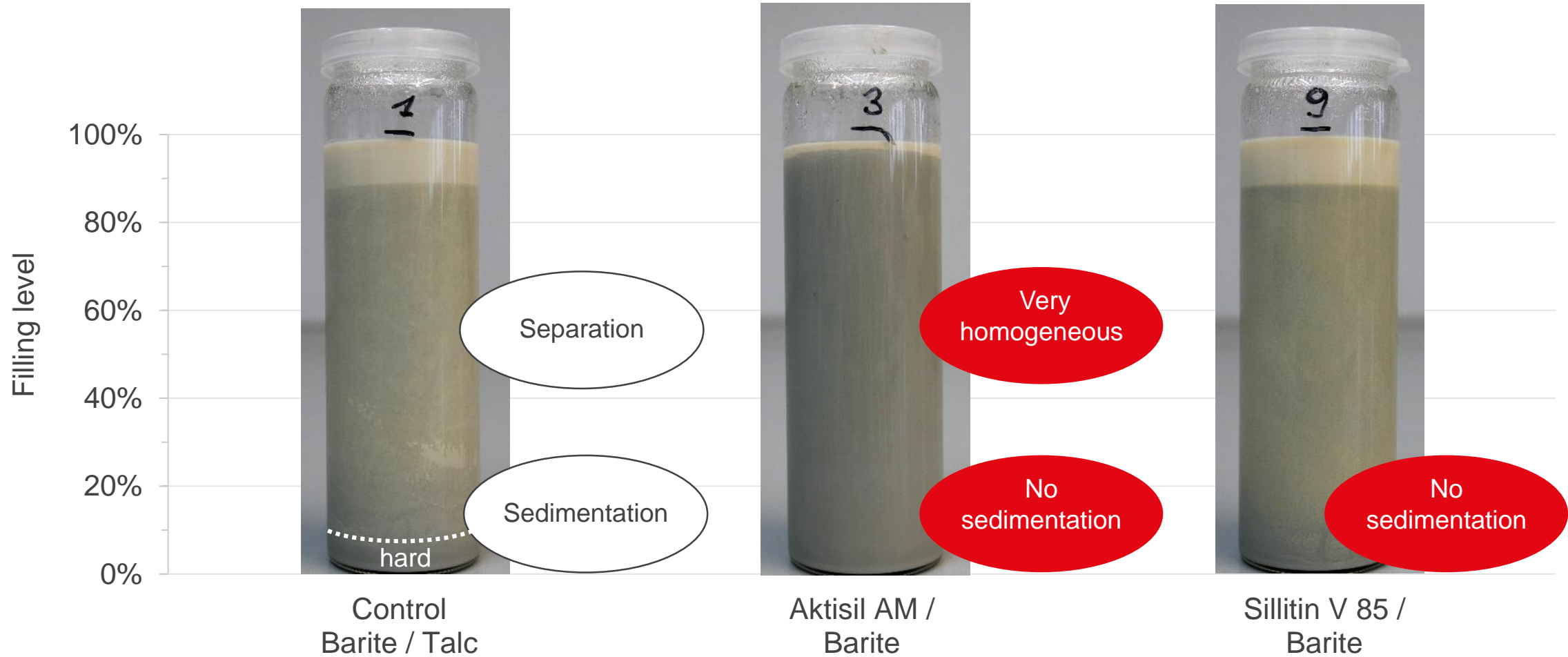


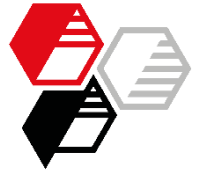
A + B Component: Overhead mixer with propeller blade 2 min 1000 rpm



Storage stability

A-Component 28 days, 40°C

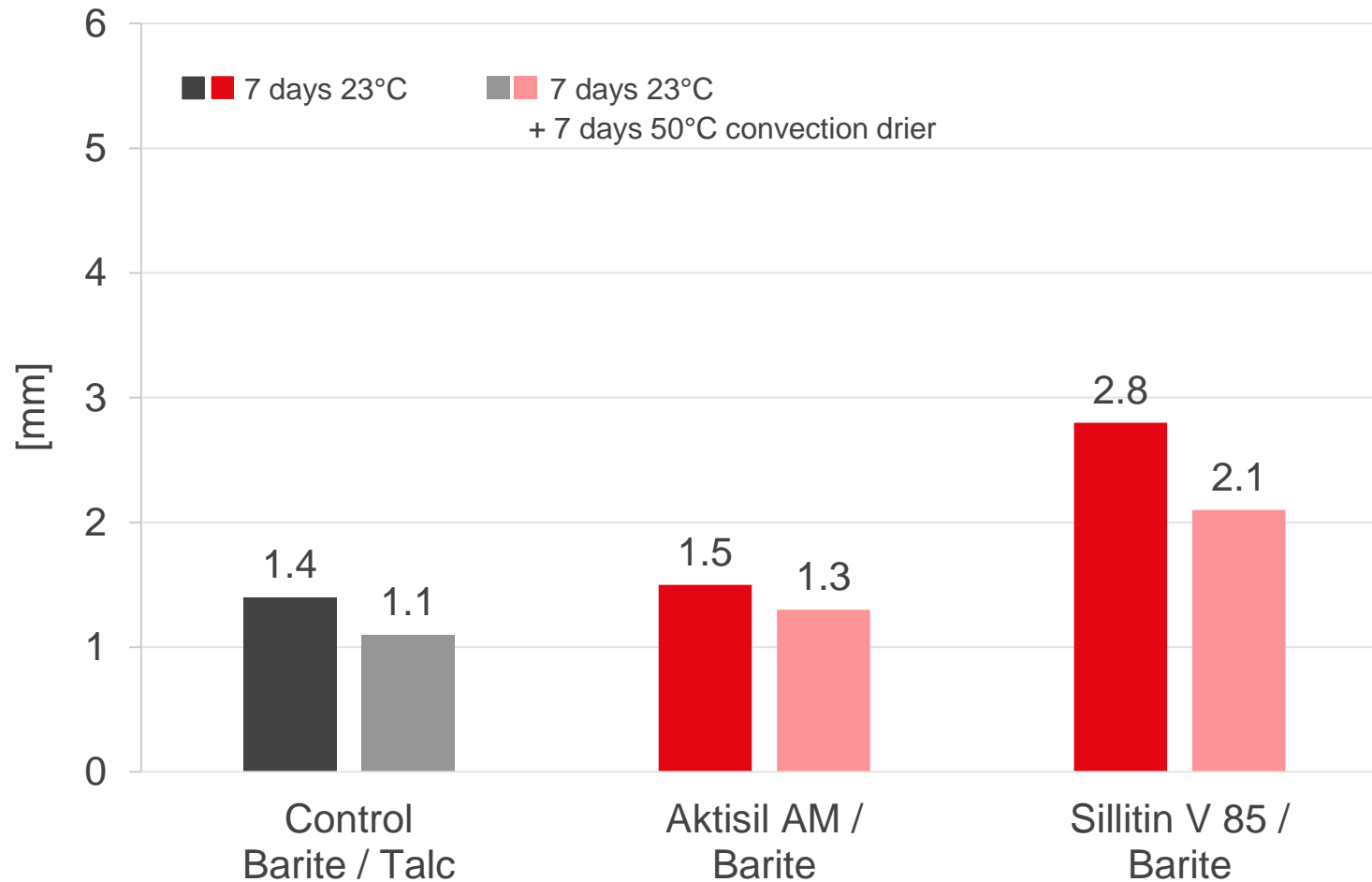




Mechanical flexibility – Cupping

i Preparative methods

Blasted aluminum

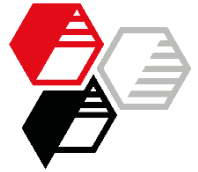


In contrast to control
benefits with
Neuburg Siliceous Earth

- More flexibility with

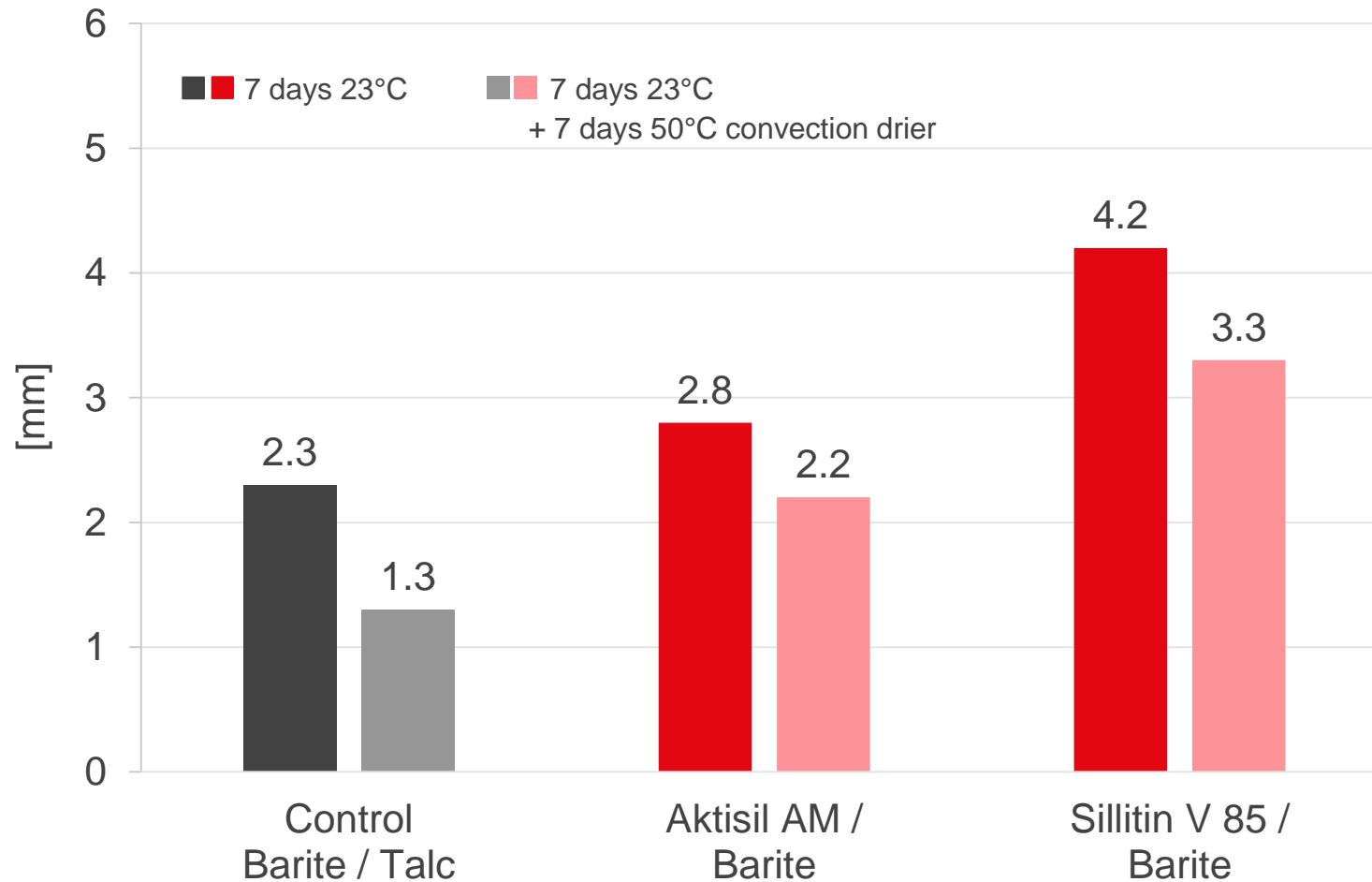
Aktisil AM
+ 10 %

Sillitin V 85
+ 100 %
= Doubling !



Mechanical flexibility – Cupping

Blasted steel



In contrast to control
benefits with
Neuburg Siliceous Earth

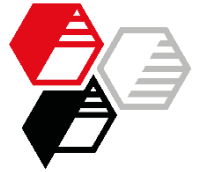
- More flexibility with

Aktisil AM

+ 20 to 70 %

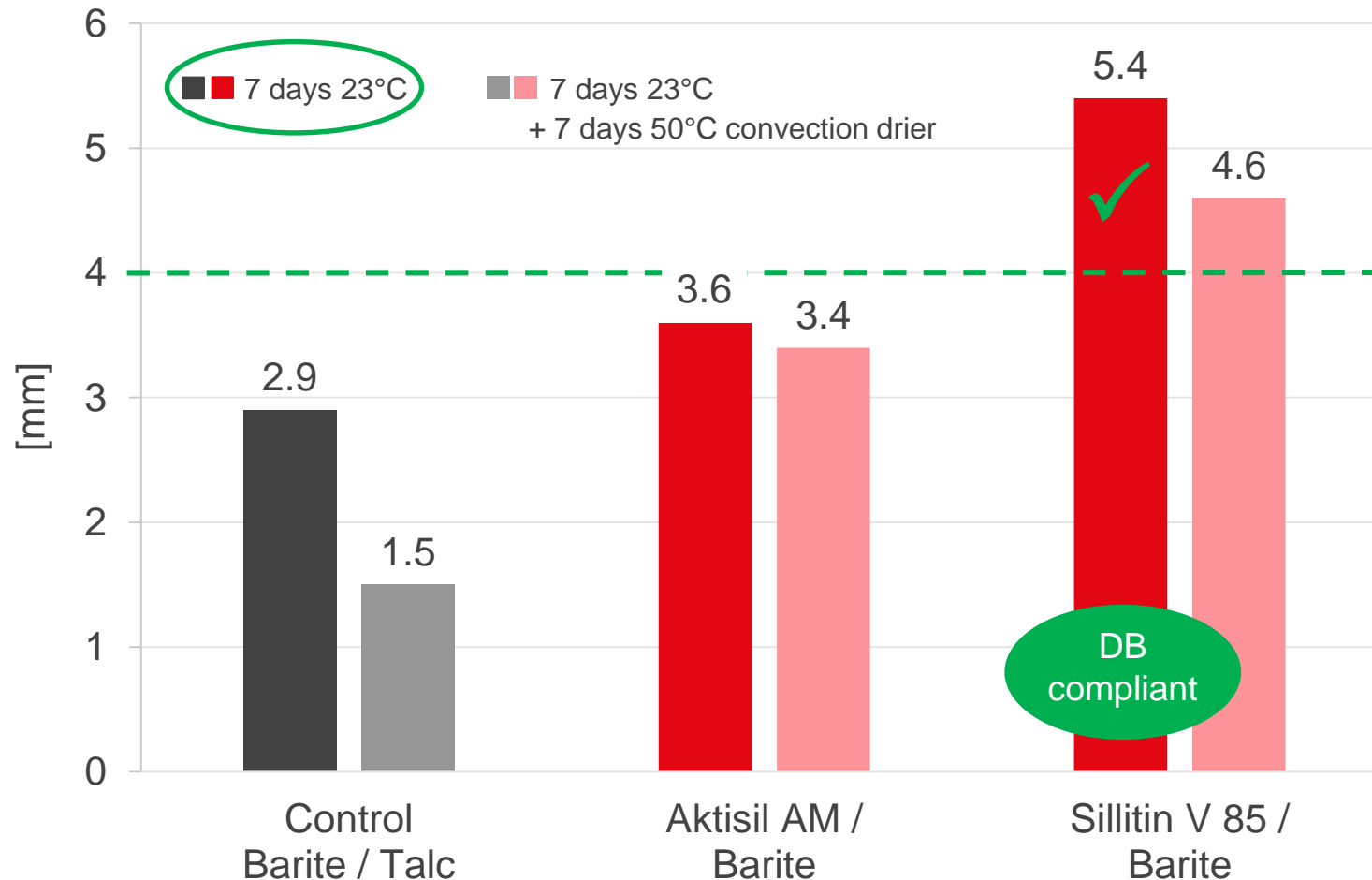
Sillitin V 85

+ 80 to 150 %



Mechanical flexibility – Cupping Requirements DB ≥ 4 mm

Slightly sanded steel



In contrast to control
benefits with
Neuburg Siliceous Earth

- More flexibility with

Aktisil AM

+ 25 to 125 %

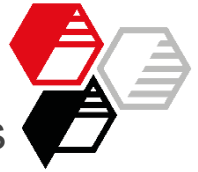
Sillitin V 85

+ 85 to 205 %

= up to tripling !

Requirements DB exceeded

- Almost preservation of flexibility
after oven drying



Cyclic corrosion test Requirements DB = 4 Cycles / 672 h

i Test specifications

Blasted aluminum

Adhesion

0 h

GT ≤ 1

Blistering 0(S0)

Rusting Ri 0

Scribe

No blistering

Delamination /
Corrosion ≤ 2 mm



Blasted steel

Adhesion

0 h

GT ≤ 1

Blistering 0(S0)

Rusting Ri 0

Scribe

Blisters ≤ 2 mm

Delamination /
Corrosion ≤ 2 mm



All formulations
identical results:

Perfect
wet / dry adhesion

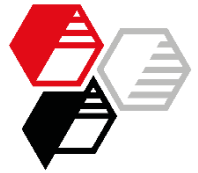
Defect-free protection in
non-scribed area

Very high protective effect
at scribe

Requirements DB
met

DB
compliant





Cyclic corrosion test ... extended to 10 Cycles / 1680 h

Blasted aluminum

Adhesion

0 h

GT ≤ 1

Blistering 1(S2)

Rusting Ri 0

Scribe

No blistering

Delamination /
Corrosion



Blasted steel

Adhesion

0 h

GT ≤ 1

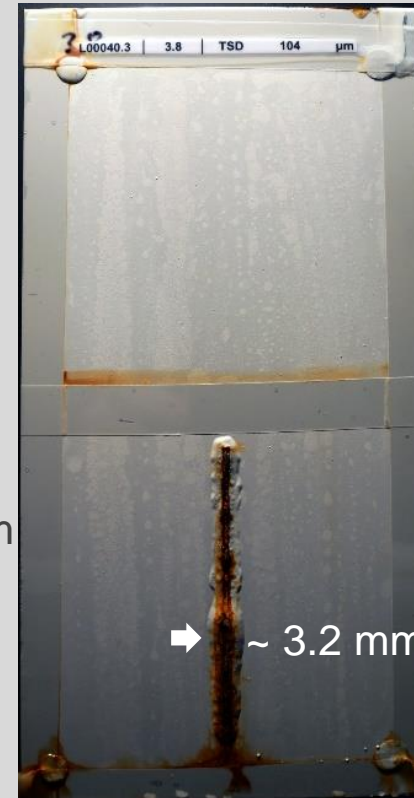
Blistering 2(S2)

Rusting max.
punctual

Scribe

Blisters ≤ 4 mm

Delamination /
Corrosion



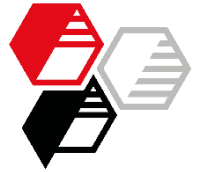
All formulations
identical results:

Perfect
wet / dry adhesion

Continued high level
of protection
non-scribed area / scribe
particularly on aluminum

Greatly extended
resistance
and durability





Humidity Test Requirements DB = 480 h ... and extended to 1000 h

Blasted aluminum

Adhesion
0 h / 24 h
GT ≤ 1

Blistering 0(S0)
Rusting Ri 0

Scribe
No blistering
Delamination /
Corrosion



Blasted steel

Adhesion
0 h / 24 h
GT ≤ 1

Blistering 0(S0)
Rusting Ri 0

Scribe
Blisters ≤ 1 mm
Delamination /
Corrosion



All formulations
identical results:

Perfect
wet / dry adhesion

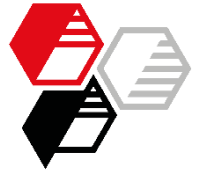
Defect-free protection in
non-scribed area

Excellent protective effect
at scribe


Requirements DB
met and exceeded

DB
compliant





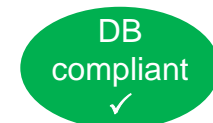
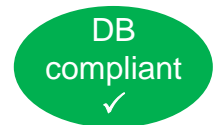
Conclusion – Use of optimized fillers

- Compensation for the disadvantages of a barite / talc filler combination 
- Improved technical property profile

Ideal new filler combination = Barite (1/3 Volume) + **Neuburger Siliceous Earth** (2/3 Volume)

- **With Aktisil AM**
 - ✓ Improved, very high storage stability without settling or separation phenomena
 - ✓ Sag resistance of high layer thicknesses due to high low shear viscosity stable over time
 - ✓ Accelerated build-up of mechanical coating hardness / strength
 - ✓ High mechanical flexibility (cupping test) on various substrates
- **With Sillitin V 85**
 - ✓ High sedimentation-free storage stability
 - ✓ Maximum coating flexibility in accordance with Deutsche Bahn AG requirements
 - ✓ Cost-effective filler combination

In addition, the very good drying / sandability / adhesion and anti-corrosion properties are retained



Optimized benefit for more efficient, higher-performing coating with longer-lasting protection



Starting formulations

Component A		parts by weight	[1]	[2]
Pigment preparation	Water deionised		11.94	11.94
	Additol VXW 6208	Dispersing additive	3.52	3.52
	Additol VXW 6393	Defoamer	0.16	0.16
	Texanol	Solvent, coalescent agent	0.64	0.64
	Kronos 2190	Pigment white	21.85	21.85
	Bayferrox 3920	Pigment yellow	0.43	0.43
	Bayferrox 306	Pigment black	1.17	1.17
	Barite	Filler	13.00	13.00
	Aktisil AM	Filler, Neuburg Siliceous Earth	15.37	
	Sillitin V 85	Filler, Neuburg Siliceous Earth		15.37
	Additol VXW 6388	Rheological additive	0.64	0.64
	Methoxypropanol	Solvent	1.07	1.07
	Beckocure EH 2261w/41WA	Hardener, aliphatic polyamine adduct dispersion HEW 1100 g/mol	24.90	24.90
Total			94.69	94.69
Component B				
	Beckopox EP 387/w/52WA	Binder, solid epoxy resin dispersion EEW 1000 g/mol	49.80	49.80
Mixing ratio Amine/Epoxy			1 : 2	1 : 2
Stoichiometric crosslinking ratio Amine/Epoxy			0.49	0.49
Solids content w/w [%]			62.8	62.8
PVC			32.0	32.0

Water-based 2C Epoxy Anti-Corrosion Coating

- Low VOC
- Active pigment free / inhibitor free
- Fast drying and sandability
- High mechanical flexibility
- High wet / dry adhesion

[1]
Excellent corrosion protection with
outstanding storage stability

[2]
Outstanding corrosion protection
with maximum mechanical flexibility
(cupping)

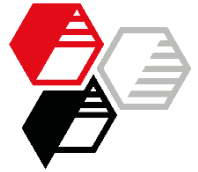


We supply material for good ideas!

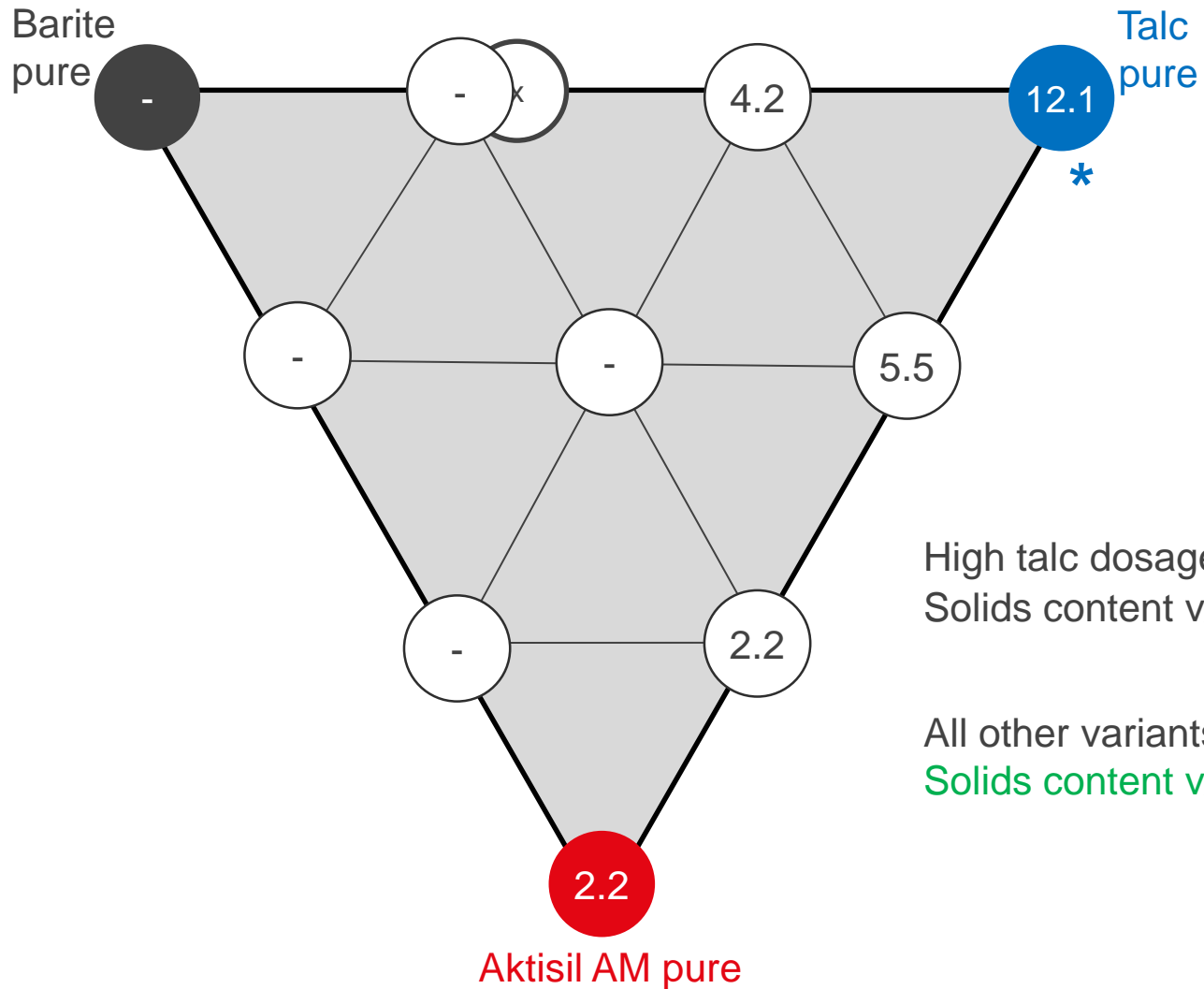
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Muenchener Straße 75
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E-mail: info@hoffmann-mineral.com

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Producibility A-Component – Water demand / solids content



Additive water dosage in [%] for

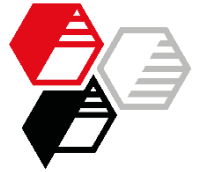
- good filler / pigment incorporation
→ Wettability
- good dispersing process
→ Circulation / Doughnut-Effect

High talc dosage* → high water demand
Solids content v/v < 45 %, requirements DB missed X

All other variants easier to produce
Solids content v/v ≥ 45 %, requirements DB achieved

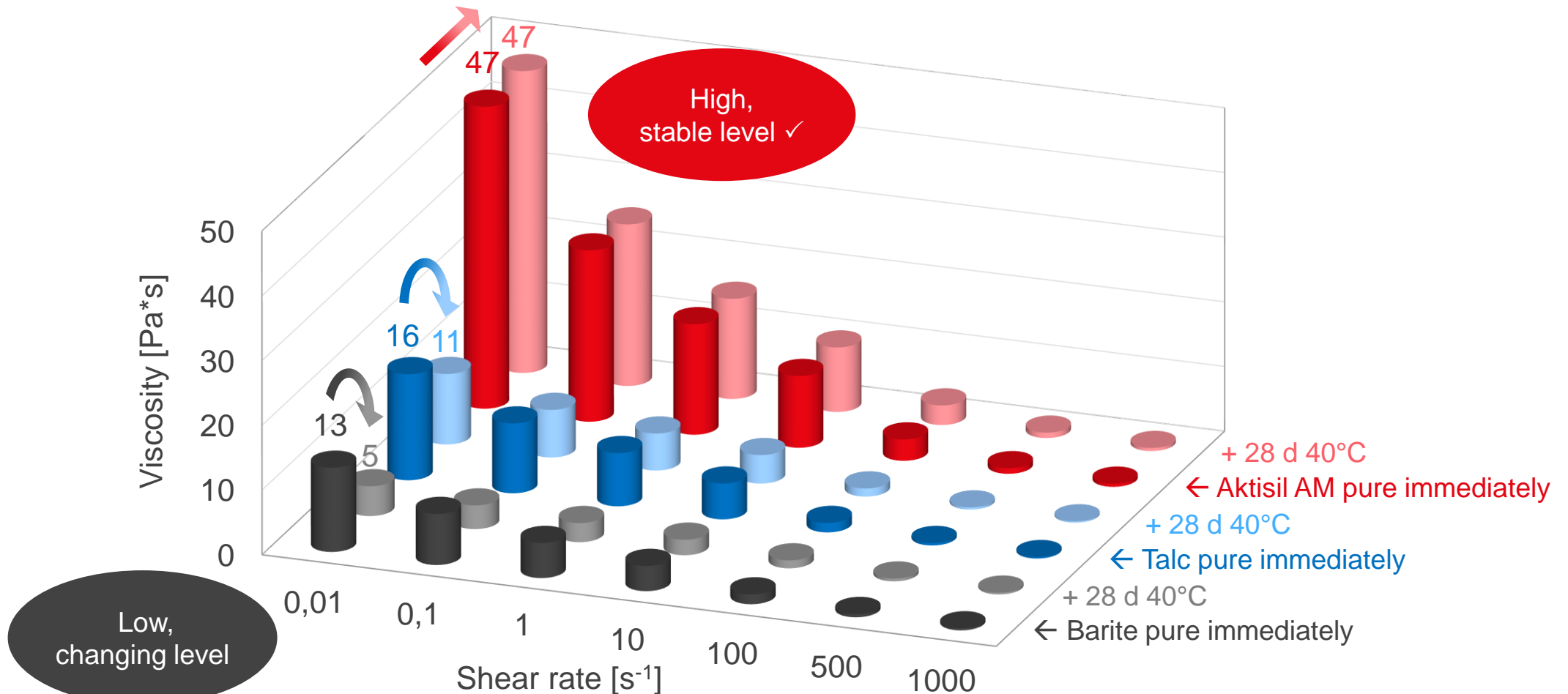
DB
compliant

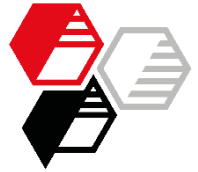




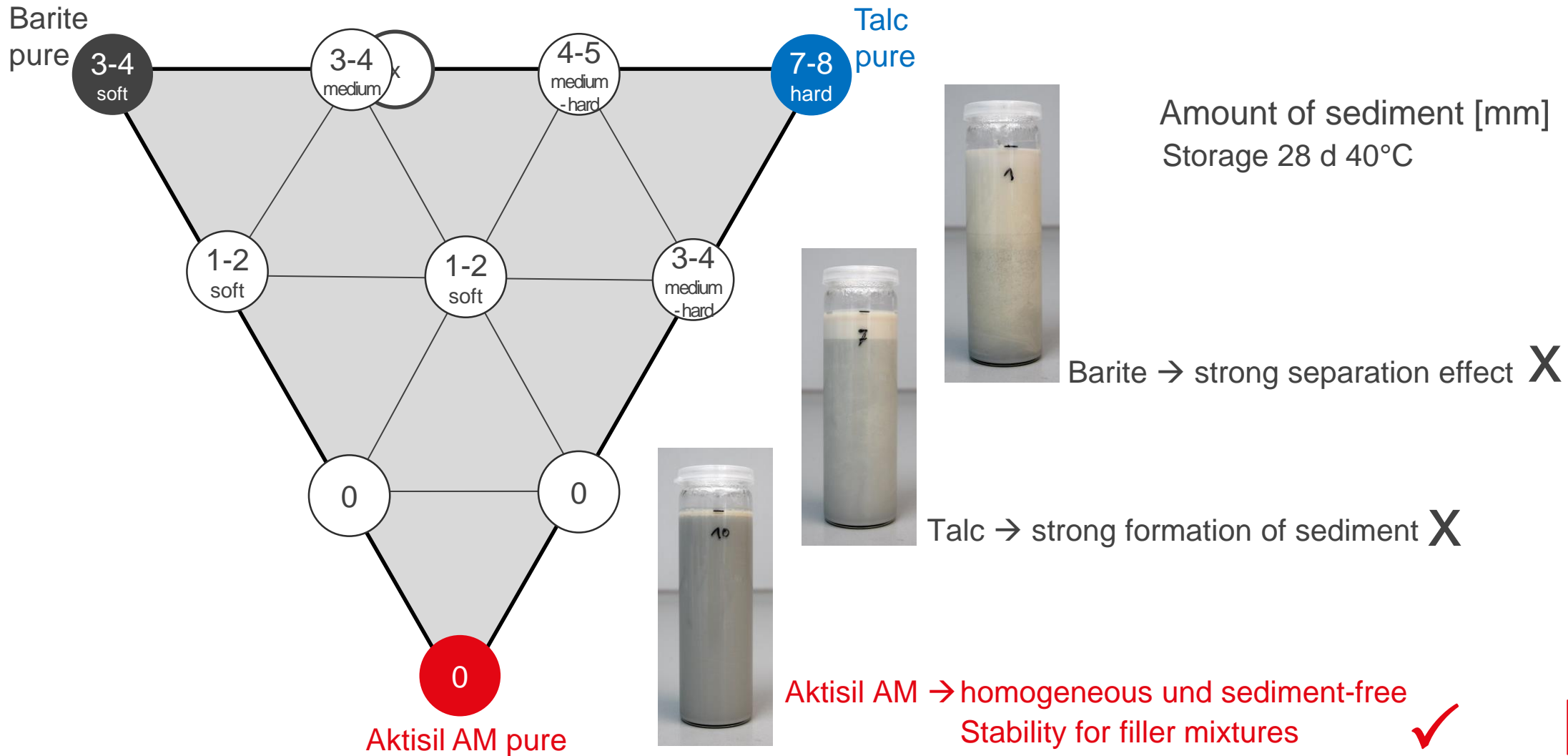
Storage stability – Rheological stability with filler pure

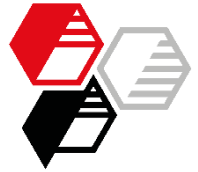
A-Component: Pseudoplastic flow curves immediately and after 28 d 40°C





Storage stability – Separation and sedimentation stability





Drying / Sandability

Drying

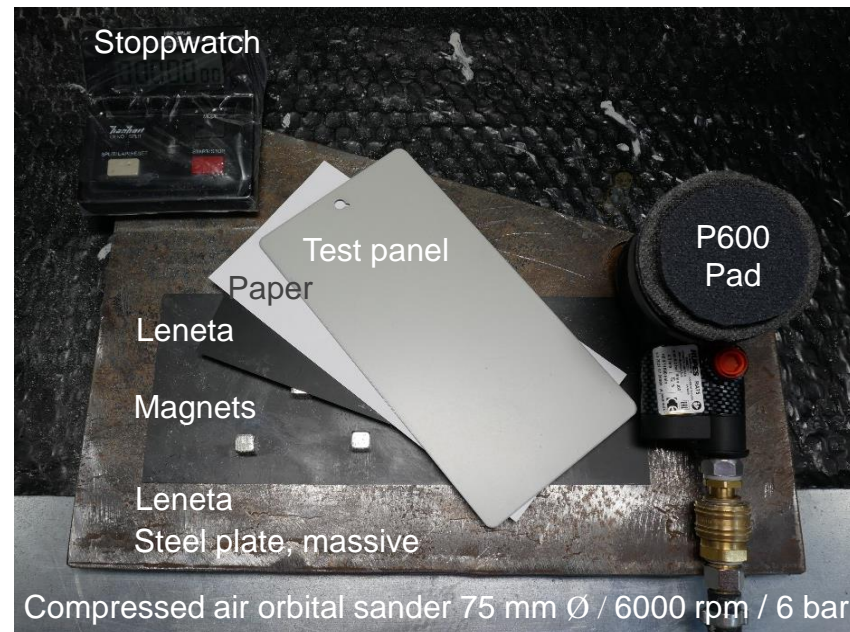
All variants: complete drying of the coating surface ≤ 2 h

Sandability

Indicator for degree of drying + early recoatability of primer

DBS 918300 Deutsche Bahn, Appendix B, Sheet 2:

„Sandable without heavy "smearing" and quick "clogging" of the sandpaper.
Slight pre-sanding must be possible“



1. ≤ 16 h 23°C / 50% RH resp.
2. 15 min flash-off + 2 h 40°C convection drier

All variants:
Very good sandability





Pendulum hardness – Koenig

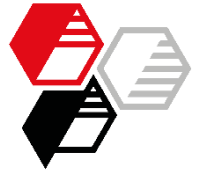


Damping time [s] from 6° to 3° deflection
Drying 7 d 23°C

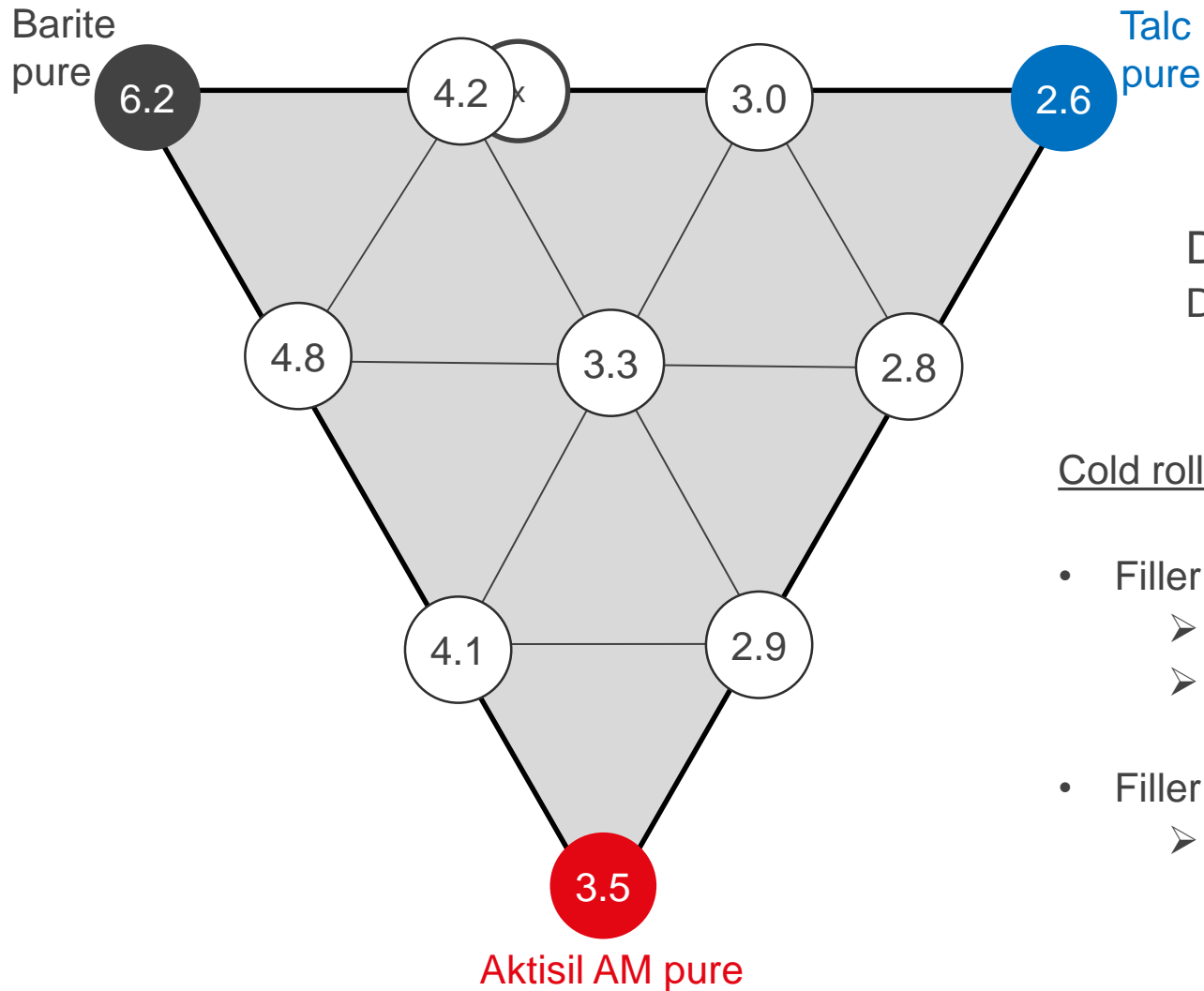
Cold rolled steel

- Faster hardness development advantageous with **Aktisil AM**
- Further drying for 7 d 50°C convection drier → **106 s**



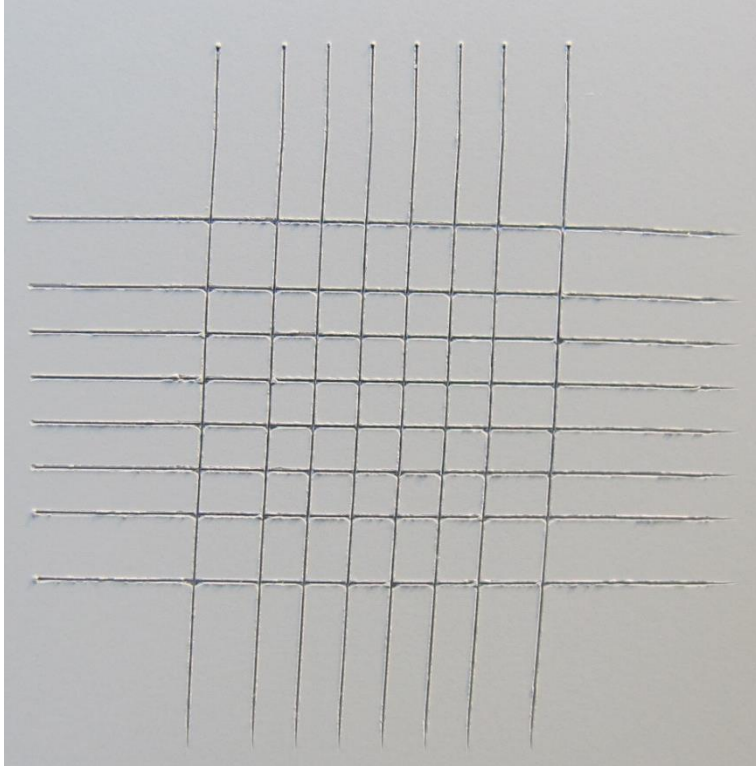


Mechanical flexibility – Cupping test Erichsen





Adhesion – Cross cut test 2 mm



Test with tape tear-off [GT]

Drying 7 d 23°C as well as + 7 d 50°C convection drier

Cold rolled steel

Slightly sanded steel

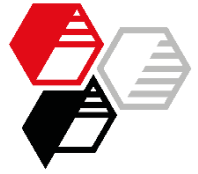
Blasted aluminum

Blasted steel

All variants outstanding adhesion

GT ≤ 1, requirements DB fulfilled





Corrosion protection – Filler effects at critical conditions

E.g. Cyclic corrosion test / low dry film thickness single-layered

Barite pure

Talc pure

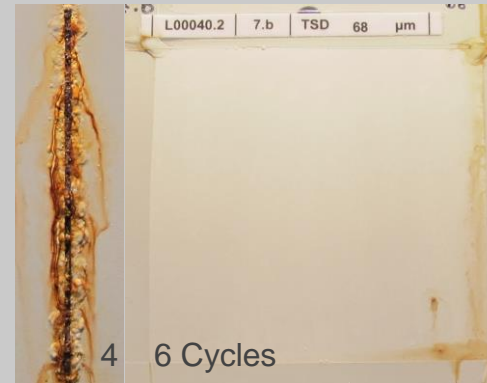
Aktisil AM pure

Cold rolled steel

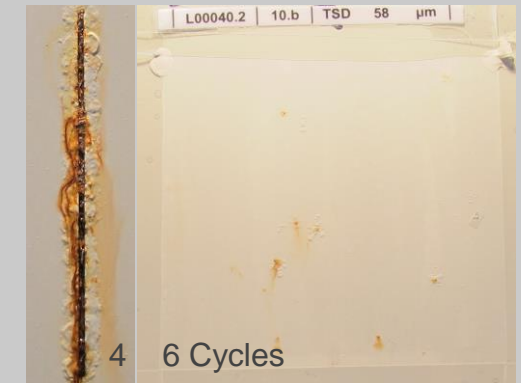


Corrosion at scribe
Delamination

Strong
blistering
+ penetrating rust

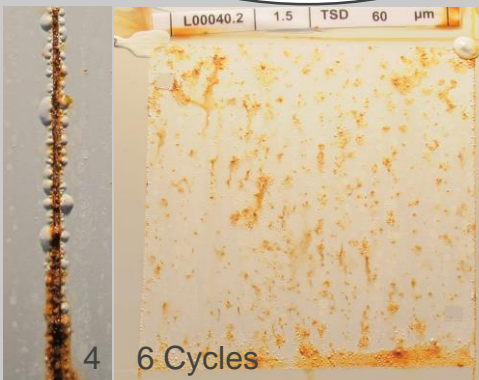


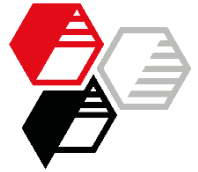
Only a few larger,
punctual defects ✓



Only a few smaller,
punctual defects ✓

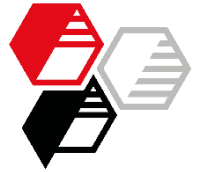
Blasted steel





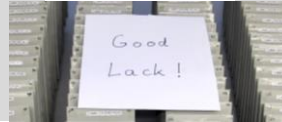
Preparative methods

Application	Thinned with water, single-layered by air pressure spraying, 2 bar, nozzle 2 mm Dry film thickness ~ 95 µm (requirement DB 80 µm)			
Substrate	 <p>Blasted aluminum</p> <p>AlMg2Mn0.8 Roughness $R_a \sim 5 - 8 \mu\text{m}$ Thickness 1.0 mm 10 x 20 cm</p>	 <p>Blasted steel</p> <p>Preparation grade Sa 2 ½ Roughness „fine (G)“ Thickness 1.0 mm 10 x 20 cm</p>	 <p>Slightly sanded steel</p> <p>DC04 Thickness 0.8 mm 10 x 20 cm</p>	<p>Conditioning:</p> <p>varied</p> <p>→ Cupping test</p> <p>14 days 23°C</p> <p>→ Cyclic corrosion test DIN EN ISO 11997-1 Cycle B</p>  <p>Coated panel</p> <p>Scribe 1 mm Sikkens</p> <p>→ Humidity test DIN EN ISO 6270-2 CH</p>
Requirements DB →	Corrosion test	Corrosion test	Cupping test	



Specifications Corrosion Tests – Requirements DB

Cyclic corrosion test 4 Cycles / 762 h DIN EN ISO 11997-1 Cycle B

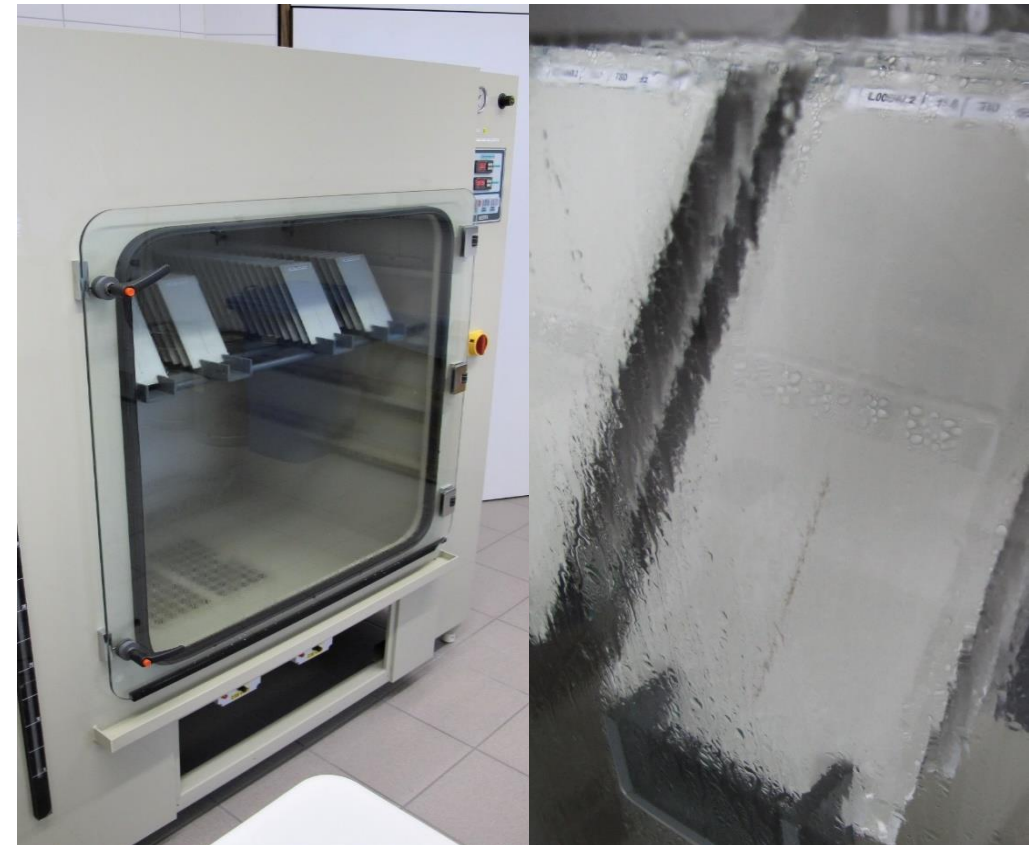


- 1 x 24 h Neutral salt spray test 35°C
 - 3 x 8 h Humidity test 40°C +
16 h Conditioning 23°C / 50% RH
 - 1 x 48 h Conditioning 23°C / 50% RH
- 1 Cycle
=
1 Week



Humidity test 480 h DIN EN ISO 6270-2 CH

- Constant climate 40°C / 100% RH





Performance Control formulation

- Outstanding wet / dry adhesion on various substrates
- Good corrosion protection without need for active anti-corrosion pigments or inhibitors

Present filler combination Talc / Barite reduces maximum possible performance

- Barite :
 - ✓ Very good cupping results if dosed higher
 - 👎 Storage stability (separation, sedimentation)
 - 👎 Corrosion protection at critical conditions difficult if dosed higher
- Talc:
 - +/- No noticable adhesion benefit of coating prior, during or after corrosion tests
 - 👎 Massive loss in cupping-flexibility, particularly after convection drying in oven
 - 👎 Higher doses problematic in paint production (incorporation, dispersing process) and to meet solids content requirements of DBS 918300
 - 👎 Storage stability (hard sediment)





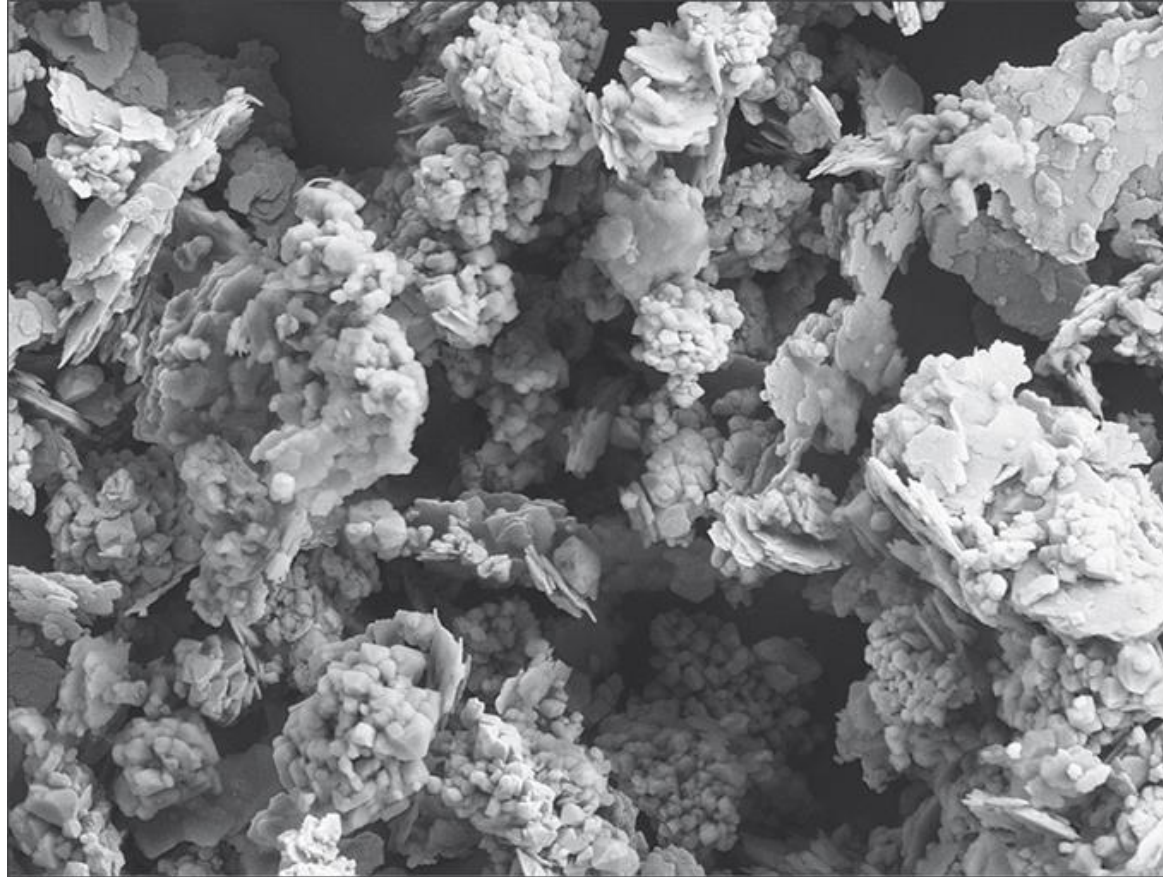
Filler characteristics

	Particle size		Oil absorption	Density	Spezific surface area BET	Special characteristics
	d ₅₀ [μm]	d ₉₇ [μm]	[g/100g]	[g/cm ³]	[m ² /g]	Surface treatment
Talc	4.4	13	62	2.8	8.3	-
Barite	2.9	14	14	4.4	0.8	-
Aktisil AM	2.2	10	45	2.6	9.0	amino-functionalized
Sillitin V 85	4.0	18	45	2.6	8.0	-





Neuburg Siliceous Earth



A natural combination of corpuscular Neuburg silica and lamellar kaolinite: a loose mixture impossible to separate by physical methods. The silica portion exhibits a round grain shape and consists of aggregated primary particles of about 200 nm diameter.