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

e. g. for Trains of Deutsche Bahn AG

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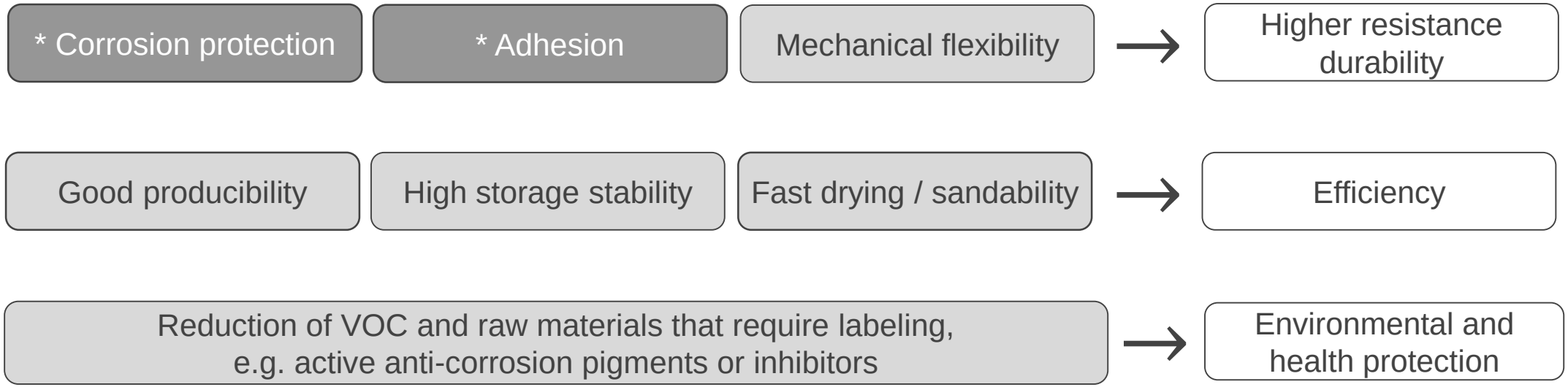
Status Quo

- 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

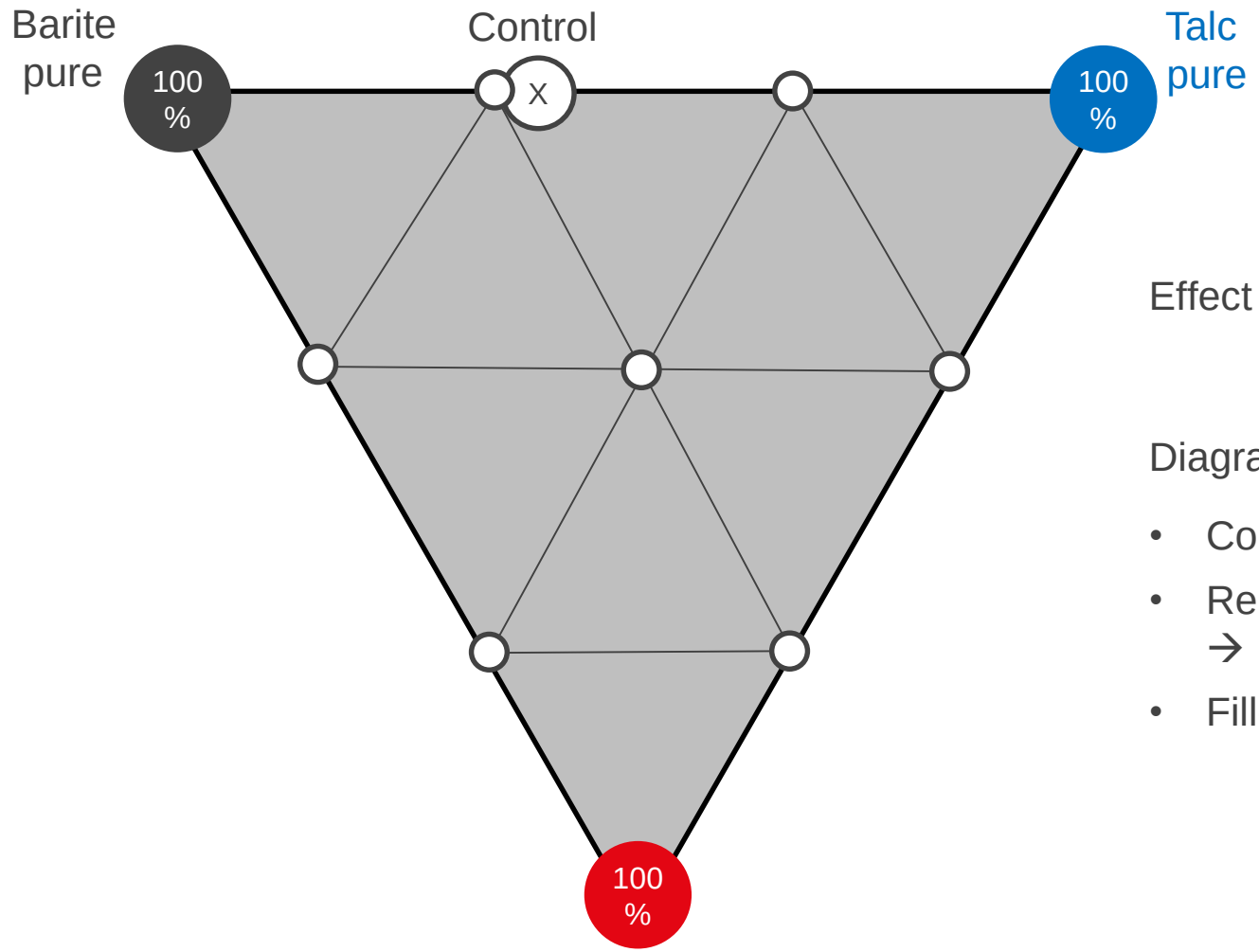
Water-based 2C Epoxy
Anti-corrosion Coating

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
Storage stability	★★★	large
Drying / Sandability	★★★★★ ✓	none
Pendulum hardness	★★★	moderate
Cupping	★★★	large
Adhesion	★★★★★ ✓	none
Corrosion protection	★★★★	large

Highest
optimization potential

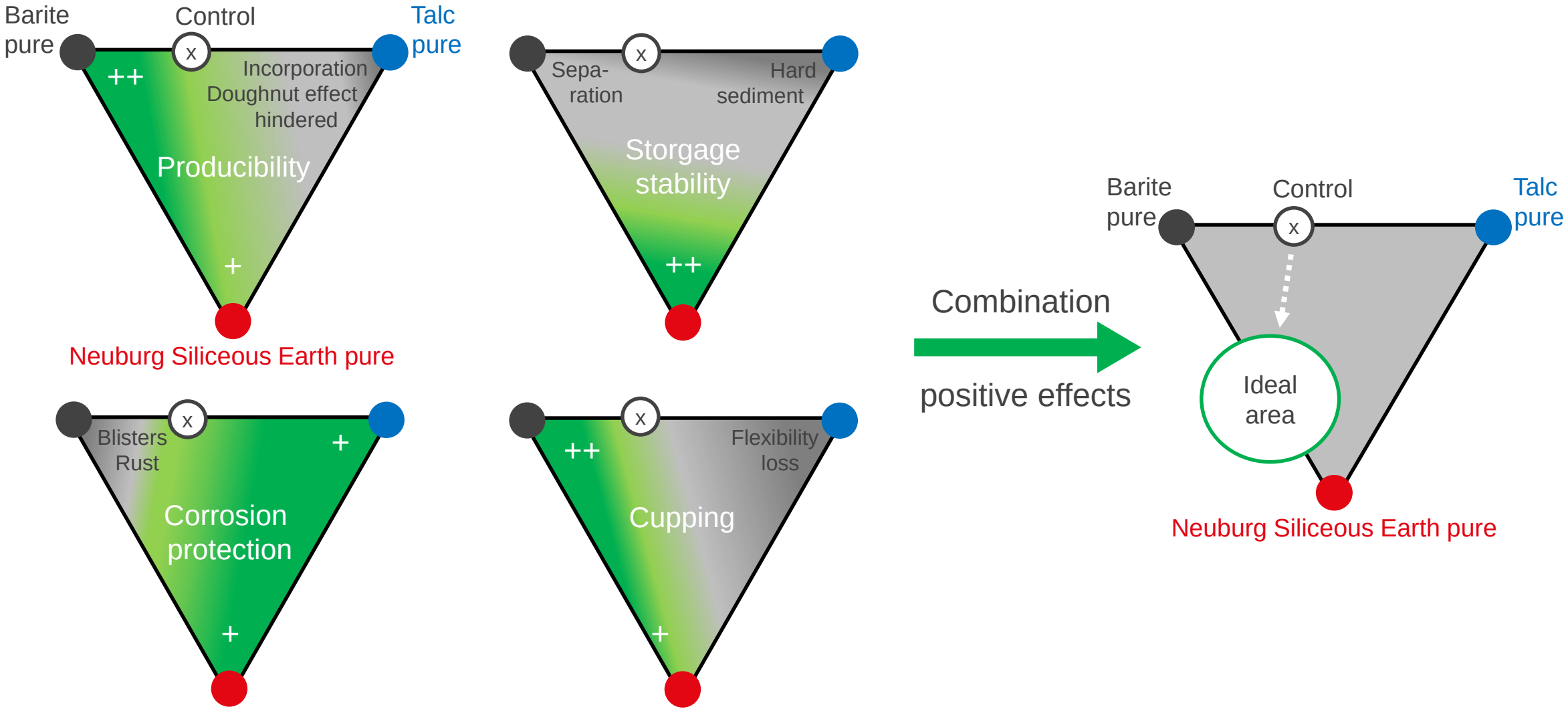
for

properties
with lower performance

+

highest
positive
filler effect

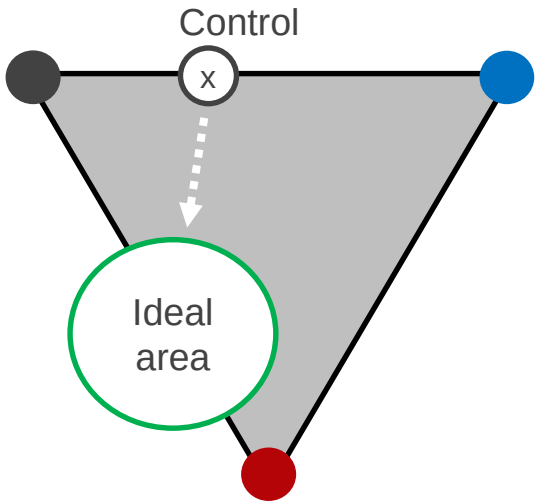
Preliminary study – Position of optimal filler package

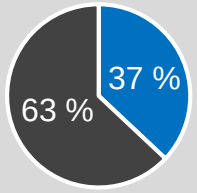
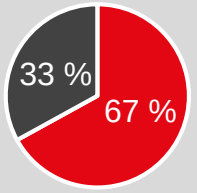
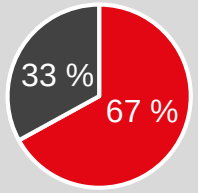


Optimisation filler package

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
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

Filler characteristics

Structure Neuburg Siliceous Earth

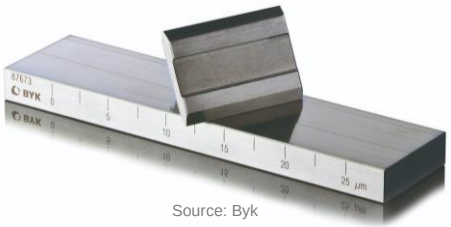
Producibility

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


Source: VMA Getzmann

Good filler / pigment incorporation and dispersing process:

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

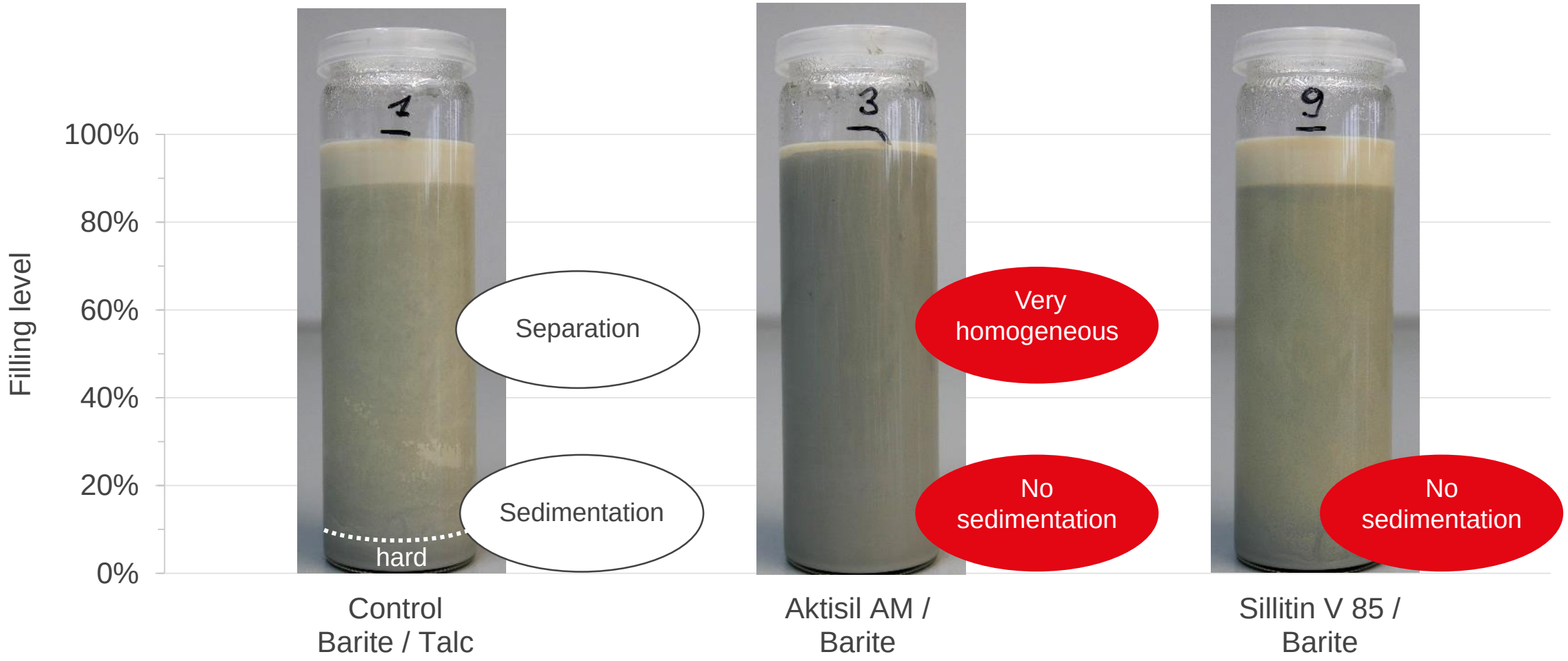

Source: Byk

≤ 35 µm
DB compliant
✓

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

Storage stability

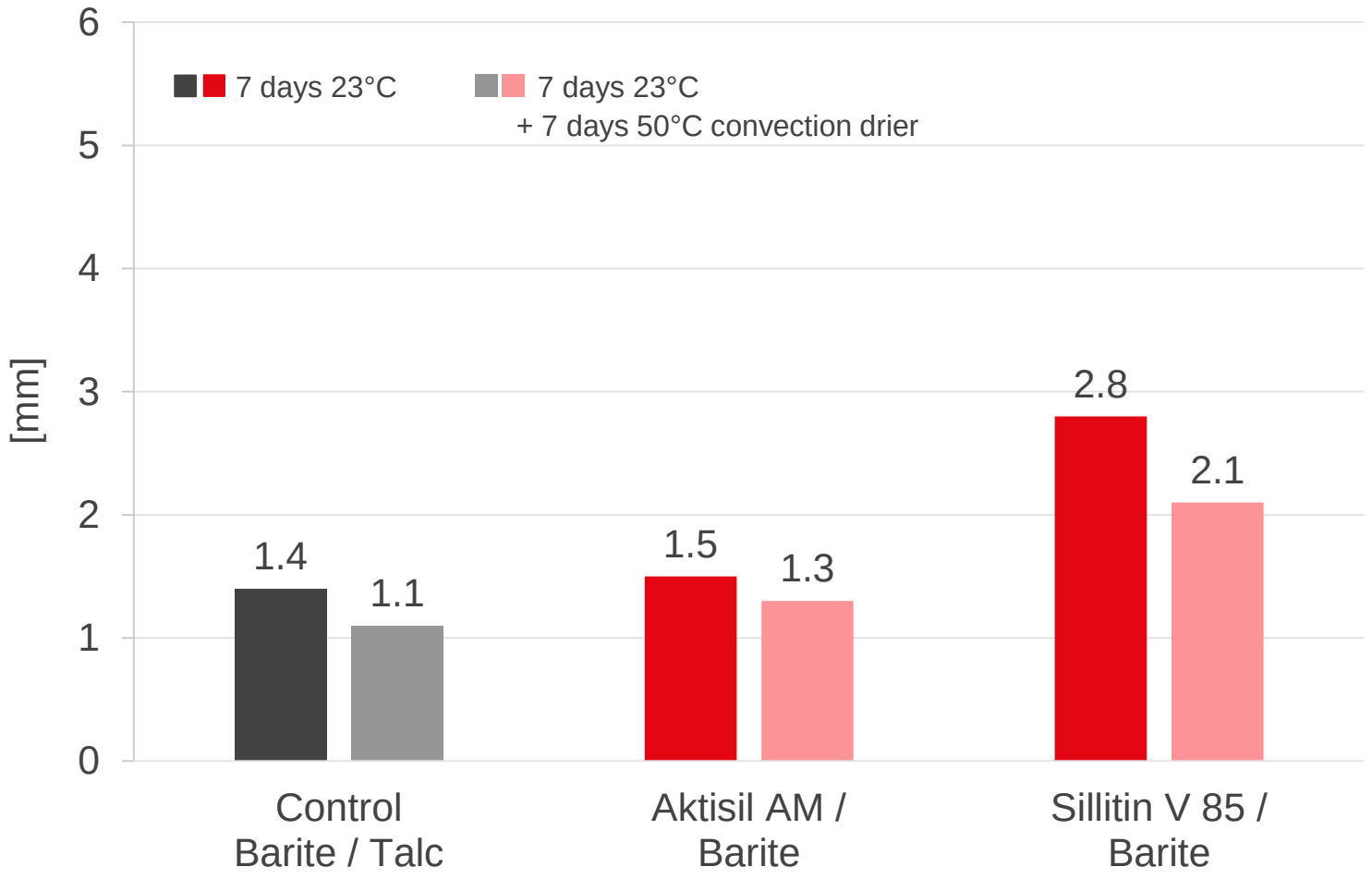
A-Component 28 days, 40°C



Mechanical flexibility – Cupping

Preparative methods

Blasted aluminum



In contrast to control
benefits with
Neuburg Siliceous Earth

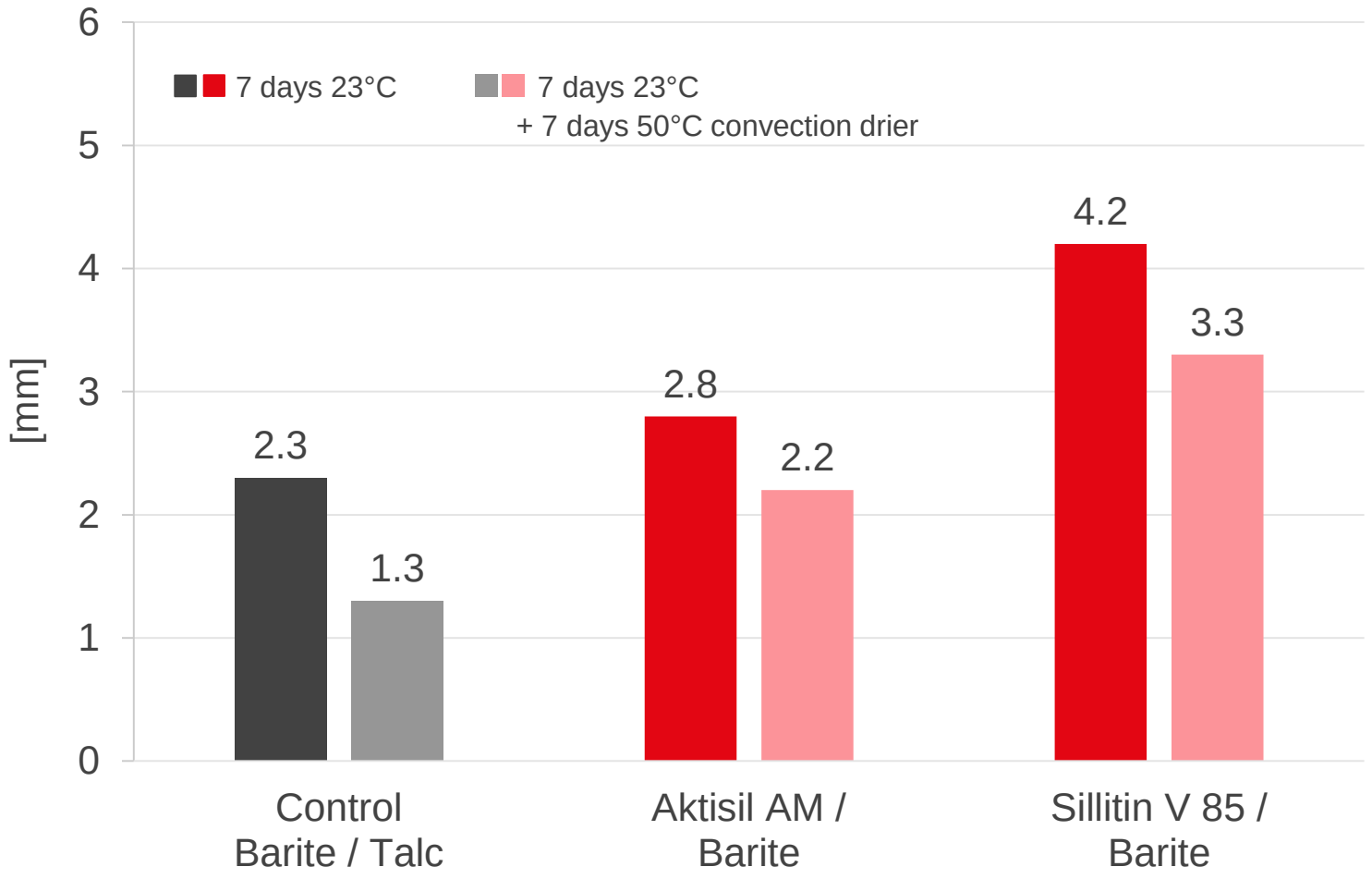
- More flexibility with

Aktisil AM
+ 10 %

Sillitin V 85
+ 100 %
= Doubling !

Mechanical flexibility – Cupping

Blasted steel



In contrast to control
benefits with
Neuburg Siliceous Earth

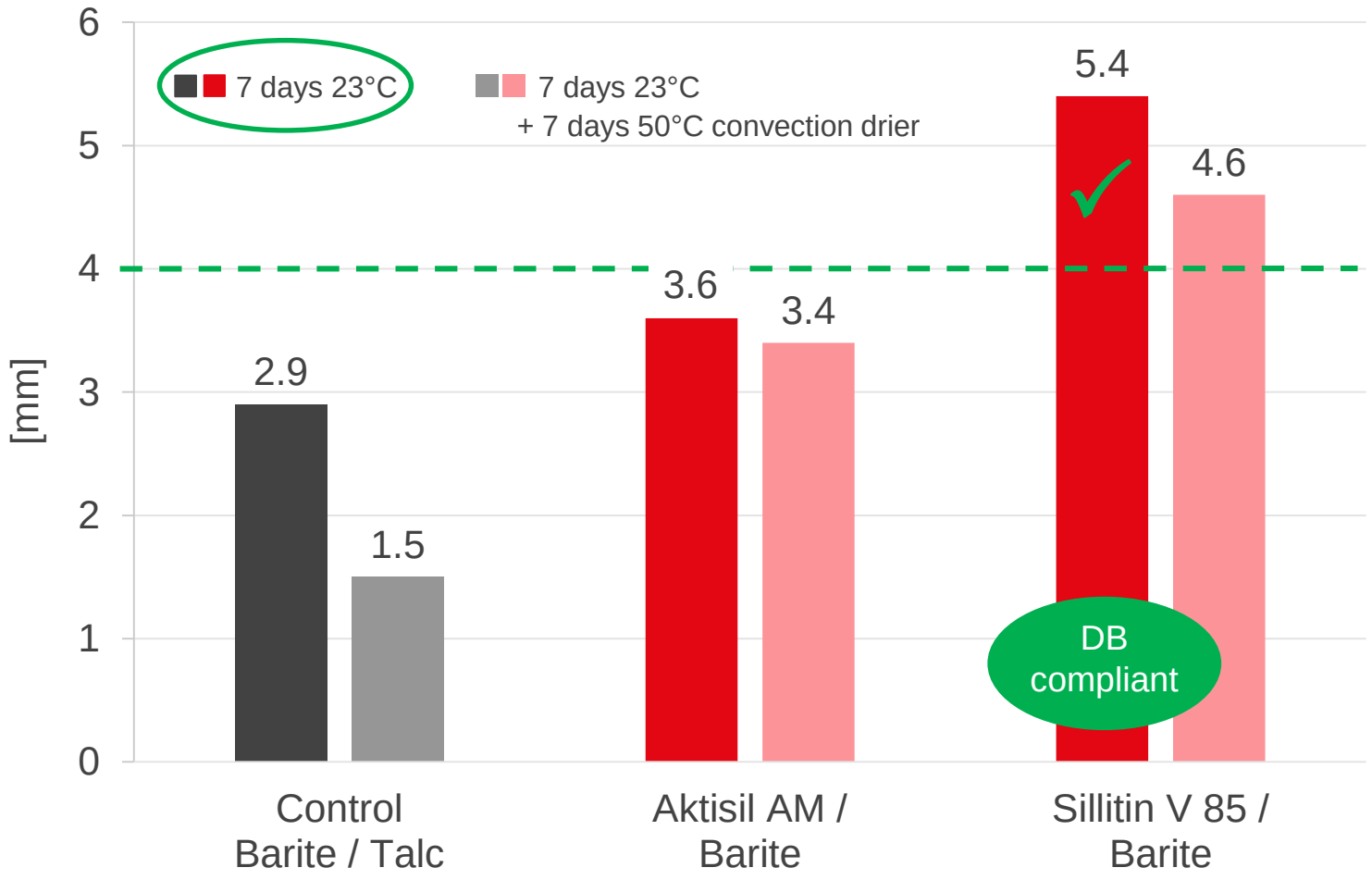
- More flexibility with

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

DB compliant ✓

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

DB compliant ✓

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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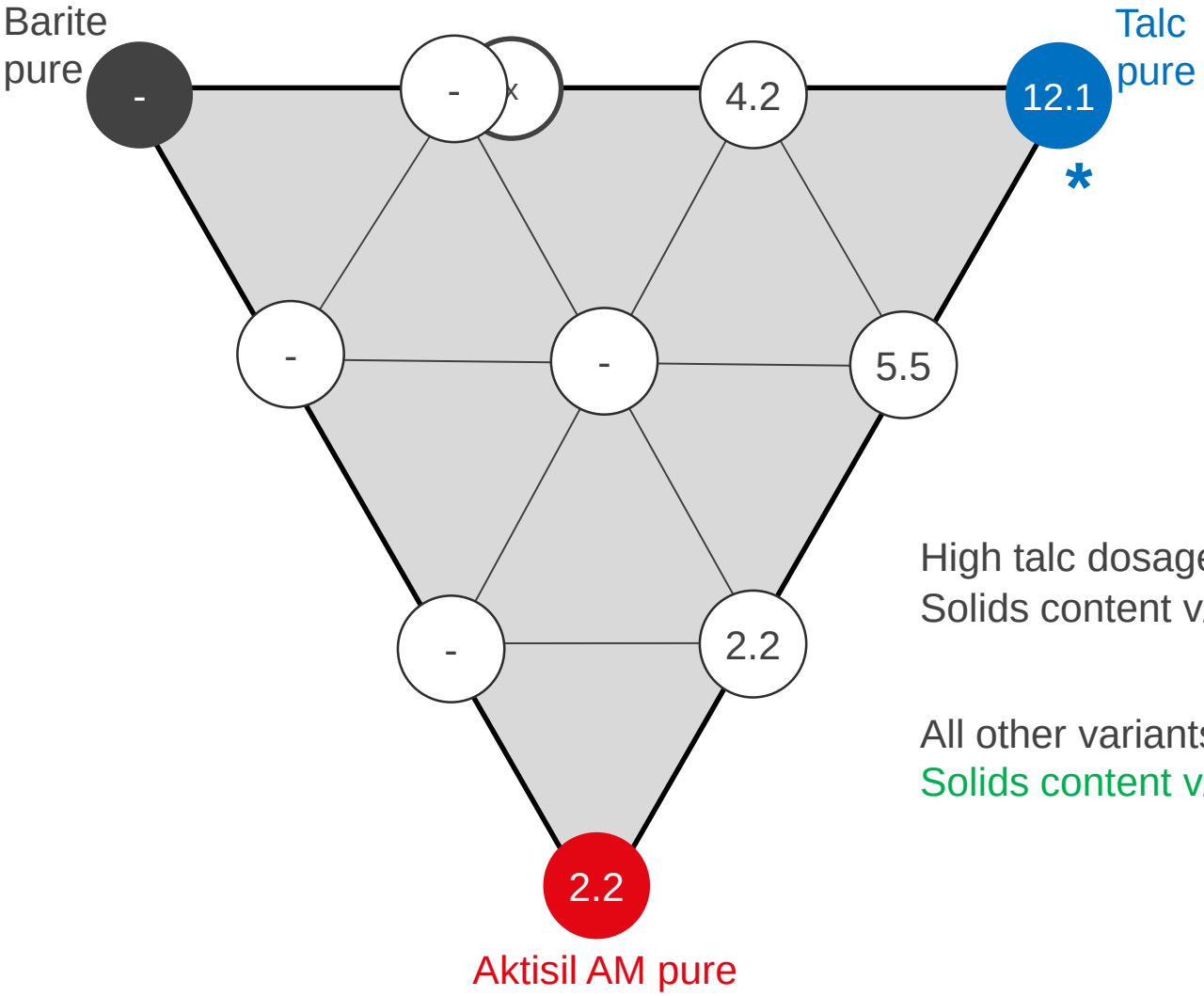
Producibility A-Component – Water demand / solids content



Additive water dosage in [%] for

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

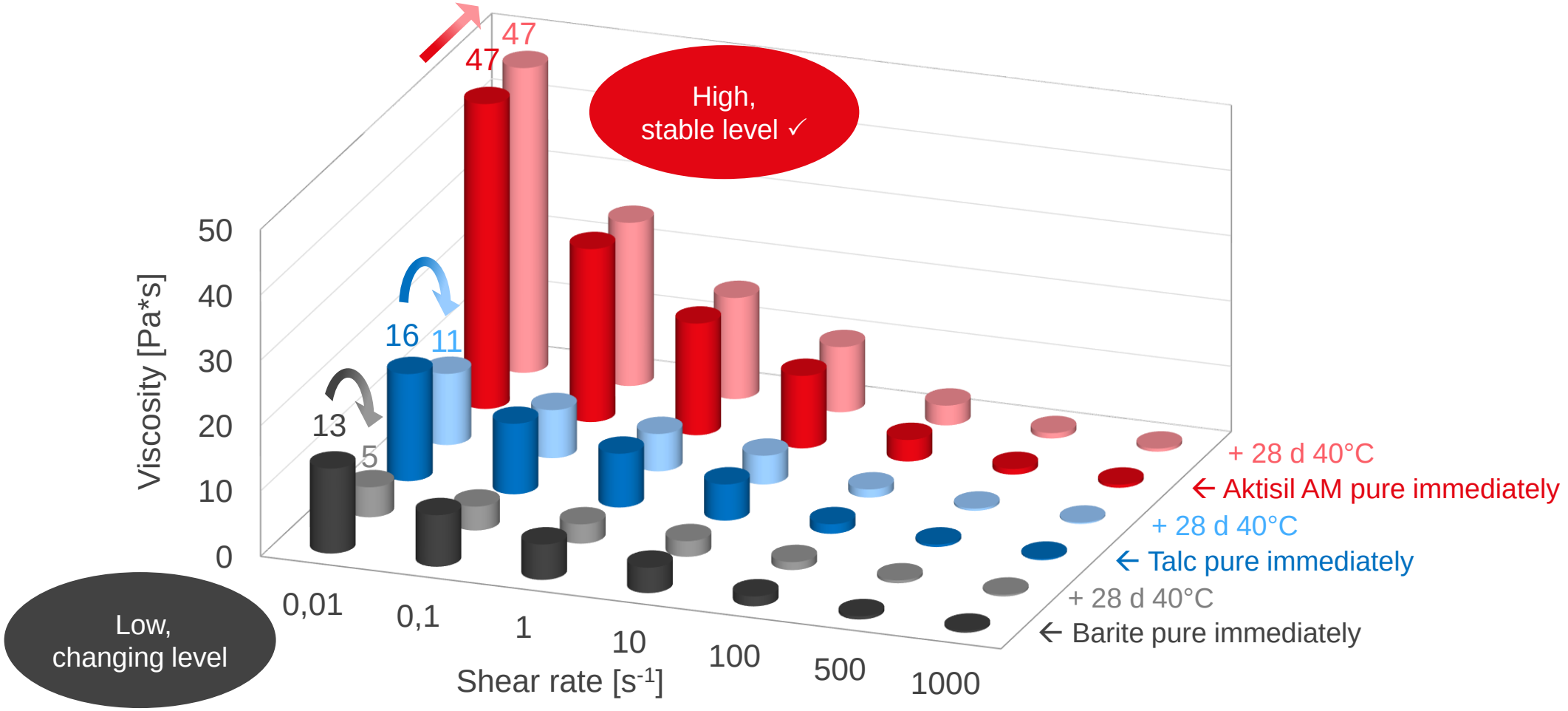
High talc dosage* → high water demand
Solids content v/v < 45 %, requirements DB missed X

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

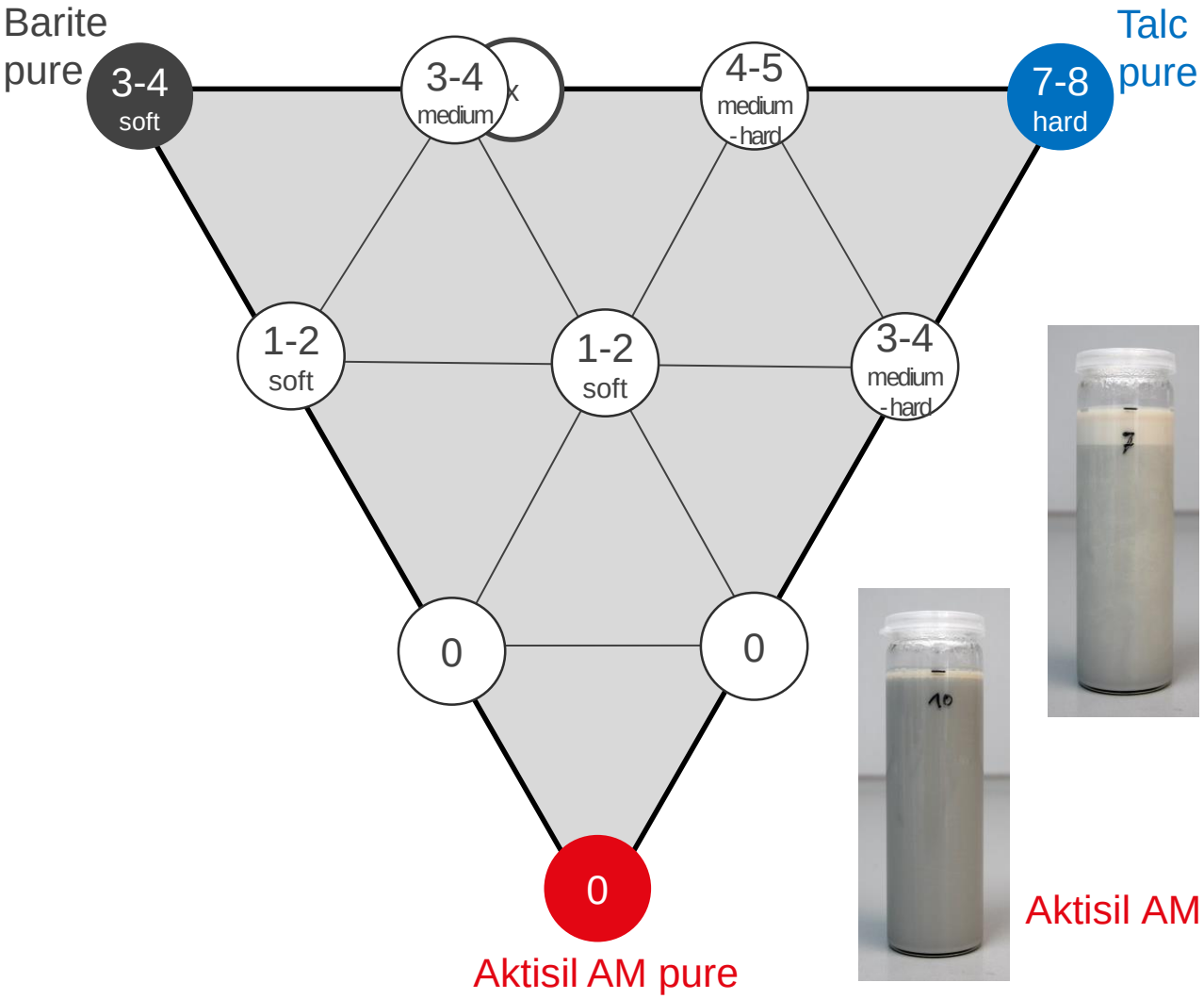
DB compliant ✓

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



Amount of sediment [mm]
Storage 28 d 40°C

Barite → strong separation effect X

Talc → strong formation of sediment X

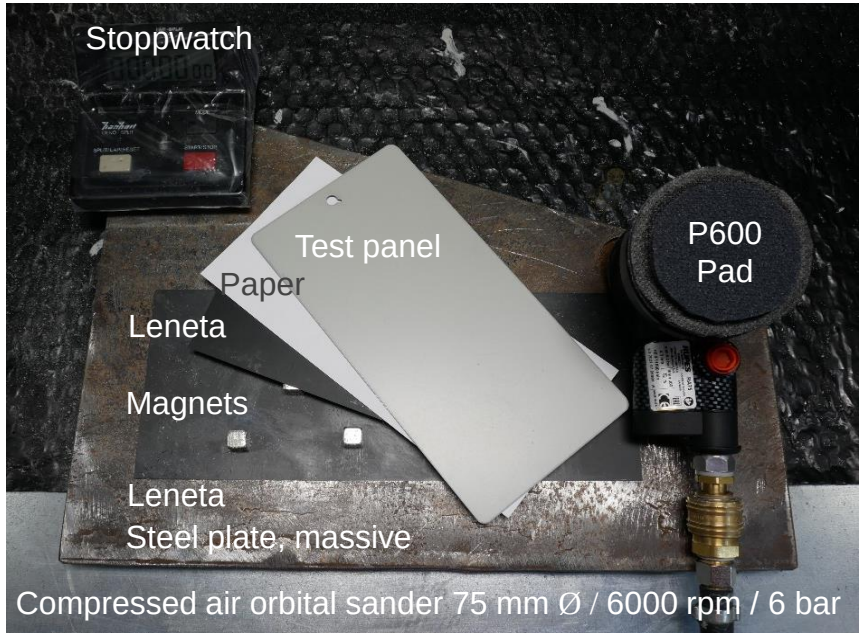
Aktisil AM → homogeneous und sediment-free
Stability for filler mixtures ✓

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“

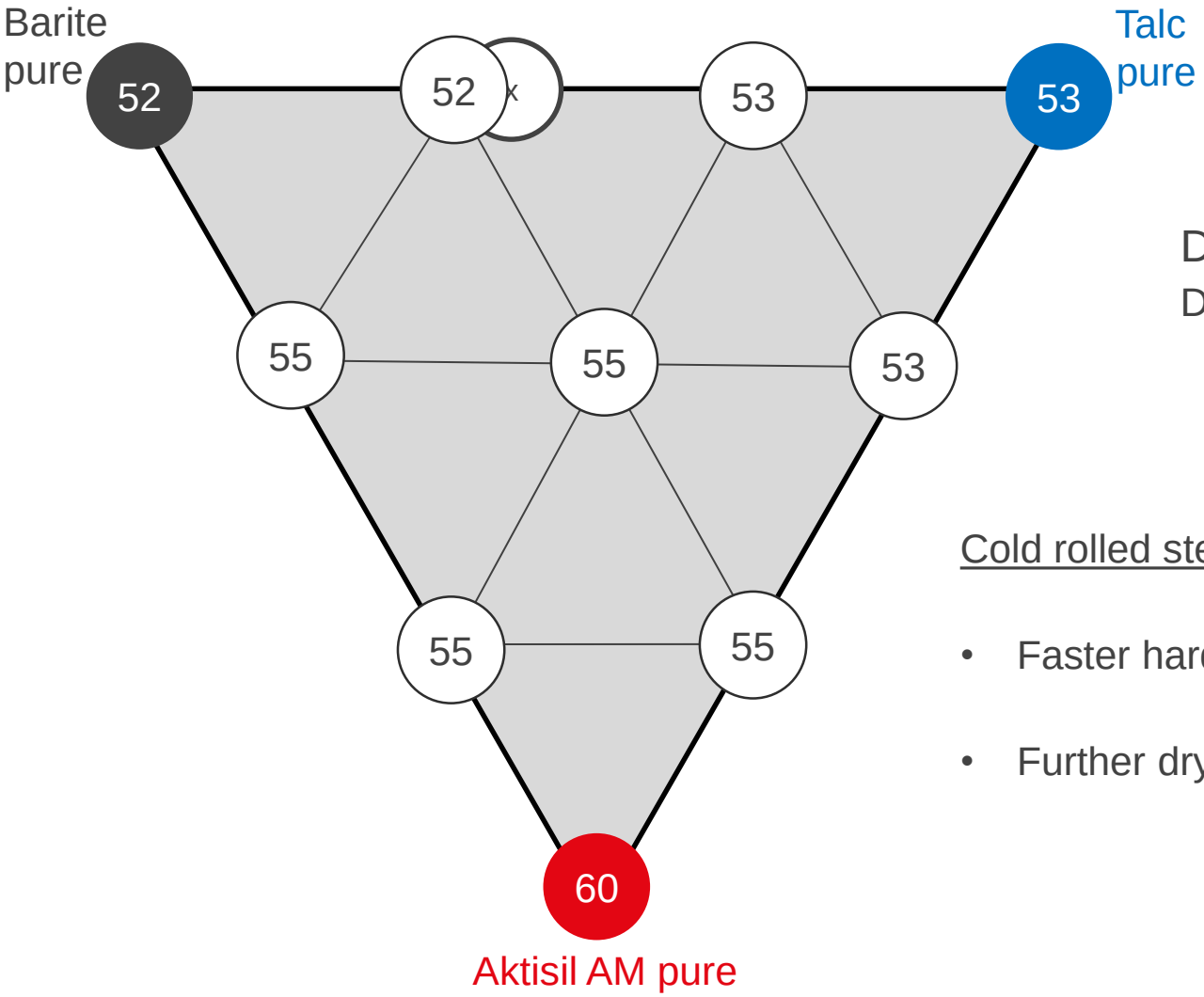


1. ≤ 16 h 23°C / 50% RH resp.
2. 15 min flash-off + 2 h 40°C convection drier

All variants:
Very good sandability

DB compliant ✓

Pendulum hardness – Koenig

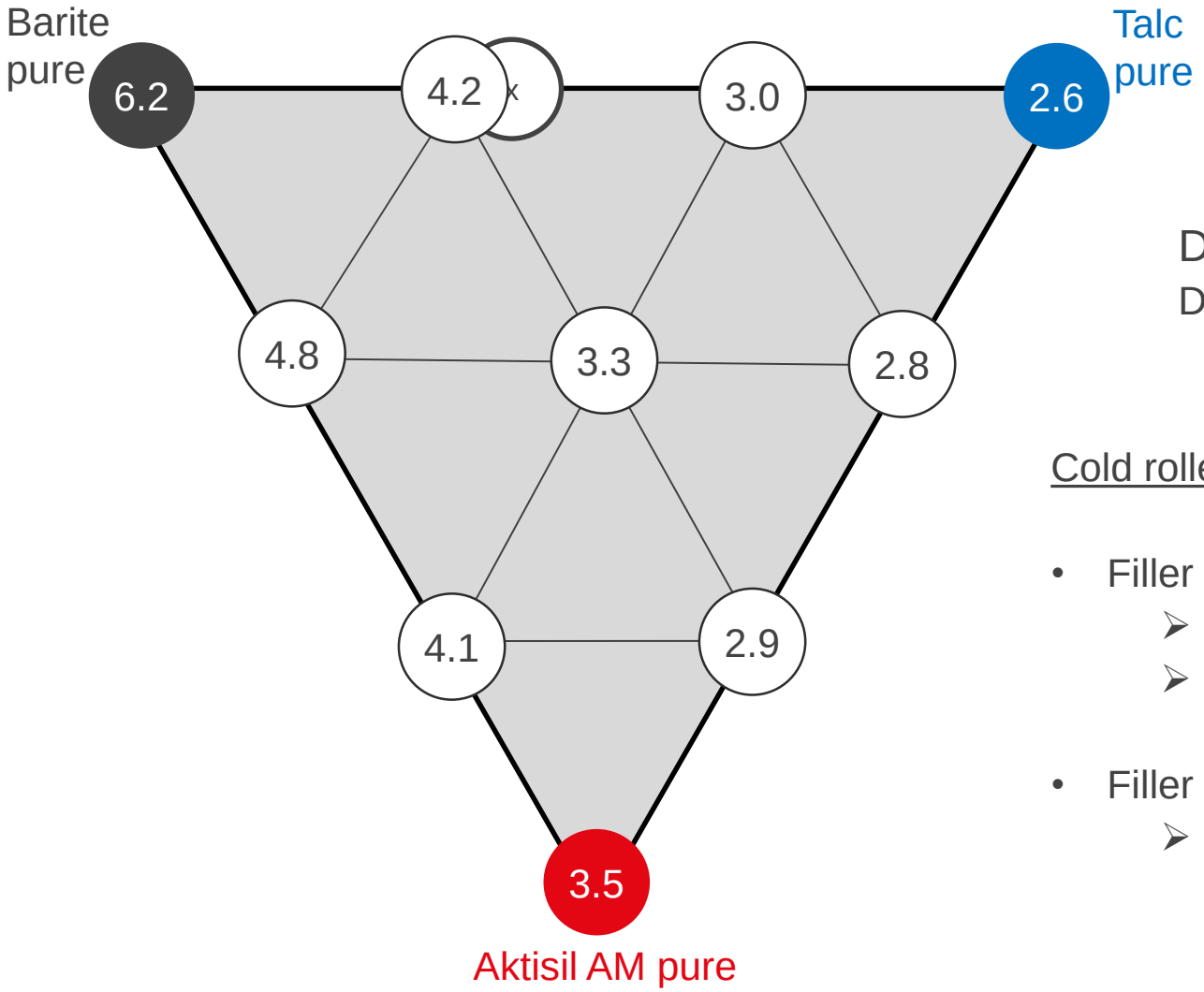


Damping time [s] from 6° to 3° deflection
Drying 7 d 23°C

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

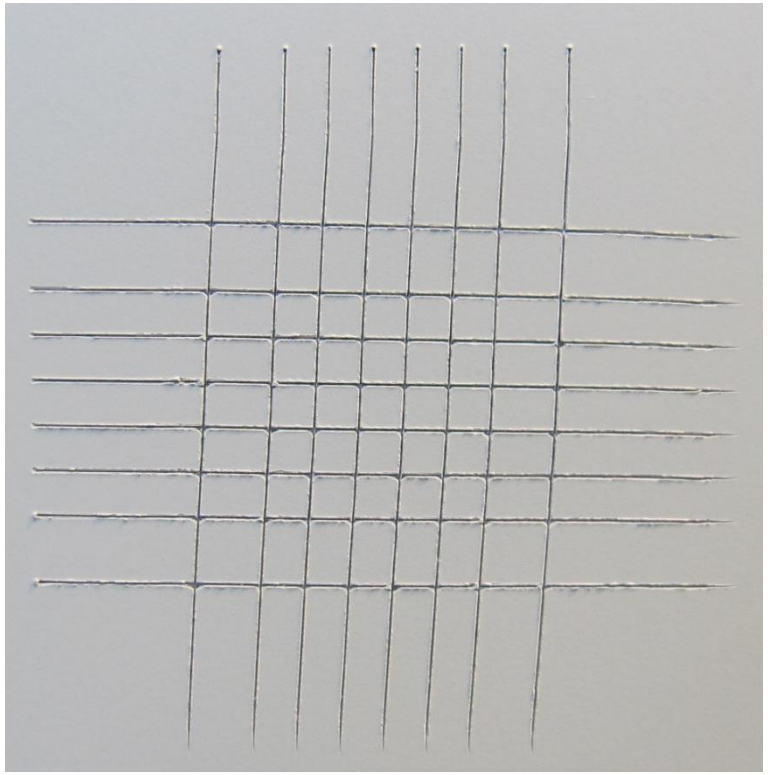


Deformation [mm] without cracking
Drying 7 d 23°C

Cold rolled steel

- Filler pure
  - Barite best ✓
  - Talc worst result X
- Filler blends
  - Preferable combination
    Barite with Neuburg Siliceous Earth ✓

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

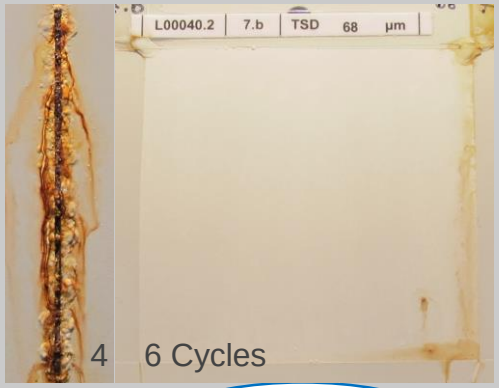
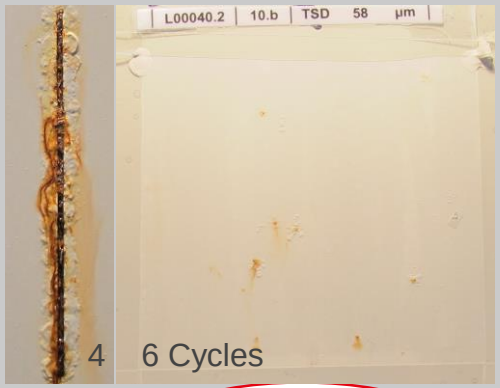
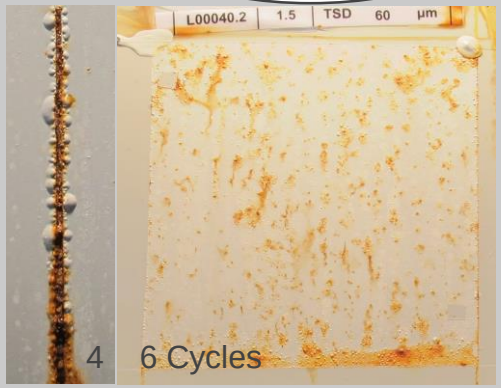
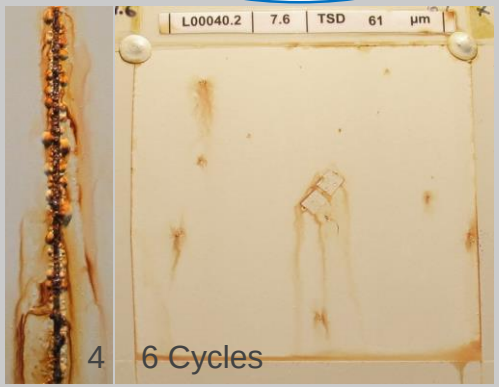
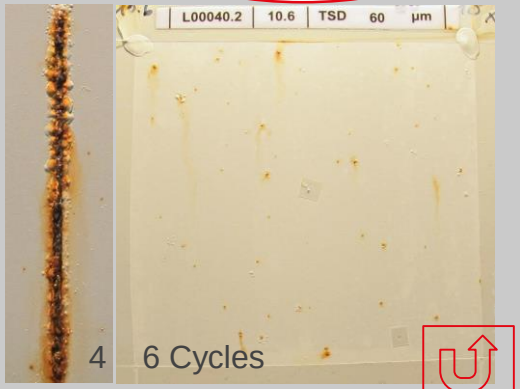
Cold rolled steel
Slightly sanded steel
Blasted aluminum
Blasted steel

All variants outstanding adhesion
GT ≤ 1, requirements DB fulfilled

DB compliant ✓

Corrosion protection – Filler effects at critical conditions

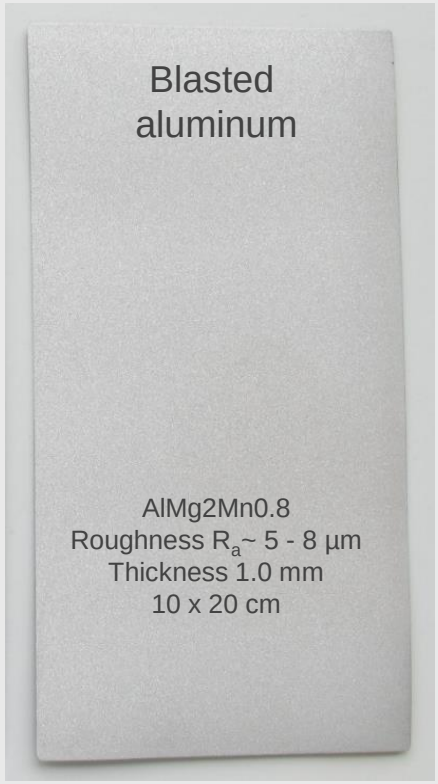
E.g. Cyclic corrosion test / low dry film thickness single-layered

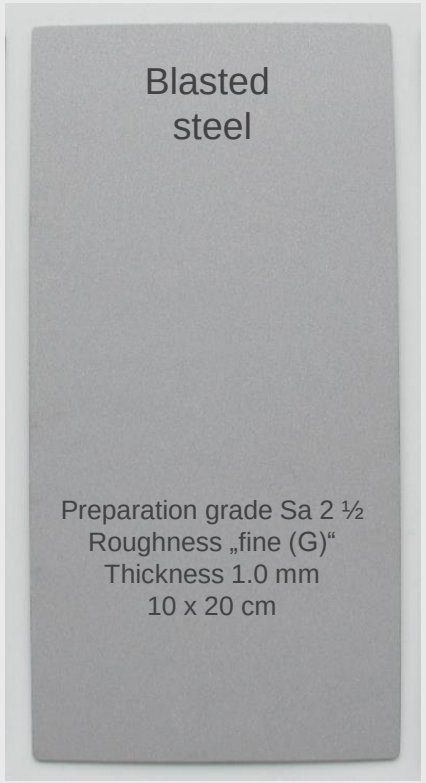
	Barite pure	Talc pure	Aktisil AM pure
Cold rolled steel	Scribe / Non-scribed area  Corrosion at scribe Delamination Strong blistering + penetrating rust	 Only a few larger, punctual defects ✓	 Only a few smaller, punctual defects ✓
Blasted steel			

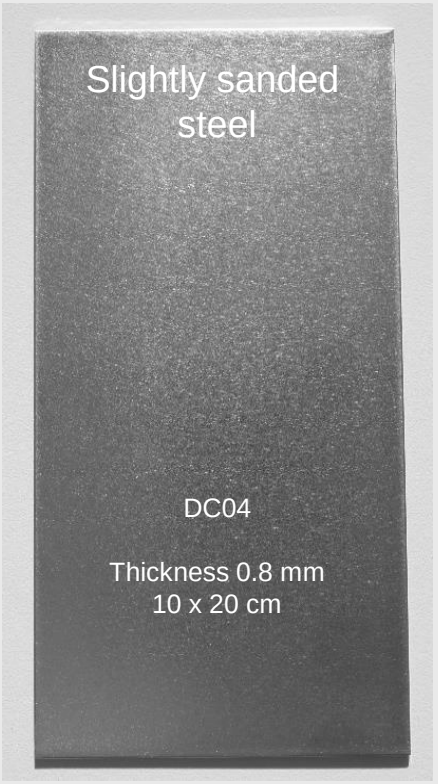
Preparative methods

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







Conditioning:

varied

→ Cupping test

14 days 23°C

→ Cyclic corrosion test
DIN EN ISO 11997-1 Cycle B

Coated panel

Scribe 1 mm
Sikkens

→ Humidity test
DIN EN ISO 6270-2 CH

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

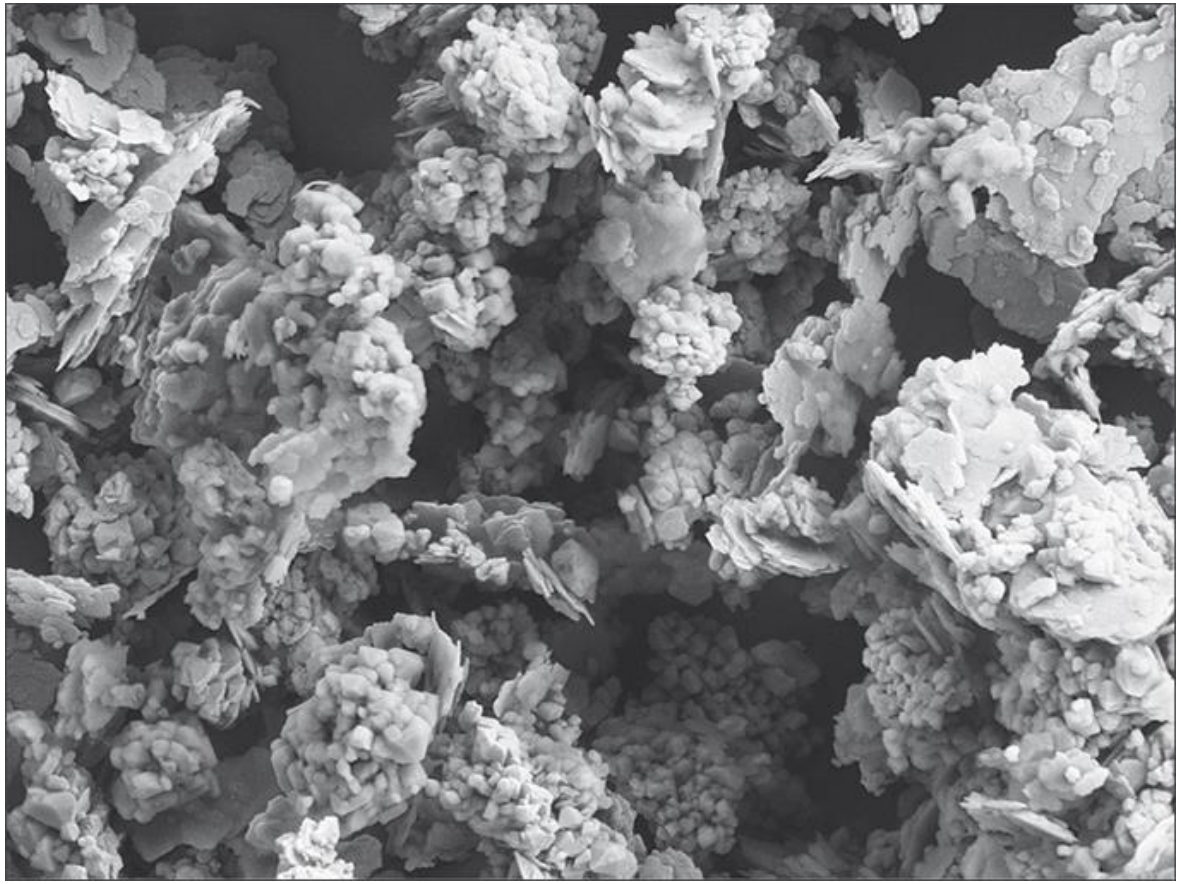
➢ Barite :
- ✓ Very good cupping results if dosed higher
- Storage stability (separation, sedimentation)
- Corrosion protection at critical conditions difficult if dosed higher

➢ 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/cm³]	[m²/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.