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## Eckart Functional Effect Pigments

Zinc flake based anti corrosion paints with reduced heavy metal content .

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Hungarocoat 2018, 28th of. Nov.

# Agenda

- History of Zinc flake pigments.
- Production process of Zinc flake pigments
- Properties of Zinc flakes in comparison to Zinc dust
- Mode of operation
- Products
- DIN ISO 12944 update
- Examples (heavy duty, dip coat, shop primer)
- Economic efficiency & Sustainability
- Outlook
- Sammery

# History of the Zinc flakes

The development goes back to the 70's .

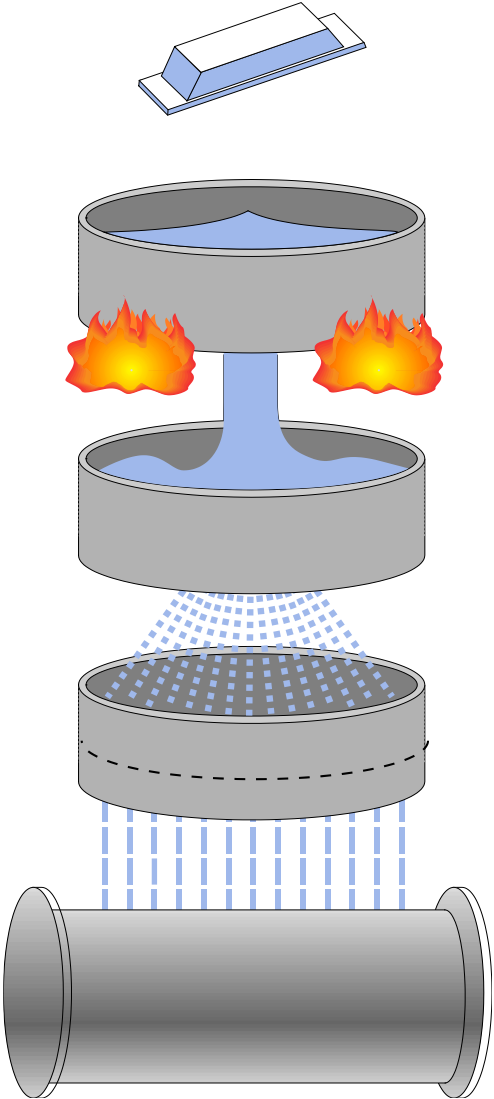
## **Project Motivation:**

- Maximum anti- corrosion properties at a very thin film thickness
- Especially for metallic components exposed to extreme mechanical forces.

## **First applications:**

- Screws, Clips and Chassis components.

# Production process of Zinc flakes



Zinc ingot  
(99.995%)

Melting process

Atomization  
process

Sieving  
process

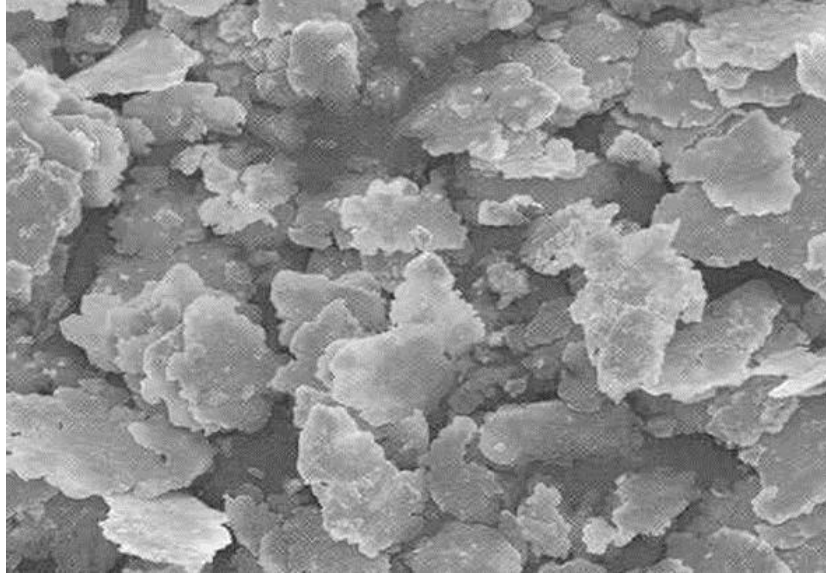
Grinding process

- ⇐ Mineral spirit
- ⇐ Lubricant  
(Stearic acid )



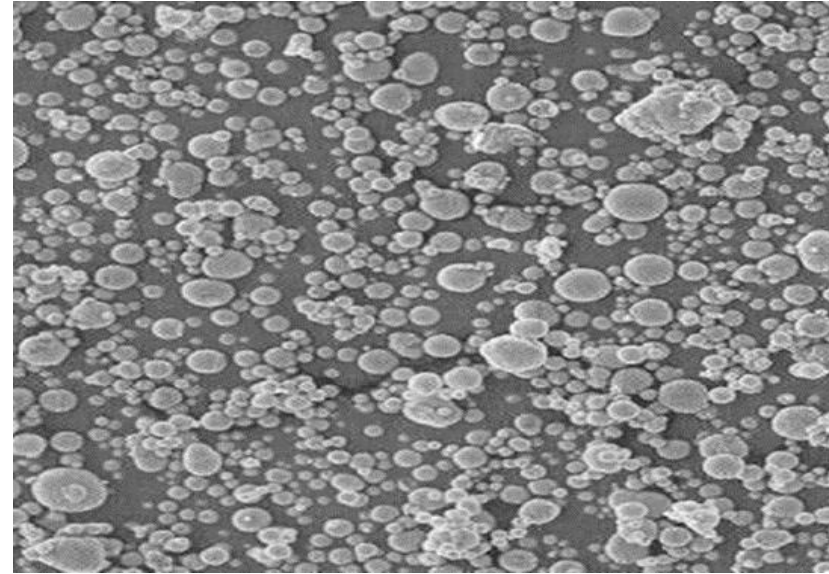
# Properties of Zinc flakes in comparison to Zinc dust

## SEM Pictures



Zinc flake x 450

Average particle size: ca. 15  $\mu\text{m}$



Zinc dust x 700

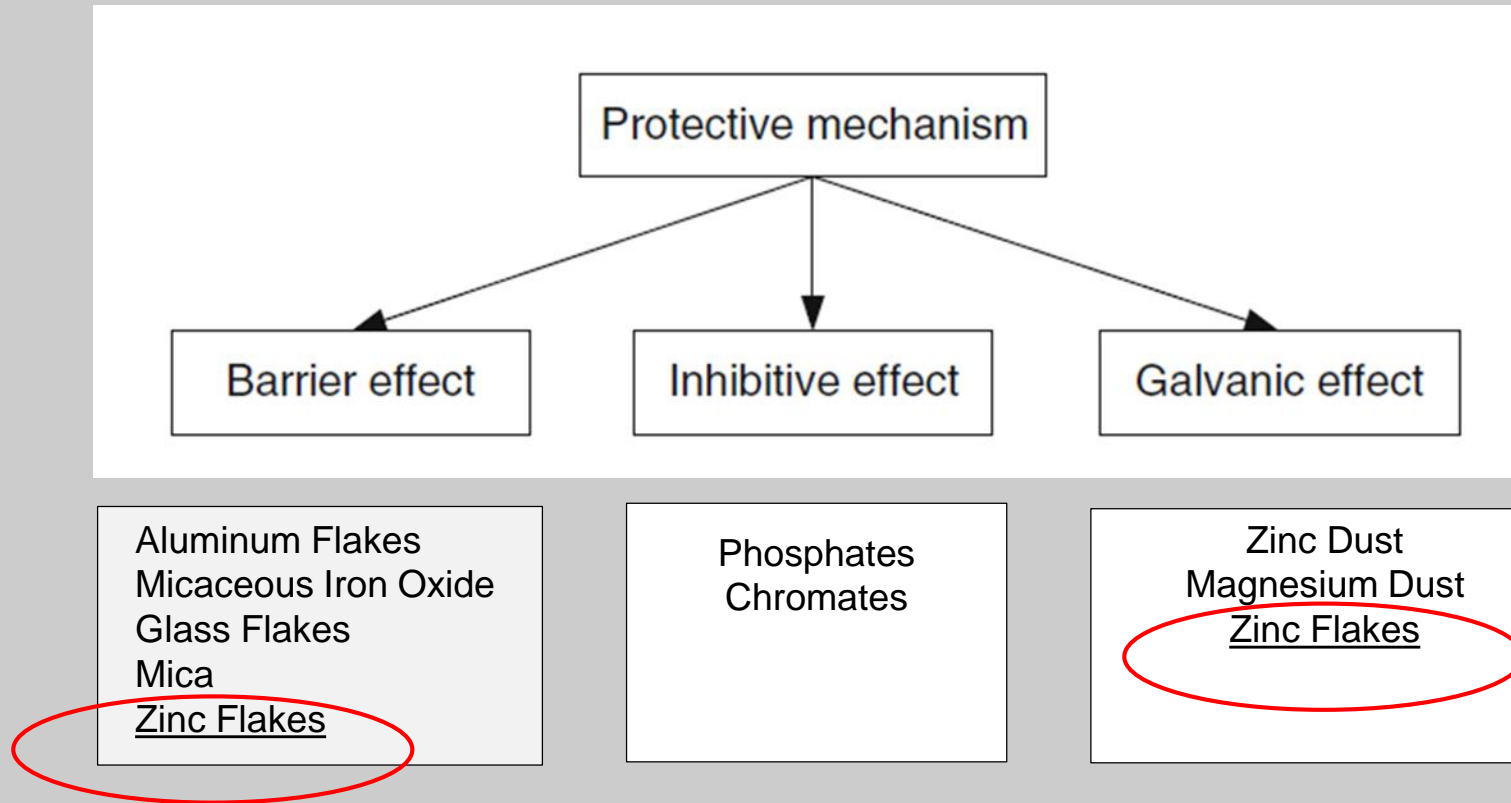
Average particle size: ca. 3  $\mu\text{m}$

# Properties of Zinc flakes in comparison to Zinc dust

	<i>Zinc flake</i>	<i>Zinc dust</i>
<i>Particle shape</i>	Flaky	Spherical
<i>Aspect ratio</i>	40 / 1 (~ 350 nm thick)	1.5 / 1
<i>Bulk density</i>	~ 1.1 kg/l	~ 2.2 kg/l
<i>Oil absorption value</i>	~ 22	~ 6.5
<i>Average particle size</i>	~ 11-20 $\mu\text{m}$	~ 3 $\mu\text{m}$
<i>Specific surface area</i>	~ 1.2 $\text{m}^2/\text{g}$	~ 0.25 - 0.5 $\text{m}^2/\text{g}$
<i>Binder uptake</i>	High	Low
<i>Zinc volume concentration</i>	Low	High

# Mode of operation

## Protective mechanisms of pigments in primers



Two  
In  
One!

*The morphology of Zinc flake pigments allows to combine the roles as Barrier as well as Galvanic protection, leading to superior anticorrosion performances.*

# Mode of operation

## Galvanic effect

### 1) Electrochemical process

Direct contact zinc- iron

Iron electrochemically more precious than zinc

- Zinc sacrifices itself to protect iron
- Zinc starts to oxidize

### 2 ) Cementation ( i.e. sealing zinc layer will be formed)

Zinc pigments oxidize

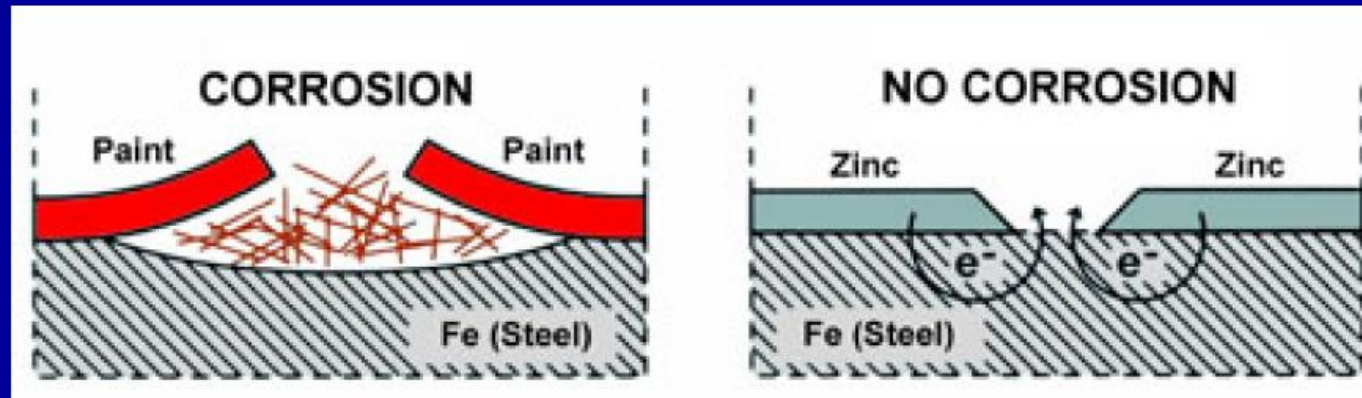
- Volume increase
- Pores are sealed ( i.e. barrier protection)

# Mode of operation

Galvanic effect

## Sacrificial Corrosion / Cathodic Protection

- Zinc oxidizes first and protects Iron

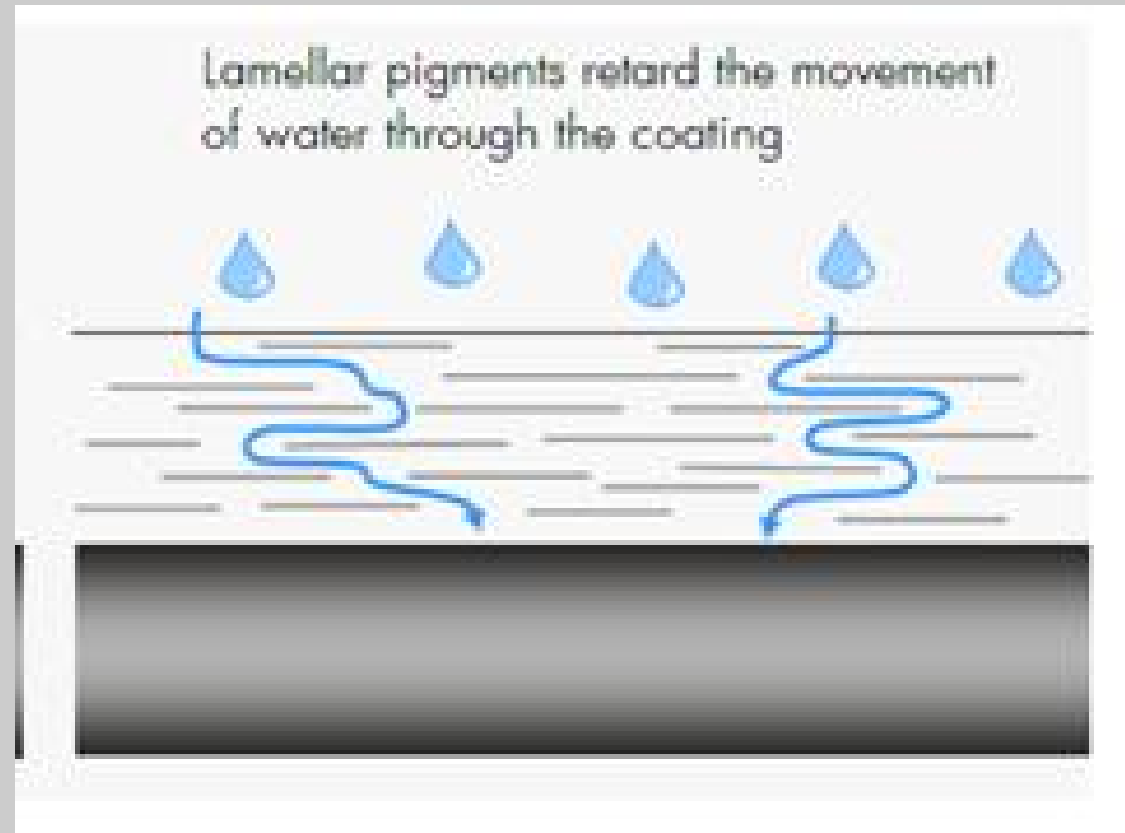


### Self-Healing:

Formation of Zinc corrosion products can seal the area and stop the corrosion process

# Mode of operation

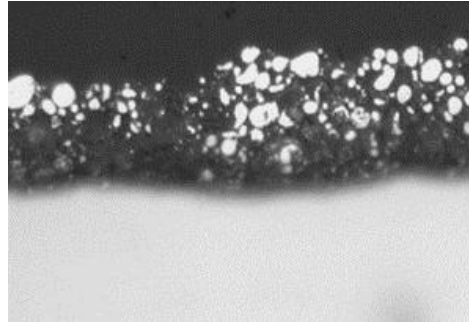
## Passive Corrosion Protection



Extended path

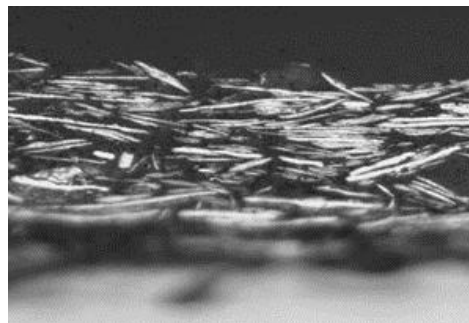
# Mode of operation

Zinc dust



- |   |            |
|---|------------|
| - Active Cathodic Corrosion Protection:                         | <b>Yes</b> |
| - Passive Corrosion Protection after Cementation:               | <b>Yes</b> |
| - Initial Passive Corrosion Protection:<br>(before Cementation) | <b>No</b>  |

Flake



- |   |            |
|---|------------|
| - Active Cathodic Corrosion Protection:                         | <b>Yes</b> |
| - Passive Corrosion Protection after Cementation:               | <b>Yes</b> |
| <b>+</b>  |            |
| - Initial Passive Corrosion Protection:<br>(before Cementation) | <b>Yes</b> |

# Mode of Operation

## Dosage: Identification of the percolation threshold

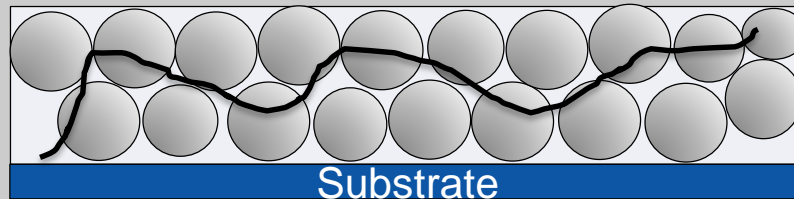
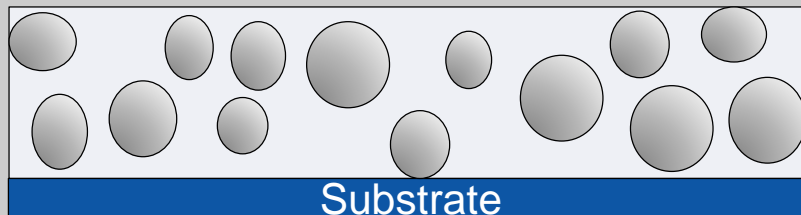
### Requirements:

- The Zinc particles have to touch each other and the substrate.

### Formation of percolation path

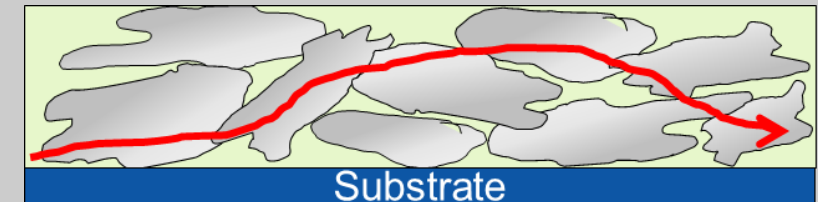
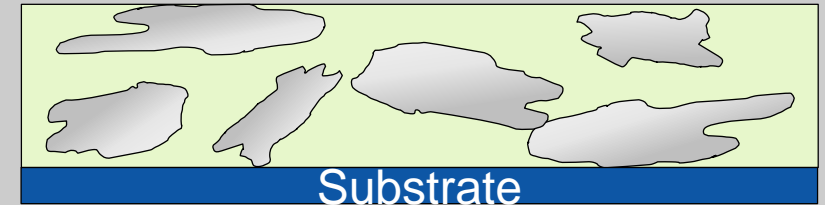
- Necessary filler content depends on size and geometry

#### Zinc dust



Percolation threshold at PVC min. 40%

#### Zinc flake



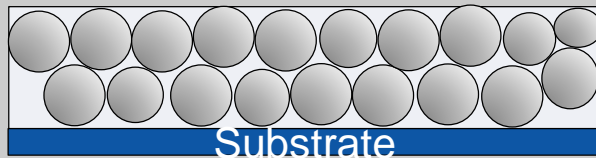
Percolation threshold at PVC min. 10 %

# Mode of Operation

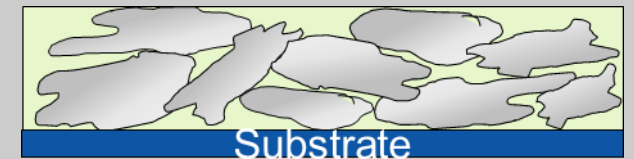
## Dosage: Identification of the percolation threshold

### Statistics:

- Probability of forming a conductive network increases with increasing surface-to volume ratio of the zinc particles at a given volume fraction of zinc particles



$$\frac{\text{Surface}_{\text{zinc dust}}}{\text{Volume}_{\text{zinc dust}}} < \frac{\text{Surface}_{\text{zinc Flake}}}{\text{Volume}_{\text{zinc Flake}}}$$



**Zinc dust have contact points**

**Zinc flakes have flat contact areas**

Optimum PVC- Range

Zinc flake: **12- 25%**

Zinc dust: **50- 60%**

# Mode of Operation

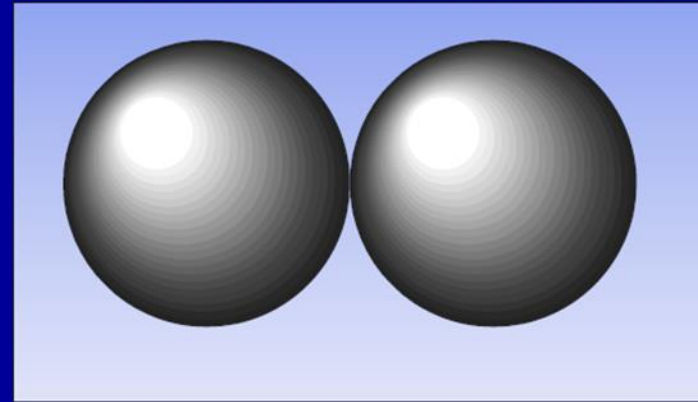
## Sammary

### Metal Powder versus Flake

- Higher contact area improves thin film performance

### Zinc Dust

- Low contact area
- Low conductivity



### Zn Flake

- Better Barrier
- Higher aspect ratio
- High contact area
- Galvanic protection maximized



## Zinc flake – Portfolio:

Type:	FK	particle size D 50
STANDART® Zinc flake TV	100 %	50 µm
STANDART® Zinc flake GTT	100 %	13 µm
STANDART® Zinc flake G	100 %	9 µm
STANDART® Zinc flake AT	100 %	20 µm
STAPA® TE Zinc Al	90 %	17 µm
STAPA® TE Zinc GTT	90 %	13 µm
STAPA® Zinc 4	90 %	14 µm
STAPA® Zinc 8	90 %	11 µm
STAPA® 4 ZnAl7	91,5 %	14 µm
STAPA® 4 ZnSn 30	91,5 %	14 µm
STAPA® 4 ZnSn 15	91,5 %	14 µm

# DIN ISO 12944 update

First test results of a Zinc flake 2 C Epoxy primer on low- alloy carbon steel (sand blasted SA 2 ½)

Dry film  
thickness  
ca. 60- 70 µm



Before SST ac. ISO 9227



After 1700 h SST ac. ISO 9227

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After 1700 h SST ac. ISO 9227

# DIN ISO 12944 update

## Formulation

V1001 (Standard Versuch)			
	PVK Gesamt		39,0
	PVK Zn		10,0
	PVK Füllstoff		29,0
Grind formulation (Component A1)			
1	<b>Epilox L25-80 (Dichte 1,12 / FK 80%)</b>	88	8,8
2	Disperbyk 102	5	0,5
3	Heucophos ZCP	32	3,2
4	Lösemittel SA	43	4,3
5	Blanc fixe micro	118	11,8
6	Micro Talcum AT extra	146	14,6
7	Sylosiv A3	2	0,2
8	Garamite 1958	3	0,3
9	Lösemittel SA	45	4,5
	<i>add while stirring</i>	482	48,2
	<i>dissolve 40 min at 3,0 m/sec (disc)</i>		
	3000U/min		
Zinc flake pre mix (Component A2)			
1	<b>Epilox L25-80 (Dichte 1,12 / FK 80%)</b>	43	4,3
2	<b>Epilox AF 18-30 (Dichte 1,16 / FK 100%)</b>	24	2,4
3	Disperbyk 102	5	0,5
4	MIBK	36	3,6
5	Stapa Zinc 4 (FK 90%)	245	24,5
	<i>add while stirring</i>		
	<i>dissolve 20 min at 2,0 m/sec (disc)</i>		
6	MIBK	41	4,1
7	BYK 410	5	0,5
8	n-Butanol	37	3,7
	<i>add one after another Pos. 6 to 8 under stirring and mix homogeneously</i>	436	43,6
Component B (Hardener Component)			
1	<b>Epilox H 14-50 (FK = 100%)</b>	65	6,5
2	<b>Novares LA300</b>	17	1,7
	<b>GESAMT</b>	<b>1000</b>	<b>100,0</b>
Lack(ier)parameter			
	<b>Auslaufzeit DIN 4</b>		28 s
	<b>Lackdichte</b>	<b>1,566</b>	<b>g/cm<sup>3</sup></b>
	<b>D3 Spindel (250 U/min)</b>	<b>nM</b>	<b>cP</b>
	<b>0</b>	<b>56%</b>	222
	<b>80 min</b>	<b>58%</b>	227
	<b>140 min</b>	<b>60%</b>	238
<b>Gänge</b>	<b>Durchfluss</b>	<b>naß</b>	<b>trock.</b>
3	2.2.0	250	70

## Example Shop Primer:

- Shop Primer are thin & fast drying coatings, mostly for steel
- In the end of the steel production the parts will be sand blasted. That process is necessary to remove oxide layers (layer of scale). After that the parts will be coated by a shop primer to prevent the steel of corrosion.
- In this condition the steel can be stored until the further processing.



# Example Shop Primer:

## Technical requirements

- Thickness of the dry film app. 20  $\mu\text{m}$
- Protect against corrosion for min. 6 month
- Drying time 3- 5 min.
- No toxic fumes during welding processes
- No negative impact on the welding quality
- Good intercoat adhesion to the top coat.

# Example Shop Primer:

## Testing formulation:

### 2 C EP Zinc flake shop primer

#### Component A:

Epikote 1001-X-75	9,6
Heucophos ZCP plus	3,7
- pre disperse –	
Araldite GY 783	7,3
- add and stir homogeneously –	
Solventnaphtha	5,0
MIBK	9,5
n-Butanol	4,5
Disperbyk 142	1,1
Byk 410	0,2
Blanc fixe micro	13,7
Micro Talkum AT extra	16,9
Stapa zinc 4	28,5

- add one after the other
- under stirring –

**Component B:** Aradur 450 BD ( hardener )

Mix ratio : 100p.b.W comp.A : 6,0 p.b.W.comp.B

This paint is ready to use

### 2 C EP Zin shop primer

#### Component A:

Toluene	7,0
n-Butanol	3,0
Epicote 1001X75	7,0
Anti-terra U	0,5
BYK-052	0,3
Byk-323	0,05
Zinc dust	76,0
Xylene	4,15
Byk-410	2,0

#### Component B:

Toluene	17,5
n-Butanol	60,3
Anti-terra 203	0,5
Aradur 115 ( hardener )	21,7

Mix ratio:  
100 p.b.W.Comp.A  
9,1 p.b.W Comp.B

### 1K Silikat shop primer

Commercially available system

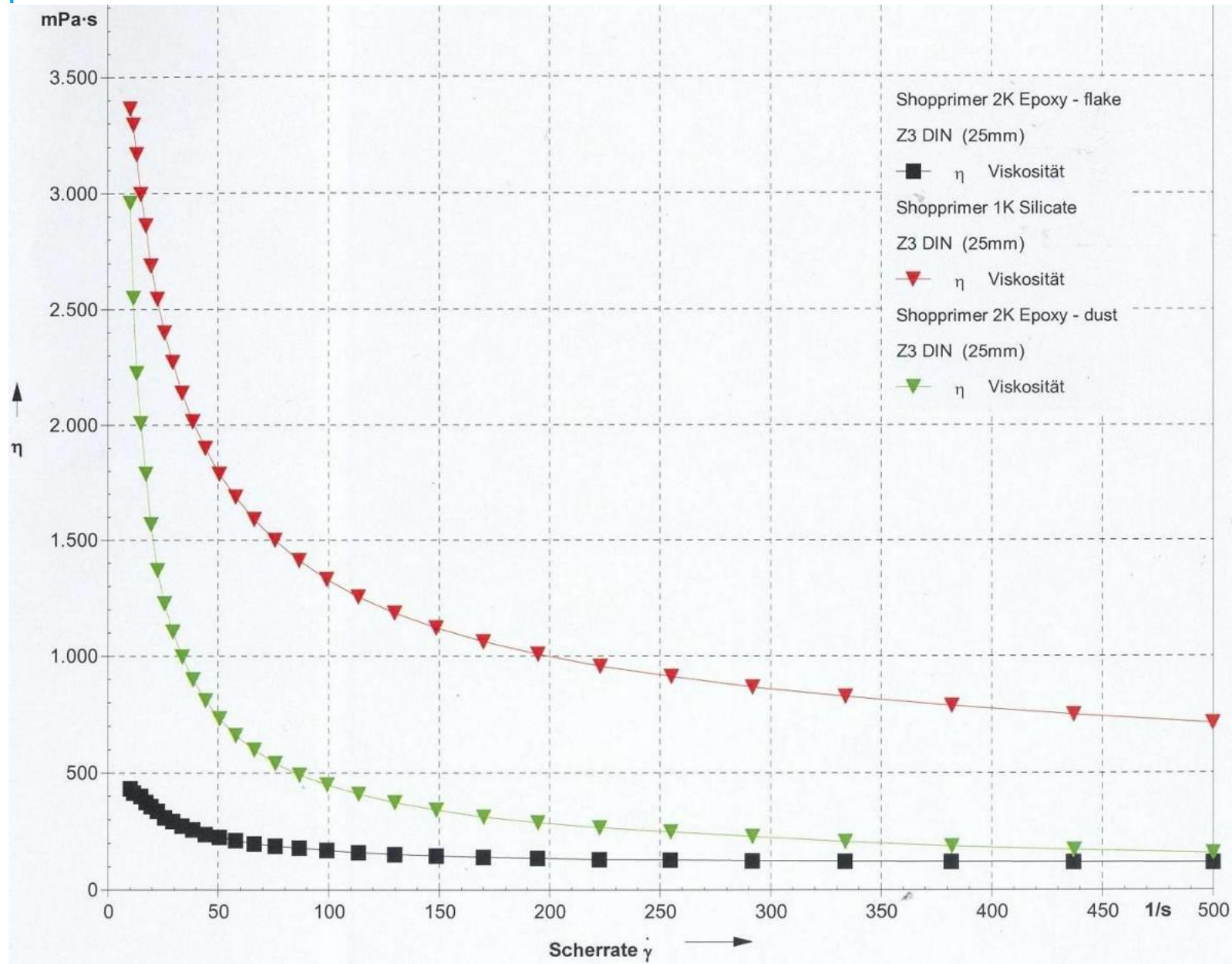
## Example Shop Primer:

Technical data of the formulations:

	<b>2C EP Zinc flake</b>	<b>2C EP Zinc dust</b>	<b>1C Silikate Zinc dust</b>
Density (ready to use):	1,650 g/cm <sup>3</sup>	2,420 g/cm <sup>3</sup>	2,417 g/cm <sup>3</sup>
Solid (ready to use):	76,60%	77,60%	86,10%
VOC (ready to use):	390 g/l	540 g/l	416 g/l
Spreading rate (20µm df):	17,3 m <sup>2</sup> /kg	8,2 m <sup>2</sup> /kg	13,9 m <sup>2</sup> /kg

# Example Shop Primer:

Rheological profile:



# Example Shop Primer:

Test results after 10 days SST (DIN EN 23270)

Comparison of the zinc oxide formation

**Zinc dust**

**Zinc flake**



# Example Shop Primer:

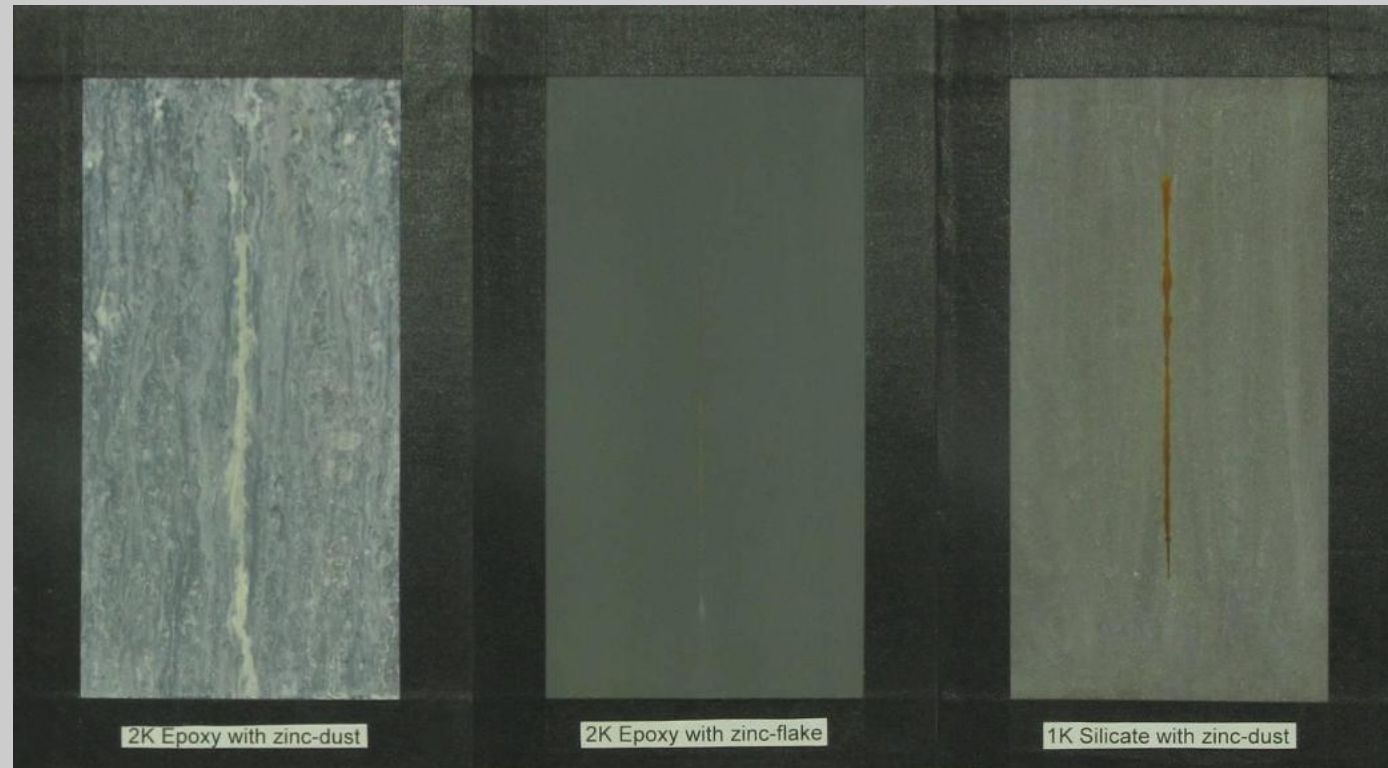
Test results after 10 days SST (DIN EN 23270)

1 mm Steel panel; roughness: ca. 30  $\mu\text{m}$   
( Pretreatment: sand blasted)

**2C EP Zinc dust**

**2C EP Zinc flake**

**1C Silikat Zinc dust**



# Example Shop Primer:

Test result after 10 days SST (DIN EN 23270)

5 mm Steel panel; roughness: ca. 80  $\mu\text{m}$   
( Pretreatment: sand blasted)

2C EP Zinc dust



2K Epoxy with zinc-dust

2C EP Zinc flake



2K Epoxy with zinc-flake

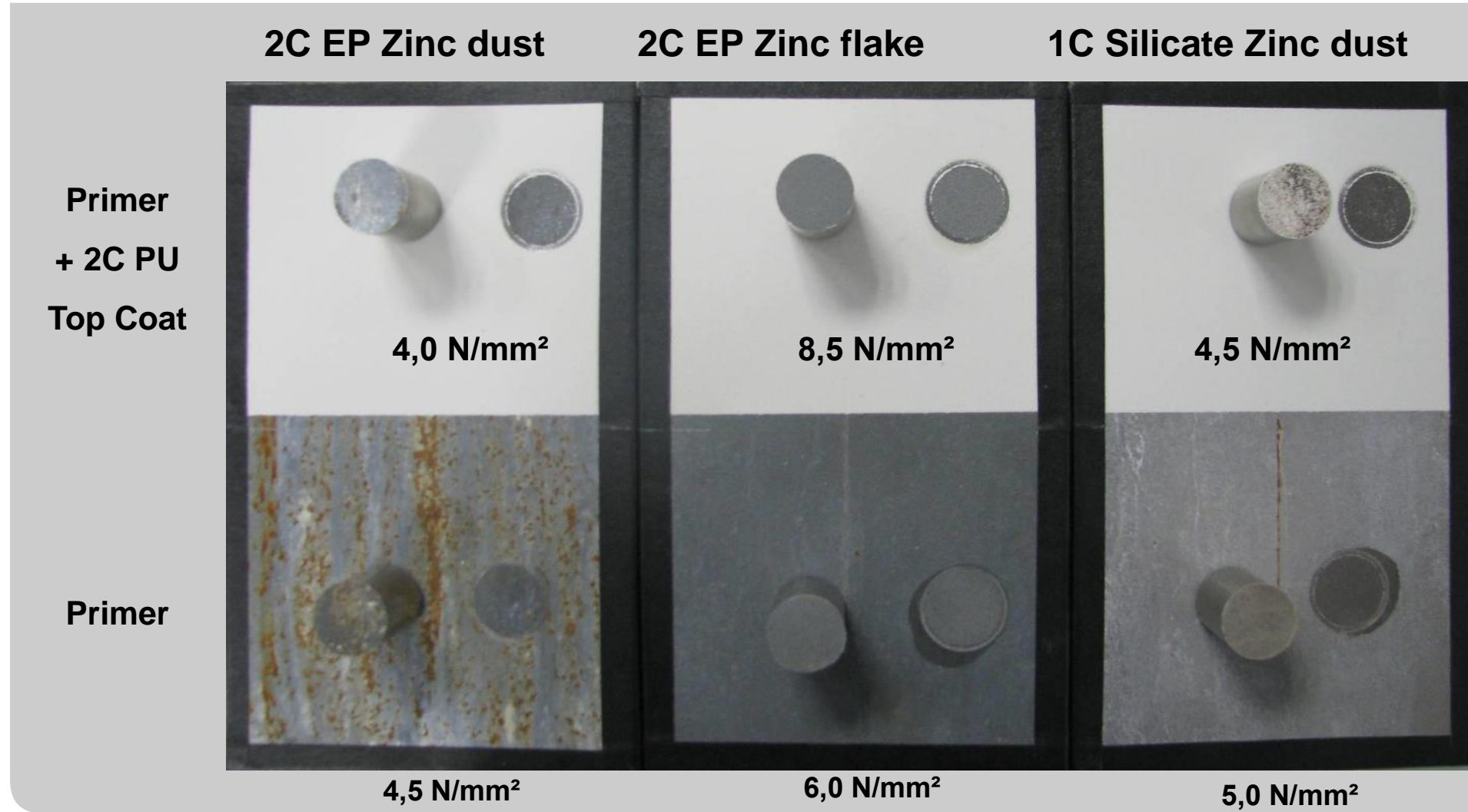
1C Silicate Zinc dust



1K Silicate with zinc-dust

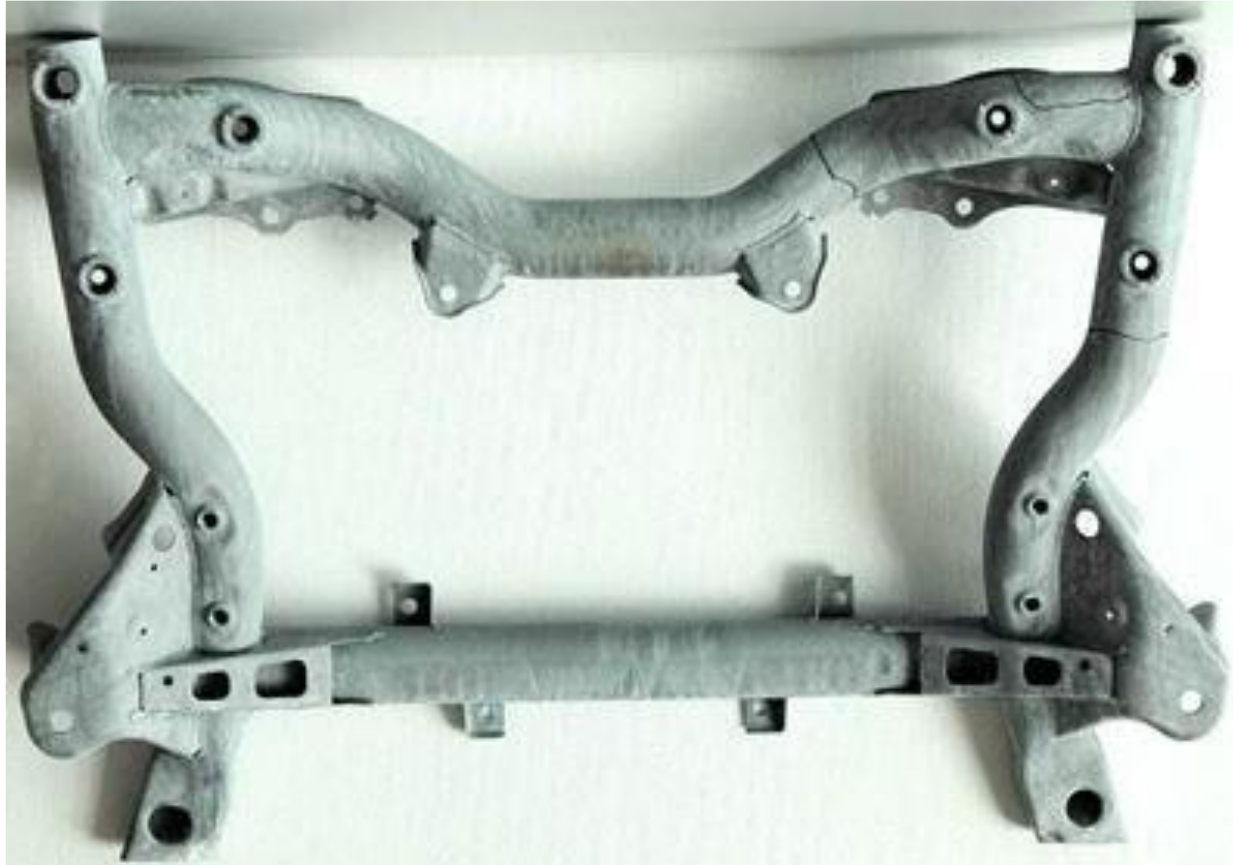
# Example Shop Primer:

Adhesion and intercoat adhesion after 300h Salt spray test



# Example: Dip coat

Axle Carrier Mercedes E-Class-After 2000 hours of salt spraying test



Zink flake primer:  
Top coat:

12- 14  $\mu\text{m}$   
8- 10  $\mu\text{m}$

# Example: Heavy Duty

Railway bridge in Immenstadt Germany after 20 years exposure



## Coating System

### ➤ Primer :

2 K Epoxy – Zinc flake  
ca. 60-100  $\mu\text{m}$  dft.

### ➤ Intermediate layer:

2 K Epoxy- iron- mica:  
160- 200  $\mu\text{m}$  dft.

### ➤ Top Coat:

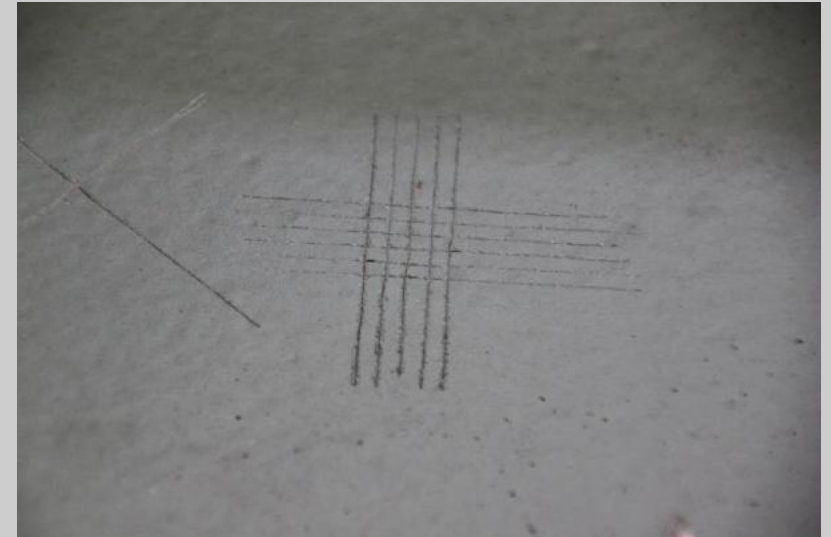
2 K PU ca. 50-80  $\mu\text{m}$  dft.

# Example: Heavy Duty

Railway bridge in Immenstadt Germany after 20 years exposure



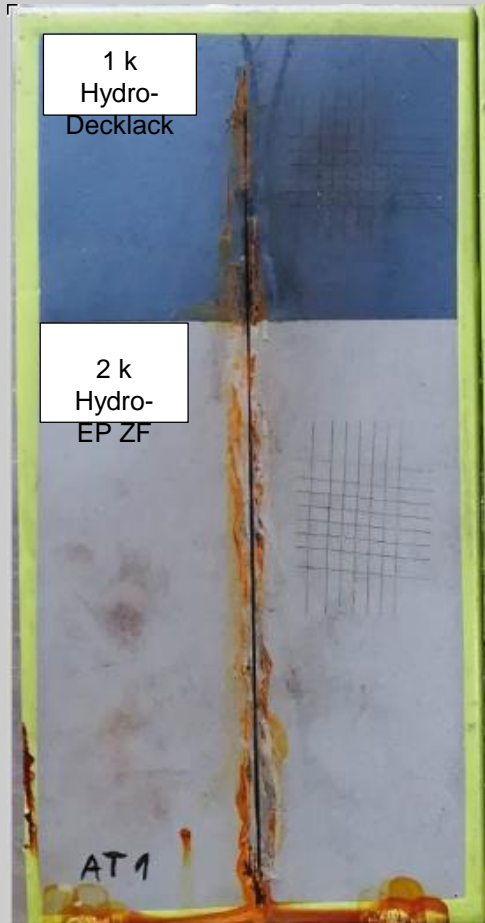
Dirt can be easily removed mechanically



Cross cut after 20 years

# Outlook

## Development of a zinc flake 2 C epoxy waterborne system



PVK: 16 %



The next test series are running with an iron mica intermediate layer.

Of course the panels of the current test series are prepared with a 2mm cut.

# Cost effectiveness

The zinc price is subject to strong price fluctuations



■ Zink London Rolling Volumen

LME- Zinc in USD per ton

# Cost effectiveness

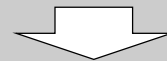
## Cost saving potential

### Assumption:

- If the zinc dust primer will be replaced by a zinc flake primer, in a DIN ISO 12944 C 5 very long compliant coating system, than the savings potential, at todays zinc prices, would be around **15- 20 %**

(formulation and application- adjusted)

- Note: This calculation does not take extended renovtion cyles In in to account.



Further coast saving potential !

# Sustainability

## Economic use of resources

### Zinc dust demand

- The estimated zinc dust demand in the coating industry was between ca. 200.000- 250.000 tons in 2014.

### Theoretical adoption:

- If the zinc dust will be replaced by zinc flake in all relevant coating applications, the theoretical savings potential for the metal zinc would be between **120.000 to 150.000 tons per year**.

**Theoretical savings potential up to 60 %**

**The proof of concept is well known since many years, especially in the dip spin market.**

➤ **Technical Advantages**

- better intercoat adhesion
- more flexible coating films
- less heavy coating container (lower density of a zinc flake based primer)
- very low white rust formation
- very good anti- corrosion properties (two in one concept)

➤ **Economic & Sustainability Advantages :**

- less VOC content (calculated on the coated area)
- less heavy metal content !
- At high metal prices more price flexible

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Thank you for your  
Attention!

