Comparative Report on the Performance of Polyester Powder Coatings

Excellent Corrosion Protection from a Single Coat

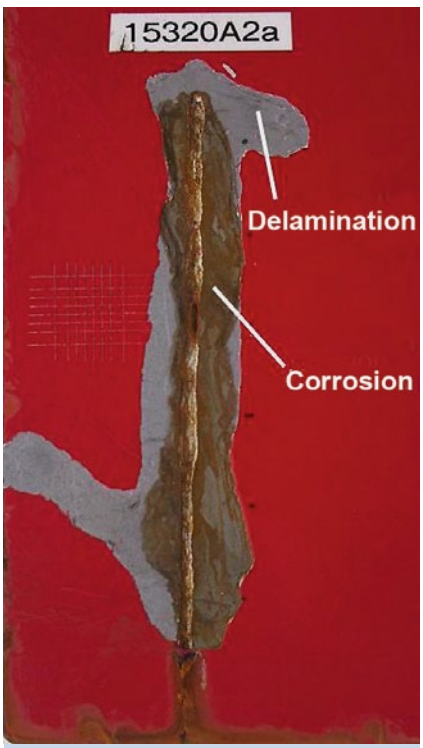
In a recent study, the influence of the curing conditions on the corrosion protection properties of coatings on a number of different substrates was investigated. In addition, powder coatings which provide corrosion protection of at least category C4 medium with a single coat were identified. The objective was to find alternatives to the widely used primid systems that provide significantly improved protection against corrosion in the low-temperature range.

Acid-functional polyester powder coatings, which are cross-linked with β-hydroxyalkylamide or aromatic glycidyl ester (Araldite PT910 or PT912), are normally used in Europe for external applications. The specific type of system depends on the application and the properties needed.

The construction and agricultural machinery industry has specific technological requirements for its powder coatings, as a result of the complex welded structures and the combination of solid steel components, which are sometimes centimetres thick, and thin sheet steel:

- high resistance to overbaking, especially on parts with thin walls, because of the very high curing temperatures of up to 220°C
- a wide range of curing temperatures
- no blooming
- good edge and weld coverage (corrosion protection)
- no running when the coating is applied thickly
- good degassing properties in coatings of normal thicknesses up to 200 µm, in particular when applied to electrocoated or blast-cleaned steel
- good interim adhesion when a second coat is applied to an electrocoating or epoxy powder primer
- high gloss finish with good levelling properties
- high levels of UV resistance (the benchmark is a two-component polyurethane top coat)
- good mechanical properties
- highly resistant to chemicals
- excellent corrosion protection from a single coat

As coating large, solid components is particularly time-consuming and costly because of the long heating and cooling processes, powder coatings with higher reactivity are often needed. These coating systems allow for a lower curing temperature or a shorter process time, which leads to an increase in productivity.



Evaluation of the corrosion and delamination from the scribe line after corrosion protection tests.

However, the closer the production process comes to the minimum curing conditions of the powder coating in question, the more likely it is to reach the limits of the coating properties. This has a disproportionately negative effect on the corrosion protection and mechanical properties.

The objective of the study was to investigate the influence of curing conditions on the corrosion protection properties of coatings on different substrates and to identify powder coating systems that provide corrosion protection of at least category C4 medium with a single coat.

The corrosion tests were carried out in accordance with DIN EN ISO 12944, which is now increasingly applied to industrial goods made from steel with a thickness of less than 3 mm. This means that the standard is not relevant for the whole of the components in question. In general terms, only the division of the atmospheric conditions into the six corrosivity categories (C1-CX) and the laboratory tests for each category can be used.

The corrosivity categories are broken down into three time ranges or protection periods:

Short: 2 to 5 years
Medium: 5 to 15 years
Long: more than 15 years

The protection period does not provide a guarantee and should only be regarded as a guideline. As on-

System	Article	Curing	Weather resistance	Reaction mechanisms
Primid-G	PF1004	10 min/180°C	+++ (GSB standard)	Polycondensation (separation of water) results in pinholes on thick coatings
LT-Primid-G	PR1004	10 min/160°C	+++	
Primid-M	PP1001	10 min/180°C	+++	
LT-Primid-M	PP3501	10 min/160°C	+++	
PT910-G	PT3005	10 min/180°C	+++	Polyaddition (no decomposition products)
LT-PT910-G	PT3504	10 min/160°C	+++	
LT-PT910-M	PT3501	10 min/160°C	+++	
PT910-SD-G	PS2005	10 min/180°C	+++++	
LT-PT910-SD-G	PS2505	10 min/180°C	+++++	

(G: glossy; M: matt (dry-blend of 2 components); LT: low-temperature/energy-efficient; SD: super durable; (highly weather resistant); Primid: β-hydroxyalkylamide; PT910: aromatic glycidylester)

Table 1: Overview of the polyester-based powder coatings in the test

System	Article	CT	SST	Pre-treatment	Category
Primid-G	PF1004	240h	480h	Iron phosphating	C4 medium
PT910-G	PT3005	480h	720h	Iron phosphating	C4 long
LT-PT910-G	PT3504	240h	480h	Iron phosphating	C4 medium
LT-PT910-M	PT3501	240h	480h	Iron phosphating	C4 medium
PT-910-SD-G	PS2005	240h	480h	Iron phosphating	C4 medium
Primid-G	PF1004	720h	1440h	Zinc phosphating	C5 long
LT-Primid-G	PR1004	480h	720h	Zinc phosphating	C4 long
Primid-M	PP1001	720h	1440h	Zinc phosphating	C5 long
PT910-G	PT3005	720h	1440h	Zinc phosphating	C5 long
LT-PT910-G	PT3504	720h	1440h	Zinc phosphating	C5 long
LT-PT910-M	PT3501	720h	1440h	Zinc phosphating	C5 long
PT910-SD-G	PS2005	720h	1440h	Zinc phosphating	C5 long
LT-PT910-SD-G	PS2505	720h	1440h	Zinc phosphating	C5 long

Table 2: These coatings achieved a corrosion protection category greater than or equal to C4 medium.

ly corrosion from a scribe line is evaluated by this standard, no information is provided about the possible delamination of the powder coating. For this reason, FreiLacke has introduced an additional requirement that the delamination of the powder coating from the scribe line must not exceed 3 mm in order to fall into the relevant corrosion protection category.

The tests were carried out on steel with the following pre-treatments:

- Iron phosphating (Gardobond WH WOC) – 3-zone pre-treatment
- Zinc phosphating (Gardobond 26S 6800 OC) – chrome-free passivation using a titanium and zirconium-based treatment
- Blast cleaned to the Sa 2.5 standard in accordance with DIN EN ISO 8501-1, surface roughness 30 – 40 µm

The figures show the partial results, which highlight the advantages and disadvantages of each system most clearly.

The results for the different pre-treatments can be summarised as follows:

- The category C4 medium cannot be achieved on blast-cleaned steel with a single coat. Two coats consisting of an epoxy primer and a polyester top coat should be used in this case to obtain the required level of corrosion protection.
- Depending on the coating, it was possible to achieve category C4 medium and long on an iron-phosphated material. In practice, systems with a high level of corrosion protection are increasingly used on iron-phosphated substrates because of rising quality requirements.
- Depending on the coating, it was possible to achieve category C4 long and C5 long on a zinc-phosphated material. However, experience shows that in order to achieve category C5 long reliably, two coats consisting of an epoxy primer and a polyester top coat should be used.

The study clearly demonstrated that the PT910 systems offer higher levels of corrosion protection than the primid systems, in particular in the condensation test. In the case of the low-temperature PT910 systems, the level of corrosion protection can be maintained when the curing temperature is reduced (a larger range of curing temperatures), which is not true of the low-temperature primid systems. This brings obvious advantages for very large, solid components which reach only low peak temperatures in the oven. The study also showed that the level of corrosion protection provided by the coating is heavily dependent on the quality of the pre-treatment process.

The reasons for the differences in corrosion protection are currently based only on theoretical assumptions and have not yet been scientifically proved.

Conclusion

The range of PT910 systems recently developed by FreiLacke presents a viable alternative to the commonly used primid systems and offers a significantly higher level of corrosion protection, particularly in the low temperature range.

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