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AN EDGE RETENTIVE COATING SOLUTION BASED ON A TOLERANT SOLVENT-FREE EPOXY SYSTEM

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SUMMARY

Edge retention is a major concern in protective coating. A solvent-free epoxy system is able to complement edge retention properties with tolerance to moisture and surface.

INTRODUCTION

Whenever a coating scheme is specified for the corrosion protection of a given steel structure, there are some key points to assure during application, in order to achieve the performance of the coating system and hence the success of the original specification. The thickness of the applied coatings is one of those vital concerns. Another important key point is the surface preparation, which should meet the coating requirements.

From the above stated, it is clear that specified thickness should be kept constant all over the surface to be coated. However, during the curing, coatings shrink and pull away from the sharp edges and weld seams. This effect leads to a situation where the final dry film thickness (dft) in the edges is smaller than the thickness deposited on the surrounding flat surfaces. Since this effect is different, among different types of coatings, one must define a new coating property: the Edge Retention Ratio (ERR, %). Solvent-based coatings present ERRs that can go down to 30%.

$$\mathbf{ERR = (dft\ (edge) / dft\ (flat)) \times 100.}$$

Deficient edge retention will originate sharp edges to be considerably vulnerable to corrosion and to mechanical damage (and subsequent corrosion). This localized corrosion acts like a starting point for corrosion dissemination, which yields substantial early coating failure.

Any solution to avoid poor edge retention should pay attention to common concerns such as dew-point restrictions or new ones like emergent surface preparation technologies using water (e.g. Ultra High Pressure (UHP) Hydroblasting). This article will present a double-coat edge-retentive epoxy scheme where the second coat gives a decisive answer to the edge-retention problem, while the first coat assures an outstanding tolerant capacity, not only to oxides, but also to moisture (no dew-point restrictions).

CONSEQUENCES OF BAD EDGE RETENTION

The early corrosion process caused by the lacking of coating thickness is related to the way coatings protect steel from corrosion. There are several mechanisms with which coatings protect steel, two of them being related to film thickness: **physical barrier** and **electrolytic resistance**. Smaller thickness will ease the access of chemicals to the steel surface, such as water, oxygen, and salts, which are responsible for the corrosion process. On the other hand, the decrease in thickness will lower the electrolytic resistance through the film, which helps the corrosion cell to work, meaning that corrosion will progress easily.

The small edge retention can be observed in weld seams. The corrosion in weld seams may lead, apart from the loss of steel, to serious structural problems, so a small localized corroded area can be responsible for a big problem.

Sharp edges, in many cases, are more exposed to mechanical damage: impact and wear/abrasion. If thickness drops, the edges will be more vulnerable to

mechanical damage, and subsequent corrosion development.

Another nasty effect of deficient edge retention is the general aspect of an area with a lot of corroded sharp edges. The total corroded area may be small; however there may be a lot of rust bleedings that contribute to a general picture not pleasant to the eyes. Apart from a certain shock from the observation of such an area, there is the extra difficulty in making a correct assessment of the real corrosion extension.

HOW TO SOLVE THE PROBLEM

There are two ways to solve the edge retention problem. The classical solution is the application of extra coats (**stripe coats**) in critical areas (sharp edges and weld seams). This option increases the total cost of the job, since more paint and manpower are needed. Ultimately the job takes more time to be done (another extra cost).

The alternative solution is the use of coatings with **high Edge Retention**. Such coatings should be specially formulated in order to increase its edge retention ratio, so the thickness in sharp edges will be very close to that in flat areas, after curing. We believe that this option to be the most cost effective and technically acceptable solution, if the new coating scheme is able to complement such a physical behaviour with an excellent intrinsic anticorrosive performance. A combined solvent-free epoxy double-coat scheme, joining two versions of the same product, proved to be the best answer:

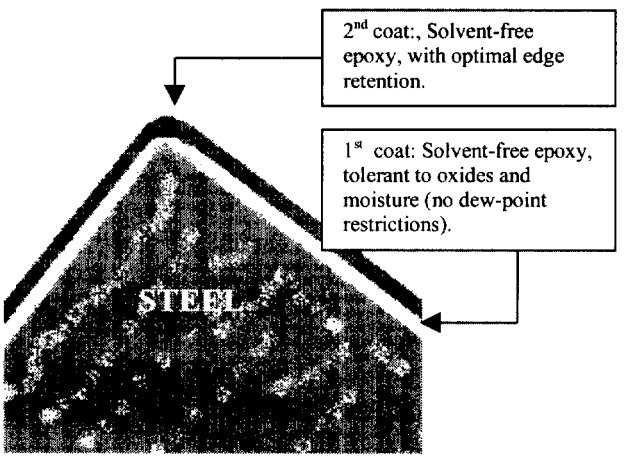


Fig. 1: Solvent-free epoxy double coat system

To build such solution, the same solvent-free epoxy technology was used to generate two product versions, maximizing the fulfilment of two major demands: tolerance (to surface condition and moisture) and edge retention.

DEVELOPING AN EDGE-RETENTIVE COATING: OPTIONS TO TAKE

One detrimental factor for the edge retention is the presence of solvents. As previously commented, the edge retention of some solvent-based epoxy coatings can go down to 30%. Solvent evaporation can be faster in the sharp edges, generating a gradient of density and surface tension between the edge and the flat areas. As result of this, there is a flow of coating away from the edge, giving rise to low edge retention ratios. Thus, the first option made in order to develop an edge-retentive coating was the selection of a solvent-free epoxy formulation system as basis to such coating. The company former success with such system (solvent free epoxy, tolerant series) turns it a natural choice. The objective becomes more ambitious: create a double-coat system that, with two parent products (of the epoxy solvent free family), which join tolerance to moisture & surface preparation (1st coat) and edge retention (2nd coat).

DEVELOPING AN EDGE-RETENTIVE COATING: FORMULATION TOPICS

Solvent-free epoxy coatings should exhibit increased edge retention. However, even in the absence of solvents, we found that some progress should be made in terms of edge retention. This may be related to surface tension and rheology.

The paint should have a rheological structure that exhibit a thixotropic behaviour. The paint appears to be a thick liquid, but, when relatively small forces are applied, it becomes relatively mobile. However, when this force is removed, the paint recovers its rheological structure relatively quickly, this fast recovery of rheological structure may play an important role in the edge retention.

Decreasing the surface tension of the paint should have some contribution for the edge retention. Since the edges have an extra area, then the tendency for "pulling" the surface molecules towards the bulk is higher in the edge comparing with the adjacent flat areas. This "pulling" will then result in an extra area decrease and consequently an extra thickness decrease. Since the referred "pulling" effect decreases with surface tension, then the decrease in surface tension should contribute for an improved edge retention.

The development of an edge retentive version of the epoxy solvent-free series followed those two concerns, as resumed in Table 1.

Table 1. The path to an edge retentive coating development.

RHEOLOGY MODIFICATION TOWARDS A IMPROVED THIXOTROPIC BEHAVIOUR	
OBJECTIVE	Promoting edge retention after application, without loosing the capacity of wetting the surface during application
SURFACE TENSION DECREASE	
OBJECTIVE	Reducing the "pulling" strength effect at the edges.

Both objectives were fulfilled. After 24 months of formulation trials and product testing, the company efforts resulted in an solvent-free epoxy coating with excellent edge retention properties.

RESULTS

The new edge retentive coating behaviour was tested with the help of cross section microscopic photography of coated steel edges. Figure 2 presents a conventional paint behaviour (with poor edge retention). The improved edge retentive product behaviour can be observed in Figure 3

Figure 2: Conventional coating behaviour, with poor edge retention.

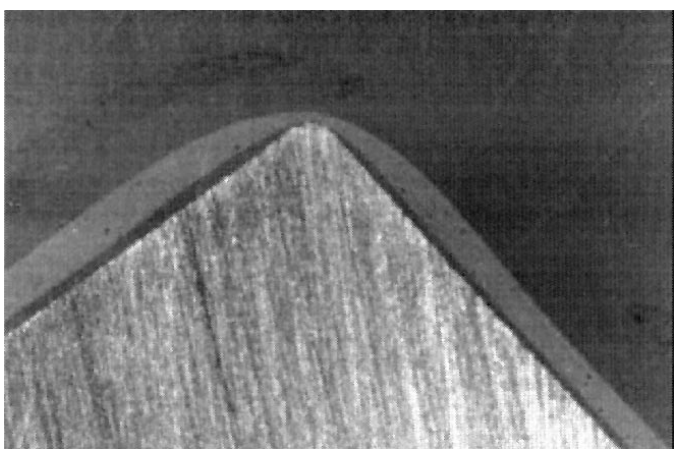
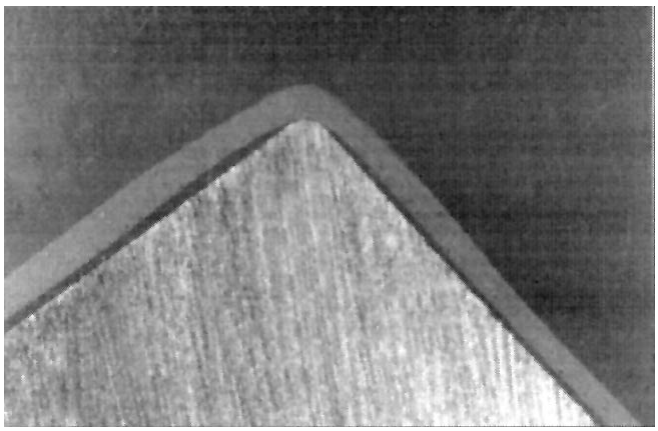


Figure 3: ES301 S edge retentive behaviour.



The new developed product achieved edge retention ratios from a minimum of 85% to maximum values of 90%. The compatibility with is parent primer (tolerant, no dew-point restricted) was total, as expected. A new coating system was born, joining together two important requirements: surface and moisture tolerance and edge retention.

CONCLUSION

The needs of anticorrosive protection are changing. New performance concerns, emergent environmental issues that should be carefully looked, cost analysis issues and increased safety concerns are creating new trends in the world of anticorrosive protective coatings.

Table 2 resume the four kinds of changing needs (performance, environmental, cost and safety).

Table 2 a): Changing performance concerns

PERFORMANCE NEEDS
• Increased coating service life demanded
• The extended service life demands extra care about some application issues: o Coverage on steel angles / edges o Salt level at the steel surface o Surface preparation and dew-point restrictions

Table 2 b): Changing environmental concerns

ENVIRONMENTAL NEEDS
• New legal impositions concerning solvent and residues disposals.
• Media and social pressures in order to adopt cleaner technologies.
• Increasing costs for disposal treatment
• Ambiental certification of industrial activities implies more demanding environmental control

Table 2 c): Changing cost concerns

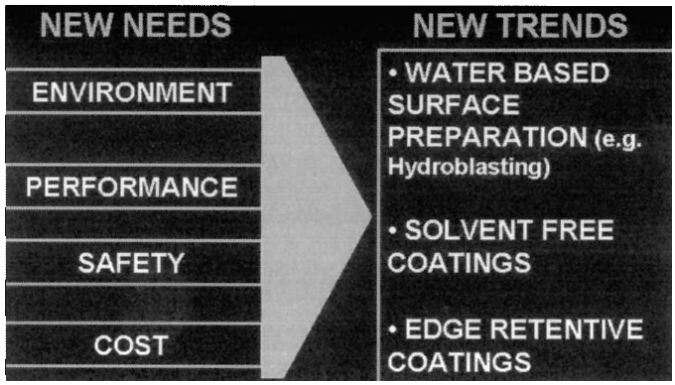
COST NEEDS
• Cost-benefit new attitude.
• Coating cost analysis integrates several components: o Product cost o Surface preparation cost o Application time cost o Environmental cost o Disposal removal and treatment cost o Safety procedures cost

Table 2 d): Changing safety concerns

SAFETY NEEDS
• Risk assessment procedures for anticorrosive treatments.
• More attention to the health impact of surface preparation and coating procedures.
• Increased constraints to the use of technologies that introduce additional risks within industrial environments (for people and equipments).

In Figure 4, the impact of the emergent needs over the new trends is shown.

Figure 4: The New Trend in anticorrosive coating technology.



The development of an edge retentive solvent-free system that is able to be applicable over wet surfaces, without dew-point restrictions, seemed the best possible answer to the new trends presented in Figure 4. The solvent-free moisture tolerant epoxy, the parent primer of the edge-retentive version, is the best possible leverage of hydroblasting surface preparation, and is the best support for the edge retentive last coat.