New Technology from Hempel improves zinc-rich epoxy primers

Hempel have developed a new technology that they claim improves the corrosion protection of traditional zinc-rich epoxy (ZRE) primers, which can still be applied using the same application techniques. This technology is called AvantGuard® and is said to make the metallic zinc pigment more active by combining it with hollow glass spheres and proprietary activators.

Introduction
Zinc coatings have a range of uses, including protecting industrial structures and equipment in tough C4 and C5 environments where saltwater and high humidity rapidly corrode unprotected steel. Zinc is more reactive than iron and so it acts as a sacrificial anode when in a protective coating, i.e. the zinc pigment corrodes instead of the iron to leave the steel intact. This process is known as the galvanic effect which requires the presence of electrical contact between the zinc particles.

However, not much has changed within zinc coatings since they were first introduced in the 1960s. But, back in 2007, the R&D team at Hempel discovered that only around one-third of the zinc in a standard zinc epoxy provides galvanic protection. Hempel has now discovered a method of activating the zinc to improve the galvanic protection of zinc epoxy coatings.

Josep Palasi, Hempel’s R&D Director, explained: “Zinc is the single most important protective element in a zinc coating. However, our research showed that only the zinc in the first 20-30 microns of the coating is able to release electrons and become oxidised. As a normal zinc coating is around 60-80 microns, around two-thirds of the zinc is too far away from the point of corrosion and so is not able to protect the steel.”

AvantGuard®
Hempel’s solution was to combine the elements used in traditional zinc epoxies with two new substances: hollow glass spheres and proprietary activators. The new technology, known as AvantGuard®, can be used in all types of applications and leads to three main performance improvements over traditional zinc epoxies.

1. When the zinc particles and proprietary activators in the modified ZRE coatings come into contact with water and corrosive species, the proprietary activators increase the zinc particles’ ability to release electrons. As a result, the zinc particles are activated throughout the whole film, which improves the galvanic effect without increasing zinc content. In addition, modified coatings are more water impermeable than unmodified ZRE and, once the zinc becomes oxidised, it forms a layer of insoluble salts on the surface and within the film that further increases the coating’s resistance to water.

2. Over time, chloride ions penetrate protective coatings and cause pitting corrosion, especially in aggressive saltwater environments. Hempel claim that their AvantGuard® modified coatings capture chloride ions by forming chloride-containing salts around the glass spheres. This significantly delays the corrosive process as some chloride ions are trapped in the coating so cannot reach the steel substrate.

Several experiments performed by Hempel between 2005 and 2007 explored the galvanic effect in zinc-rich primers. The experiments showed that in zinc epoxies with 80% zinc, only the zinc in the first 20-30 microns was consumed around the scribe area of a panel in a salt spray test.
3. Zinc epoxies are often used for application where the steel is exposed to severe mechanical stress, such as during extreme temperature fluctuations found in some industries and environments. In a typical zinc protective system, the zinc primer is the weakest mechanical point and as a result, cracks can form in the coating as the steel expands and contracts. AvantGuard® coatings are different due to a phenomenon that Josep Palasi at Hempel calls “self-healing”. “When we put the AvantGuard® activated zinc epoxies through thermal cycling resistance tests, cracking tests and welding tests, we saw that they outperformed traditional zinc-rich epoxies with no activated zinc technology. The performance difference was extraordinary, and we were determined to find out why.”

Hempel believes this improved performance is the result of two processes: the properties from the hollow glass spheres and the achieved positive effect from the unique zinc activation process.

Josep Palasi explains: “When a crack forms, the first penetrating step requires the most energy. After that, it takes very little energy for the crack to widen and affect the integrity of the coating. We discovered that the glass spheres could absorb most of the impact from the initial crack and stop it from developing. In addition, we observed that the sub-products formed during the zinc activation process actually occupy the space left by the micro-crack, preventing it from developing into a more serious crack. So we can say that AvantGuard® has a self-healing effect on micro-cracks, which is something that we have never seen before.”

Hempel has recently launched HEMPADUR AvantGuard®, the first activated zinc primers to take advantage of their new technology. These coatings have been shown to outperform traditional zinc epoxies in tests performed by Hempel following international standards, including salt spray tests (ISO 12944 part 6), cyclic corrosion tests (ISO 20340 - NORSOK M-501 revision 6), water permeability tests (SSPC Paint 20 Type II) and thermal cycling resistance tests (NACE cracking test).

In addition, internal Hempel tests show that their modified coatings can be applied in both higher humidity and higher temperatures without blistering, and that there is reduced cracking risk at high dry film thicknesses.

(Ed: This article is based on information supplied to the ACA by Hempel)

**Technical Note**

**Traditional zinc-rich epoxy**

Traditional zinc-rich epoxy 80%w zinc, 74 µm

**Zinc epoxy with AvantGuard® technology**

Zinc epoxy with AvantGuard®, 79 µm

When comparing traditional zinc-rich epoxies to AvantGuard® modified ZRE primers during salt spray tests, we see an abundant and uniform formation of a thin layer of zinc salts in the surface of the panel. This thin layer becomes an extra barrier against water and other corrosive species and helps improve the overall anti-corrosion mechanism. The tests were performed according to ISO 12944 (35°C, saturated atmosphere of an aqueous solution of NaCl (50 g/L)).

The pictures on the left shows the full panels, moving right the pictures show enlargements of the same panel.

**Micro-crack covered by zinc corrosion sub-products**

The glass spheres in the coating absorb the impact of the initial crack and stop it from propagating. The picture on the right shows an enlargement of the crack seen on the left.

This SEM shows the hollow glass spheres forming at the base of a crack and stopping it from getting larger. The picture on the right shows an enlargement of the crack seen on the left.