

# Benefits of Zinc Thermal Spraying

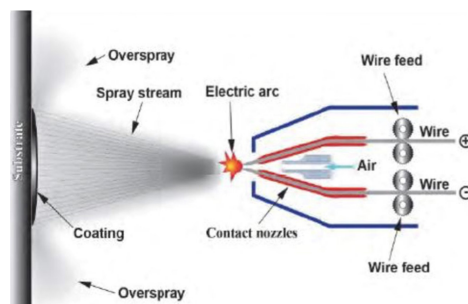
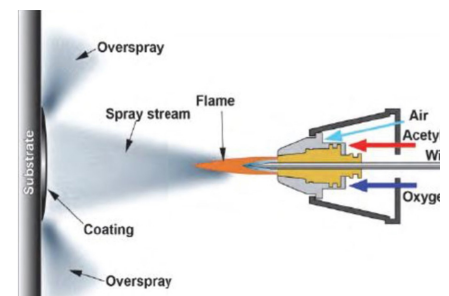
Zinc thermal spraying or zinc metallizing provides the same barrier coating and sacrificial protection properties inherent in all zinc coatings, but has several advantages in terms of application. Thermal sprayed zinc coatings can be applied to both onshore and offshore structures that are still being fabricated or are already installed. There are no size restrictions to the part being coated. Both pure zinc, or zinc-aluminum alloys can be thermal sprayed. For offshore applications, the Zn-15%Al alloy is optimized as a corrosion resistant coating for harsh marine weather conditions. Thermal sprayed zinc also makes an excellent base for duplex coatings. The zinc plus paint duplex coatings create a synergistic effect whereby the total lifetime of this duplex system is longer than the sum of the separate lifetimes of the zinc and the paint alone. Duplex coatings have been proven to provide the most cost-efficient corrosion resistant coatings for severe atmospheric exposures.

## Thermal Spraying Application Process

The zinc thermal spraying process has four steps. The surface of the steel structure should be cleaned of any oil or other contaminants. The surface should then be prepared by grit blasting to ensure a rougher surface that allows for “good bond strength between the steel target and the sprayed metal coating.” (Goodwin, 2012) After grit blasting, the zinc spraying can commence. Finally, after the spraying, the coating is usually sealed and or painted to provide additional protection. There are two types of thermal spraying:

### Flame spraying

“An acetylene-oxygen flame is used to melt a wire that is continuously fed to the flame. Individually melted droplets are accelerated in the direction of the substrate surface with the aid of an atomizing gas, generally compressed air.” (Prenger & Spriestersbach, 2012)



### Arc spraying

“An electrically conductive material is melted by an electrical discharge process and then applied onto a substrate surface. The process is based on the fact that two wire shaped electrically conductive spray materials are moved towards each other at a constant advance rate.” (Prenger & Spriestersbach, 2012)

## Duplex Coatings

Zinc coatings are widely used to protect steel against corrosion. Zinc not only acts as a barrier, but also has sacrificial properties. The sacrificial properties rely on the galvanic protection of steel by zinc, meaning that if any area of the coating is damaged or exposed to a corrosive environment, the nearby zinc will corrode rather than the steel, leaving the steel structure unharmed.

The barrier protection nature of zinc can be enhanced by painting. A paint coating will protect the zinc from exposure to corrosive environments, and slow the natural corrosion of the zinc. In turn, the zinc also protects the paint from any underfilm corrosion at scratches or damages in the paint film. The beneficial mutual protection that each

layer (zinc and paint) provides to the other, produces a coating with a longer life than than the sum of the expected lifetimes of the zinc and the paint alone. This is the synergistic effect.

The synergistic effect of duplex zinc plus paint coating systems provide a much longer life to the structure. The sum of the life of a zinc coating and a paint coating is multiplied by a factor ranging from 1.5 to 2.7 depending on the environmental conditions.

**ie. The duplex service life = (factor) x (Zinc life + Paint life)**

In an industrial or marine area the factor is in the range of 1.8 – 2.0; when there is immersion with seawater it is typically 1.5 – 1.6; and in a non-aggressive climate the synergistic factor can range from 2.0 – 2.7.

In a duplex coating, the paint provides extra barrier protection to the zinc and the zinc is there to support the paint when it begins to fail.

## Different Environmental Conditions and their Corrosion Rates

### Corrosion Performance

The corrosion performance of sprayed coatings is directly linked to the severity of the atmosphere. The adjacent table differentiates between environmental types according to ISO 9223 and categorizes them from *Very Low* to *Extreme*. Each is linked to the corrosion rate for the first year of exposure.

It also includes the time to first maintenance for Zn duplex to 5% rust. (Goodwin, 2012)

ISO 9223		Typical environment	Corrosion rate for the first year of exposure (µm/y)		Time to 1 <sup>st</sup> maintenance, Duplex Coating
Category	Description		Mild steel	Zinc	
C1	Very low	Dry indoors	≤1.3	≤0.1	Not required
C2	Low	Arid/Urban inland	>1.3 to ≤25	>0.1 to ≤0.7	Not required
C3	Medium	Coastal or industrial	>25 to ≤50	>0.7 to ≤2.1	Not required
C4	High	Calm sea-shore	>50 to ≤80	>2.1 to ≤4.2	45-90 y
C5	Very High	Surf sea-shore	>80 to ≤200	>4.2 to ≤8.4	23-45 y
CX	Extreme	Ocean/Off-shore	>200 to ≤700	>8.4 to ≤25	7 -23 y

### Field Studies

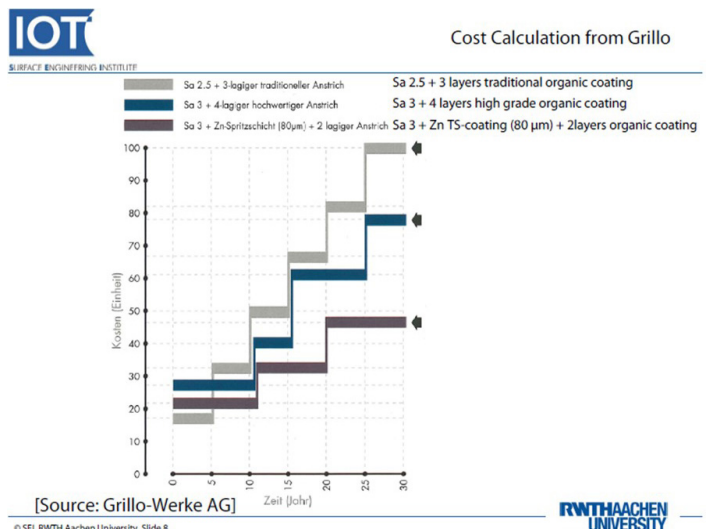
Three-layer paint systems (primer, tie coat and topcoat) are widely used to protect steel structures. The addition of a thermal sprayed zinc layer under the paint system to produce a duplex coating has been shown to significantly reduce maintenance costs for repainting and provide a much lower life cycle cost for corrosion protection.

A study by SINTEF (Society for Industrial and Technological Research in Norway) found that after 30 years of service life, a three layer paint system, despite its lower initial costs, was found to have a higher total cost due to the requirement for much more maintenance painting over the life of the structure. These maintenance costs become vivid after 12 years. In contrast, the synergistic zinc thermal spray plus paint coating system has a lower total cost due to the reduced maintenance costs required by the duplex system. (Knudsen, Bjorgum, & Dossland, 2012).

In addition, the University Aachen performed a study comparing a duplex coating (thermally sprayed zinc with two layer paint) with a three-layer and a four-layer paint only coatings. The initial cost of the duplex coating was

inbetween the cost of the three-layer and the four-layer paint systems, but over the 30 year life of the structure, was much cheaper overall. The duplex coating proved to be the most cost-efficient alternative.

The Zinc thermal spray plus paint duplex coating has a longer lifetime, is cheaper and is in need of less maintenance than a paint-only system.



### References

Knudsen, O., Bjorgum, A., & Dossland, L. (2012). Long Life, Low Maintenance Coating Systems. *Materials Performance* (51), 54-59; Goodwin, F. E. (2012). A Review of the Zinc Thermal Spraying Process and its Protective Qualities for Steel Structures, with a Focus on Windmill Conditions. Workshop "Innovative Beschichtungen für Windkraftanlagen", Fraunhofer-Forum Berlin, Oct 2012; Prenger, F., & Spiestersbach, J. (2012). Thermal Spraying of Zinc and Zinc- Aluminium Alloys for Corrosion Protections. Grillo- Werke AG