

Combining Thermal Spray Zinc and Hot-Dip Galvanizing To Achieve an All-Metallic Zinc Coating System

Bernardo Duran
International Zinc Association
2530 Meridian Pkwy Suite #115
Durham, NC 27713
United States

ABSTRACT

This paper discusses methods and strategies for combining thermal spray zinc and hot-dip galvanizing to create an all-metallic zinc corrosion protection system. Hot-dip galvanizing is a mature industry and is commonly specified for infrastructure projects, whereas thermal spray zinc and its alloys are gaining traction with many asset owners and departments of transportation (DOTs). This has created questions about how best to combine both systems for exceptional corrosion resistance and material durability. Topics covered include processing variations, application advantages for new versus rehabilitation projects, and how material size influences the preferred processing methods.

Key words: zinc, thermal spray, metallizing, galvanizing, hot-dip

INTRODUCTION

Corrosion protection of infrastructure and assets is an area of increasing focus due to increasing financial and safety concerns. On a global scale, corrosion has an annual cost of \$2.5 trillion (USD).¹ To combat the deleterious effects of this natural phenomenon, specifiers and owners have many choices in terms of materials and protective coatings. Consideration of both initial and life cycle costs has become more important in the age of increased competition and shrinking maintenance budgets.

One of the protective coatings that has performed exceptionally in many types of applications and environments is metallic zinc. With its ability to offer barrier and cathodic protection, a relatively low corrosion rate in atmospheric applications, and along with being maintenance-free, specifiers and asset owners have increasingly specified or considered metallic zinc. Two of the most popular methods for applying this coating include hot-dip galvanizing and thermal spray metallizing. For some applications and material types, these two processes can be combined to create an all-metallic zinc coating system. This paper describes both methods and how to combine them for protecting steel infrastructure and other assets.

HOT-DIP GALVANIZING

Hot-Dip Galvanizing Process

There are several types of galvanizing, and the method described in this paper refers to batch or general hot-dip galvanizing. In this process, the material is delivered to a galvanizing plant after fabrication where it is cleaned and coated. It is necessary to have proper vent and drain holes in the metal fabrications since the dip process involves full immersion of the materials into molten zinc, and any trapped air can cause safety issues and possible damage to the material as the air and moisture within it expands as the steel is heated.

Before the steel can be galvanized, it must first be cleaned, which includes removal of organic contaminants and iron oxides. The first cleaning step is a caustic bath to remove dirt, oil, and other organic materials from the steel. Some galvanizers choose to use an acid degreaser. After that the steel is removed from the caustic bath and allowed to drain. It is then rinsed in a freshwater bath to remove any remaining caustic solution. The fabrication is then dipped into a dilute solution of hydrochloric or sulfuric acid, also known as a pickling bath. This step removes mill scale and iron oxides from the steel as it necessary to have a clean surface for development of a galvanized coating. After pickling, the material is rinsed again in fresh water. To combat the wet steel from oxidizing again, the material is dipped into a flux solution which also removes any remaining oxides. The flux is allowed to dry on the steel, and this completes the cleaning process.

After the steel has been cleaned, it is ready to be galvanized. The batch hot-dip galvanizing process consists of dipping the material into a bath of molten zinc at a temperature of approximately 830-842F (443-450C). The duration of dipping depends on the steel thickness, with thinner pieces needing less time in the bath. Typically, the dip time ranges from as few as two or three minutes to over ten minutes for very thick steel. To allow for full development of the galvanized coating, it is necessary that the outer steel surface heats to the temperature of the galvanizing bath. This allows full formation and adhesion of the galvanized coating.

The Hot-Dip Galvanized Coating

The galvanized coating consists of three zinc-iron intermetallic layers, which form during the metallurgical reaction that occurs between iron in the steel and the molten zinc. The metallurgical reaction produces a bond strength of 3,600 psi between these layers and the steel. Upon withdrawal from the galvanizing bath, the molten zinc quickly reduces in temperature as it hits the air and a layer of nearly pure zinc freezes on the steel and makes up the outer layer. In order from closest to the steel surface outward, the intermetallic alloy layers include the delta, gamma, zeta, and the free zinc layer is known as the eta layer. The fully developed coating is shown in Figure 1.² The alloy layers are harder than the base steel as shown by the diamond pyramid numbers (DPN) in Figure 1. This feature imparts excellent abrasion resistance to hot-dip galvanized coatings.

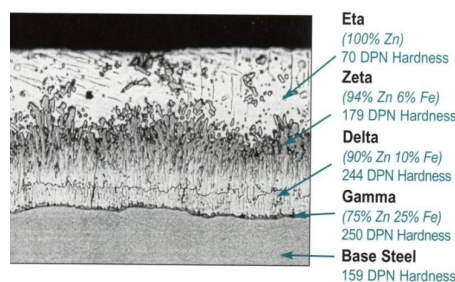


Figure 1: Batch Hot-Dip Galvanized Coating²