Zinc/Aluminum Coatings for use with Structural Fasteners
May - 2015

**Background**

There has always been a need among users of structural fasteners for coatings that can safely and cost effectively provide corrosion protection. Traditional metallic coatings, like galvanizing to ASTM B695 or ASTM F2329, have historically performed well on 120 ksi (Grade A325) fasteners, but these coatings have not been permitted for 150 ksi structural fasteners due to concerns over hydrogen embrittlement.

In recent years the ASTM F16 committee has approved three coatings for use on some 150 ksi structural fasteners.

- ASTM F1136/F1136M Zinc/Aluminum Corrosion Protective Coating for Fasteners
- ASTM F2833 Corrosion Protective Fastener Coatings with Zinc Rich Base Coat and Aluminum Organic/Inorganic Type
- F3019/F3019M Standard Specification for Chromium Free Zinc-Flake Composite, with or without Integral Lubricant, Corrosion Protective Coatings for Fasteners.

Testing* has demonstrated that fasteners with these coatings (when properly applied) do not suffer effects of hydrogen embrittlement. Since these are the first coatings approved by ASTM for 150 ksi structural fasteners there are a number of issues that should be addressed and understood regarding their use. Understanding potential issues can aid users in successful implementation.

Practical experience, specification updates and additional research will provide additional standards-based guidance in the future. The recent publication of ASTM F3125 is the first step in addressing many of the early issues with these coatings regarding nut oversize allowance, rotational capacity testing and which coating grades should be used on which fastener components, but some issues are still unresolved.

Zn/Al coatings are an accepted and commercially available coating, but they should not be considered a direct substitute for hot dip or mechanical galvanizing. Some producers of Zn/Al coatings advise the use of supplementary topcoats, such as multi-part paint systems for long-term corrosion protection. Please consult with the individual coating applicator for recommendations.

The ASTM standards for these coatings are quite weak in terms of clearly defining producer requirements and user expectations. Discussion regarding adhesion testing, storage and handling, salt spray testing, and coating thickness are encouraged between the purchaser and supplier, prior to ordering, to eliminate potential misunderstandings.

**Nut Over-tap**

Zn/Al coatings are relatively thin and uniform compared to traditional zinc coatings, however, many factors can influence the need for oversizing the nut thread to allow for the thickness of the coating. These include production dimensional limits, tool wear, actual coating thickness, coating thickness variation, coating application method, coating grade, and the applicator.
The Zn/Al specifications mention the potential need for nut thread oversizing, but provide no guidance on oversized threads. Component conditions and dimensional tolerances may permit the use of non oversized threads with thinner coating deposits, but practically speaking, thread oversizing of the nut pitch diameter may be required. There are newly established requirements for nut over-tap included in ASTM F3125.

Oversizing threads for high strength fasteners should be done with caution. The loss of functional engagement may reduce stripping strength of the fastener assembly. Particular attention should be paid to establishing controls on the minor diameter of the nut in cases where ultimate strength is a concern. ASME should consider further limiting the geometric tolerance on oversized nut minor diameters.

Proper thread allowances to permit free assembly in the field and an interference free fit should be discussed with suppliers prior to ordering. As with most coatings, intermittent assembly problems may be encountered with Zn/Al coatings.

**Proof Load Testing**

The majority of structural assemblies include an ASTM A563 DH nut. Specification requirements for DH nuts reduce the proof-load test requirement of oversized heavy hex nuts to 150 ksi. Standard DH nuts (non oversized) are required to be proof load tested to 175 ksi, which appropriately exceeds the permitted maximum tensile of 150 ksi bolts to which they are often mated.

When oversized DH nuts are used, the purchaser and supplier should consider nut proof load testing to a level exceeding the tensile strength of the bolt that the nut will be mated with. This is to help assure that bolt tensile failure will most likely remain the mode of failure. As with any oversized nut there is a possibility that thread stripping can happen prior to tensile fracture of the bolt.

The customer could also consider rotational capacity (RC) testing as a means of confirming fastener assembly strength. ASTM F3125 has also established RC test guidelines for 150 ksi structural fasteners. ASTM should modify proof load requirements for oversized A563 nuts, or alternately, develop a new nut grade for oversized nuts for use with 150 ksi bolts.

**Coating Thickness**

While thinner than traditional metallic coatings, Zn/Al coatings have high relative variability in coating thickness. Deposits are often thicker than specified minimum values, with high spots often much greater in thickness than the specified minimum value. The effect of the accumulation of these thicknesses and the impact on product thread gauging and assembly should be understood.

Coating thickness for ASTM fasteners is frequently measured using cost effective means such as magnetic induction. A potential issue with Zn/Al coatings and 150 ksi fasteners is the effect of magnetic particle testing on the results of magnetic induction coating thickness testing. When performed on 150 ksi fasteners, magnetic particle testing can leave residual magnetic fields, which might interfere with the results of magnetic induction testing. 150 ksi fasteners using Zn/Al coatings should be demagnetized after testing, or another method of coating thickness evaluation, and the costs of such testing, should be agreed upon between the supplier, the applicator, and the user.
**Rotational Capacity**

Coated 120 ksi structural fasteners have traditionally had a requirement for rotation capacity (RC) testing. Plain 120 ksi and 150 ksi structural fasteners have frequently had RC testing required by certain agencies. With the approval of coatings for 150 ksi fasteners there is also a need to provide guidance on the applicability of rotational capacity testing.

The previous A490 specification did not have provisions for RC testing, and as such were frequently tested to FHWA, AASTO or State DOT requirements. 150 ksi fasteners do not have the same ductility as 120 ksi fasteners and applying the same RC test criteria may be impractical. ASTM F3125 has established recommended RC test procedures for 150 ksi fasteners, but RC testing should be as agreed upon between the supplier and user.

There are numerous RC tests for structural fasteners and there should be a clear expectation of all parties as to which should be used for a particular project.

**Reactivity with Concrete**

The effects or possible reaction of aluminum components of Zn/Al coatings with wet concrete have not been well researched or documented. When specifying Zn/Al coatings for use where coated fasteners may be in direct contact with wet concrete or when coatings will be in high humidity applications in close proximity to concrete the user should consult with the coating applicator.

**Reactivity with Copper**

The effects or possible reaction of aluminum components of Zn/Al coatings with copper have not been well researched or documented. When specifying Zn/Al coatings for use with type 3 fasteners or type 3 steel, the coating producer or applicator should be consulted. A recent trend in bolt manufacturing has a number of producers using type 3 material for type 1 bolts, so the same advice may apply regardless of bolt grade depending on actual steel heat chemistry.

**Paint Adhesion**

A study has been performed which indicated that paint adheres well to Zn/Al coatings. Users should understand that these results were generally determined using standard Zn/Al coatings, not coatings that have a lubricated sealer, such as those used on nuts. Users should be aware of the potential need to determine paint adhesion independently on Zn/Al coatings with lubricated sealers.

**Coating Grade**

Zn/Al coating grade should be specified separately for the bolt, nut, and washer. ASTM F3125 has recommended coating grades for individual coating specifications. These are based on the coating manufacturers recommendations. The coatings may be spray or dip-spin applied depending on fastener size, applicator capacity or other special requirements. The coating grade determines the coating thickness, as well as properties like corrosion resistance, thread fit, and installation torque. At all times a grade that incorporates lubrication should be used on the nut. Please consult the coating supplier for additional recommendations.
Summary

This class of coatings has benefits and limitations that should be understood by the end user, and is the only currently approved means of achieving additional corrosion protection on 150 ksi strength level structural fasteners that can also provide desirable installation characteristics. Users should consult with coating suppliers for specific application recommendations, salt spray test requirements, inspection recommendations, touch-up procedures and supplementary paint systems to enhance performance.

This bulletin is to help the manufacturer, supplier, and end user understand the limitations of current product specifications until additional research and standards-based guidance can be provided.

*Available on ASTM International website.