Considerations for using Zinc in Refined GSI-191 Chemical Effects Testing

CCNPP-CHLE-008, Revision 3
September 24, 2013

Prepared by:
Gilbert Zigler,
Jon Cavallo

Reviewed by:
Steve Kinsey,
Craig Sellers

Approved by:
John Swailes,
Tom Konerth

Jon Cavallo & Gilbert Zigler
Rev. 3 September 24, 2013

Considerations for using Zinc in Refined GSI-191 Chemical Effects Testing

Background

STP Chemical Effects testing at UNM has revealed that the presence of zinc in a post-LOCA pool could be a source of chemical precipitates. There are two main sources of zinc in a NPP containment:

- Galvanized steel from gratings, HVAC ducts and miscellaneous structural members; and
- IOZ particulates from zinc rich coatings.

Once the quantities of either source are calculated, the issues then become the nature of the debris formed and how to scale for chemical effects testing. Scaling of galvanized steel is straightforward since actual galvanized steel gratings or galvanized steel ducting material can be used. Scaling of zinc rich coatings is not as straightforward as galvanized steel and is presented below.

Zinc Rich Coatings

The following are the types of zinc rich coatings typically found in a NPP containment:

- Qualified zinc rich coating with qualified epoxy top coat
- Unqualified and degraded qualified epoxy top coated zinc rich coating
- Qualified zinc rich coating with no epoxy top coat
- Unqualified and degraded qualified zinc rich coating with no epoxy top coat

The following are the responses of the four types of zinc rich coating scenarios (i.e., location, condition, type of coating system) following a hypothetical LOCA and the recommended zinc rich surrogate for CE testing:

1. Qualified zinc rich coatings outside a HELB ZOI will not be source of zinc since they will not fail or release zinc.
    - No qualified zinc rich coatings should be included in CE testing.
2. Qualified and unqualified and degraded qualified zinc rich coatings within the ZOI are assumed to fail as a nominal 10 micrometer diameter zinc powder.
    - Zinc plate can be used as a zinc powder surrogate where the use of zinc powder would be problematic. The zinc plate surface area is scaled based on calculating the surface area of the quantity of nominal 10 micrometer spheres of zinc powder.
    - Zinc dust with a nominal 10 micrometer diameter can be used for certain chemical tests[1] where the zinc dust transport is not problematic.

[1] Zinc dust could be used in beaker bench top chemical effects tests where zinc dust transport is not an issue.

3. Unqualified and degraded qualified epoxy top coated applied over a satisfactorily applied IOZ with satisfactory dry film thickness (DFT) are assumed to fail as a delamination of the epoxy top coat in the form of chips. The zinc powder will be firmly adhered to the substrate and loosely adhered to the back side of the epoxy topcoat. These observations are based on experiments conducted for Comanche Peak [Ref. 1, Pg. 21] zinc using samples of the containment epoxy topcoat / inorganic zinc rich primer which had failed in service. The coating system failure was determined to be the result of excessively thick inorganic zinc rich primer topcoated with excessively thick epoxy topcoat. Examination of Comanche Peak failed coating samples showed that the epoxy peeled due to excessive shrink stresses, and approximately 4 mils thickness of zinc particulates were found attached to the underside of the epoxy layer. Three to four mils thickness of sound inorganic zinc rich coating was determined to remain attached to the steel substrate at the failure sites.
    - Coupons with zinc rich coating whose DFT is equal to five mils (representing the maximum qualified thickness of inorganic zinc rich coatings used in US NPP containment structures) or as specified by the manufacturer of Nuclear grade coatings (e.g., Sherwin-Williams Zinc Clad) are an appropriate surrogate for failed unqualified and degraded qualified epoxy top coated zinc rich coatings. For scaling, the total surface area of the surrogate zinc rich coating should be twice the total surface area of the plant unqualified and degraded qualified epoxy top coated zinc rich coatings. After the application of the zinc rich coating, the coupons shall be cured for 14 days at 50% RH or greater and 70°F or greater. Once cured, the coupons should be aged for 14 days per side in a Cleveland Condensing Humidity Cabinet at 120 deg F per ASTM D4585 [Ref. 2].
4. Unqualified zinc rich coatings are generally single package, organic binder (usually alkyd or polyester) zinc rich coating sprayed as touch up or repairs to galvanized surfaces. The failure would be the dissolution of the binder releasing the 10 micrometer zinc dust.
    - Coupons with zinc rich coating with the same unqualified coating(s) as used in the NPP at the plant coating DFT are an appropriate surrogate for CE testing. The prepared coupons should be aged by accelerated laboratory techniques (e.g., environmental test chamber).
    - Zinc plate can be used where the use of coupons would be problematic. The zinc plate surface area is scaled based on calculating the surface area of the quantity of 10 micrometer spheres of zinc powder.

Reference:

1. "Design Basis Accident Testing of Coatings Samples from Unit 1 Containment, TXU Comanche Peak SES", Keeler & Long, April 13, 2006
2. "Standard Practice for Testing Water Resistance of Coating Using Controlled Condensation", ASTM D4585/D4584M – 13, June 1, 2013.