National Steel Bridge Alliance

Division of the American Institute of Steel Construction

Executive Summary

Edge/Corner Preparation of Steel Members and its Effect on Zinc Rich Primer Performance

KTA-Tator, Inc.

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The National Steel Bridge Alliance has published this document in its continuing effort to enhance the state of the art of steel bridge design and construction in the United States.

Foreword

The proper treatment of corners on steel members before coating application has been an area of uncertainty and contention for decades. In recognition of this fact, the National Steel Bridge Alliance (NSBA) and four US coating manufacturers, funded a two-year comprehensive study. This three-phase study investigated the degree of preparation required on steel corners before abrasive blast cleaning and coating.

Messrs. William D. Corbett and Eric S. Kline of KTA-Tator, Inc., a nationally-recognized coating testing laboratory in Pittsburgh, Pennsylvania, conducted the study.

The NSBA believes that the conclusions reached by KTA-Tator, Inc., will be of great interest to facility owners, engineers, steel fabricators and coating suppliers.

The NSBA is pleased to publish this “Executive Summary” from the full report “Edge/Corner Preparation of Steel Members and Its Effect on Zinc Rich Primer Performance.” The NSBA will publish the full report (item number H053) early in 2000. It will be available through our web site at www.nsbaweb.org or by calling 1-800-644-2400.

We want to especially thank the following companies, whose financial support along with the NSBA, made this study possible:

Ameron International PCG
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The Valspar Corporation

Arun M. Shirolé, P.E.
NSBA Executive Director

INTRODUCTION

During the mid 1990s, a State Agency revised its painting specification to include mandatory rounding of edges (corners) to a 1/8 inch (+/-0 inch) radius, independent of whether the corners were sheared, burned or rolled. Other public and private agencies are believed to be considering, or have already adopted similar requirements. A recent illustration of the potential impact that this type of requirement can have involved a major steel fabrication and painting shop that was required to grind all corners to a 1/8 inch radius because of enforcement of an Agency specification provision.

The term "breaking the edge" has long been used in the steel fabrication industry to refer to a grinding operation which blunts the 90^o corner. This operation produces an approximate 1/16" flat area. Subsequent abrasive blast cleaning (manual or centrifugal) was believed to sufficiently round the flattened corner and provide a paintable surface. It is believed that no formal research had been conducted to either confirm or dispute whether breaking the edge and blast cleaning is sufficient preparation for coating steel corners with inorganic or organic zinc-rich primers. Additionally, there is no data indicating whether a radius on the corners is necessary for coating performance. Further, if a radius is necessary, the exact radius required for good coating performance has not been established.

As a result of the issues cited above, the National Steel Bridge Alliance (NSBA) contracted with KTA-Tator, Inc. (KTA) to conduct a three phase study to investigate the corner build characteristics of common bridge shop primers, and to determine the extent of corner preparation required to achieve satisfactory coating performance.

Research, initiated in 1997 for the NSBA, was completed in 1999. This brochure is a reproduction of the Executive Summary from the full report.

EXECUTIVE SUMMARY

The National Steel Bridge Alliance (NSBA) contracted with KTA-Tator, Inc. (KTA) to conduct a three phase study to investigate the corner build characteristics of common industrial shop primers and to determine the extent of corner preparation required to achieve coating performance.

Summary of Phase 1 Results

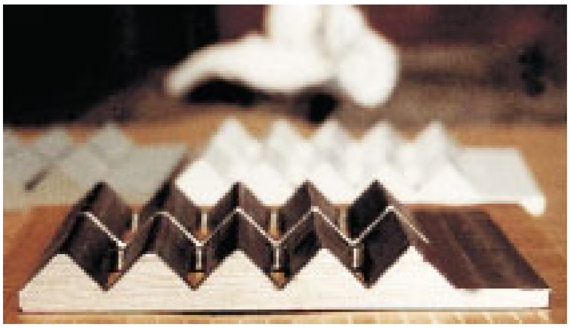
Phase 1 entailed comparing the corner build characteristics of an industrial enamel coating verses an ethyl silicate inorganic zinc-rich coating, both applied at a single coat and double coat thickness. Comparisons were based upon performance in an ASTM B117 salt fog chamber (1,000 hours) and microscopic examination of coating thickness on the corner. Evaluations were performed using specially designed test specimens depicting five (5) degrees of corner preparation (90^{o} corner; 1/16 inch broken; 1/16 inch rounded; 1/8 inch broken and 1/8 inch rounded).

The laboratory microscopic analysis revealed that the single coat industrial enamel measured approximately 5 mils on the corners. The single coat industrial enamel deteriorated over much of the surface after 500 hours of salt fog exposure. Despite the overall deterioration, it was apparent that the edge with no preparation experienced substantial corrosion, while the edges with a 1/16" corner (broken or rounded) did not exhibit substantial deterioration. The performance of the 1/8" corner (broken or rounded) appeared to be satisfactory overall, although a slight amount of corrosion may have been present.

The double coat of industrial enamel was verified in the laboratory to measure 8-12 mils on the corners. None of the corners exhibited failure until after 1,000 hours exposure. After 1,000 hours salt fog exposure, the unprepared (unground) 90^{o} corner exhibited corrosion across the entire length. The 1/16" corner prepared as a broken edge showed near total edge corrosion, while the 1/16" rounded corner showed less corrosion. No evidence of corrosion along the corner of either of the 1/8" samples (broken edge or rounded) was apparent.

Based upon the results of the industrial enamel exposure, it appears that a correlation between the extent of breaking/rounding the corner and performance may exist, with the broken/rounded corners appearing to exhibit improved performance.

The same correlation does not appear to exist in the case of the inorganic zinc-rich primer. After 1,000 hours, there is no evidence of red rusting on any of the corners, even on those which received no preparation. The laboratory microscopic analysis showed that the thickness of the inorganic zinc on the corners was 5-7 mils for the "single coat" samples and 10-13 mils for the "double coat" samples. After approximately 20,000 hours (28 months) ASTM B117 salt fog exposure, there remains no evidence of red rusting on any of the corner preparations, independent of coating thickness.



Phase 1, Photograph 2
Corner Grinding Test Specimen
"As Fabricated Edge View"

Phase 1, Photograph 3
Corner Grinding Test Specimen
"As Fabricated and Blast Cleaned"

Phase 1, Photograph 14
Inorganic Zinc-Rich Primer (single coat)
Corner MR-0 (90°)

Phase 1, Photograph 26
Industrial Enamel (single coat)
Corner MR-0 (90°)

Summary of Phase 2 Results

Phase 2 entailed preparation and coating of shop prepared steel, followed by cross-sectioning and microscopic examination of the corner build characteristics of two inorganic zinc-rich primers. Preparation and coating of the steel was performed by two independent steel fabrication shops. Each shop prepared samples for three (3) "conditions" addressing the coating build characteristics over no corner preparation; 1/16" corner chamfer; and handling marks/nicks. The applicators from each shop were not schooled on application technique for this project.

Condition No. 1 (no corner preparation)

The Condition No. 1 specimen (no corner preparation) prepared by Fabrication Shop A using Inorganic Zinc A exhibited excellent corner build characteristics when compared to the coating thickness on the edge of the same specimen. The average edge build was approximately 5.1 mils; the average thickness on the corner was approximately 5.4 mils.

The specimen prepared by Fabrication Shop B using Inorganic Zinc B did not exhibit the same corner build characteristics as the Shop A specimen. The average coating thickness on the edge was approximately 4.8 mils; however the average thickness on the corner was approximately 1.9 mils, with two (2) of the four (4) samples exhibiting no visible coating on the corner. It is not clear why the coating on the specimens from Fabrication Shops A and B revealed different corner build characteristics, as the coating systems applied were generically similar. The difference in corner build characteristics almost certainly reflects the application techniques employed by each shop.

Condition No. 2 (1/16" chamfer on corner)

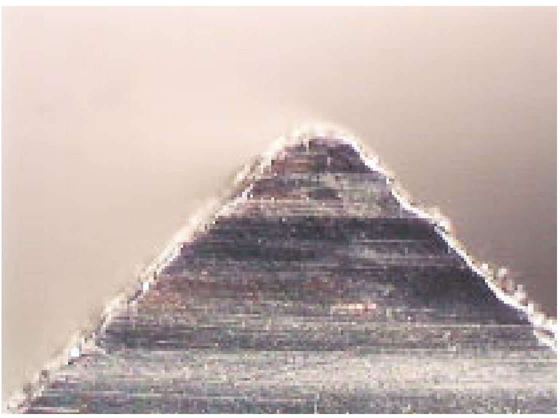
The Condition No. 2 specimen (1/16" chamfer on corner) prepared by Fabrication Shop A using Inorganic Zinc A also exhibited excellent corner build characteristics when compared to the coating thickness on the edge of the same specimen. The average edge build was approximately 6.5 mils; the average thickness on the corner was approximately 6.9 mils.

The specimen prepared by Fabrication Shop B using Inorganic Zinc B exhibited good corner build characteristics. The average coating thickness on the edge was approximately 3 mils; the average thickness on the corner was approximately 2 mils. One (1) of the four samples however had no visible coating on the corner. Again, the difference in corner build characteristics almost certainly reflects the application techniques employed by each shop.

Condition No. 3 (handling marks, nicks, etc.)

The Condition No. 3 specimen (handling marks, nicks, etc.) prepared by Fabrication Shop A using Inorganic Zinc A exhibited excellent coating build characteristics over unprepared handling marks, nicks and other substrate defects, when compared to the coating thickness on the edge of the same specimen. The average edge build was approximately 6 mils; the average thickness on the defects was approximately 7 mils.

The specimen prepared by Fabrication Shop B using Inorganic Zinc B exhibited good coating build characteristics over unprepared handling marks, nicks and other substrate defects. The average coating thickness on the edge was approximately 5.3 mils; the average thickness on the defect was approximately 4 mils. One (1) of the five (5) samples had no visible coating on the defect. This almost certainly reflects the application techniques employed by each shop.



Phase 3, Photograph 30, Specimen 26
(normal solids inorganic zinc #3)
Corner MR-0 (90°), 25X

Summary of Phase 3 Results

Inorganic Zinc-Rich Coatings

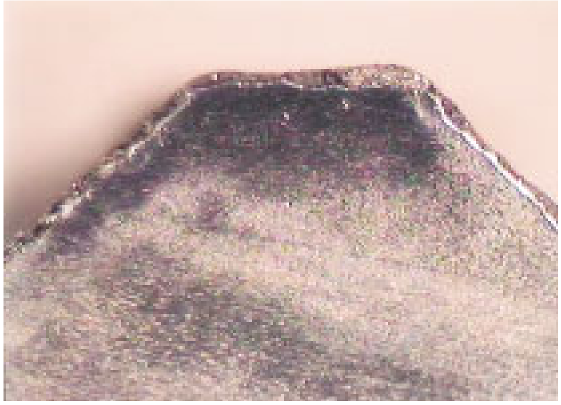
Independent of coating manufacturer and product, the inorganic zinc-rich coatings were capable of building coating thickness on an unprepared (unground) 90^{o} corner equivalent to the corners receiving additional treatment. Three (3) of the six (6) coatings systems did exhibit a corner coating thickness 0.5 mil lighter than the thickness measured on the edge. However, this slight difference in coating thickness is felt to be negligible, as the measured thickness was within the coating manufacturer's recommended minimum on the corner. The remaining three (3) systems exhibited corner coating thicknesses equal to or greater than the thickness measured on the corresponding edge. Further, it does not appear that the higher solids inorganic zinc formulations produce any higher build than the normal solids formulations.

While there are anomalous data points, none of the six (6) inorganic zinc-rich coatings illustrated any defined pattern of corner preparation and corresponding film build on the corner. The existence of such a pattern would have indicated that an increase in the degree of corner preparation has a positive affect on coating build on the corner, compared to the film build on the edge.

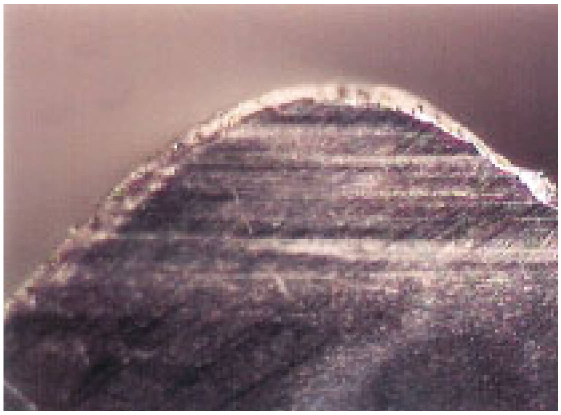
Independent of manufacture and solids content (normal verses high solids), the inorganic zinc-rich primers tested herein all performed well after 5,000 hours salt fog exposure, regardless of corner preparation (prior to coating application). The corners receiving the greatest treatment (1/8" rounded) did not perform any better than the 90^o corners. It is apparent then, that no treatment of the corners is required if an inorganic zinc-rich coating material is specified, provided that the coating materials are applied to the corners using proper spray technique to ensure full thickness and adequate coverage of the coating.

Organic Zinc-Rich Coatings

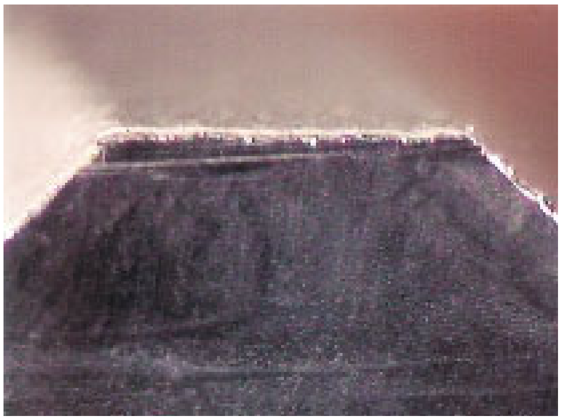
Based upon microscopic examination of the cross-sections, both of the epoxy zinc-rich coatings tested were capable of building coating thickness on an unprepared (unground) 90^o corner equivalent to the thickness on the corners receiving additional treatment. Only the urethane zinc-rich coating material tested did not build as well on the 90^o corner, compared



Phase 3, Photograph 31, Specimen 26
(normal solids inorganic zinc #3)
Corner MR-1 (1/16" chamfer)



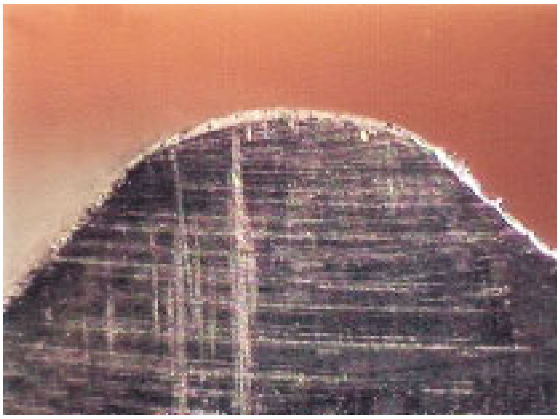
Phase 3, Photograph 32, Specimen 26
(normal solids inorganic zinc #3)
Corner MR-2 (1/16" rounded)



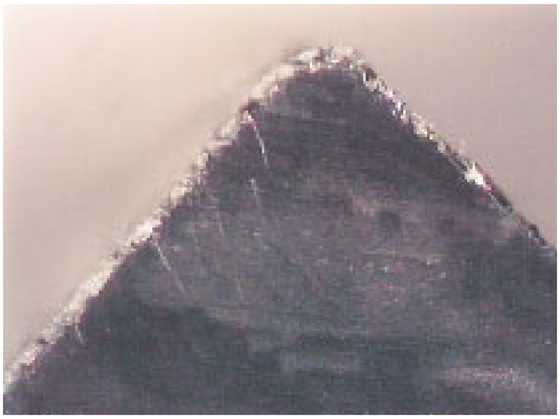
Phase 3, Photograph 33, Specimen 26
(normal solids inorganic zinc #3)
Corner MR-3 (1/8" chamfer)

to the thickness on the corresponding edge. The thickness on the corner was approximately 50% of the edge build. Minimal corner preparation (MR1-1/16" broken edge) appears to be adequate for this coating type. Three of the remaining four corner treatments indicated coating thickness build on the treated corner was as good as the film build on the corresponding edge. The fourth corner treatment (MR3) is felt to be an anomalous data point, based upon the corner coverage on treatments MR1, MR2 and MR4.

Based upon the performance of the corners after 5,000 hours salt fog exposure, all three of the organic zinc-rich primers tested require some minimal level of corner treatment prior to coating application, in order to achieve adequate film build on the corner. A common shop grinding practice known as “breaking the edge,” (i.e., MR-1 or 1/16" flat) is sufficient corner preparation for the organic zinc-rich coating systems tested, provided that the coating materials are applied to the corners using proper spray technique to ensure full thickness and adequate coverage of the coating.

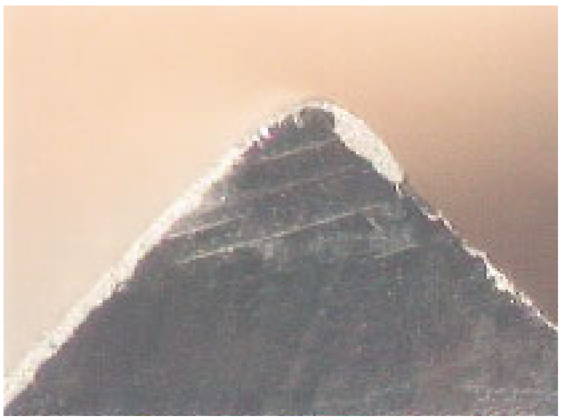


Phase 3, Photograph 34, Specimen 26
(normal solids inorganic zinc #3)
Corner MR-4 (1/8" rounded)



Phase 3, Photograph 42, Specimen 60
(high solids inorganic zinc #2)
Corner MR-0 (90º)

Phase 3, Photograph 60, Specimen 49
(organic [epoxy] zinc #2)
Corner MR-0 (90º)



Phase 3, Photograph 66, Specimen 22
(organic [urethane] zinc)
Corner MR-0 (90º)

CONCLUSIONS BASED ON COMPREHENSIVE STUDY

Based on the results of the three phases of this study, it is concluded that grinding of the corners in the shop, for the purpose of improving the surfaces for coating coverage and ultimately corrosion protection, is unnecessary when employing ethyl silicate inorganic zinc-rich primer systems with a minimum zinc loading of 83%.

Limited testing of organic zinc-rich coatings (two epoxy zinc-rich and one urethane zinc-rich) with minimal zinc loading of 84% used in Phase 3 indicates that minimal corner preparation (breaking the corner) generates a surface which provides sufficient coating performance.

RECOMMENDED PAINTING PRACTICES

Independent of corner preparation however, proper coating application technique is critical to the performance of the coating on the corners. Two Graco publications entitled, "Airless Spray Techniques" and "Air Spray Techniques" describe methods for spraying coatings to outside corners. It is acknowledged however that the actual spray technique employed is dependent on a number of variables including the type of structural member, flange thickness, degree of coating atomization and resulting size of the spray fan pattern, as well as the type of application equipment in use (airless verses conventional). Regardless of the exact spray technique for a specific configuration, it is critical that the actual spray technique employed be appropriate to ensure that corners are fully protected.

Disclaimer

All data, specifications, suggested practices, and drawings presented herein, are based on the best available information and delineated in accordance with recognized professional engineering principles and practices, and are published for general information only. Procedures and products, suggested or discussed, should not be used without first securing competent advice respecting their suitability for any given application.

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