The following appendices are supplemental to *NCHRP Research Report 1048: Corrosion Protection of Steel Bridges Using Duplex Coating Systems* (NCHRP Project 12-117, “Guidelines for Corrosion Protection of Steel Bridges Using Duplex Coating Systems.) The full report can be found by searching on the report title on the National Academies Press website (nap.nationalacademies.org).

# Appendix A: Extended Bibliography

# Appendix A: Extended Bibliography

**Ault and Farschon, 20-Year Performance of Bridge Maintenance Systems, Journal of Protective Coatings and Linings, January 2009.**

Author Abstract

In 1986-1987, New Jersey DOT applied forty-seven (47) different coating systems to various individual spans of the Mathis Bridge. The eastbound Mathis Bridge carries Route 37 over the Barnegat Bay from Toms River to Seaside Heights, New Jersey. Each experimental system was applied to a complete span comprising approximately 4,000 square feet of steel. Experimental coating systems included metallizing, various zinc-based systems, various levels of surface preparation, and several overcoating strategies (e.g., alkyd over a hand-tool cleaned surface).

This paper will present the results of an inspection conducted in 2007, nominally 20 years after the initial coating application. The inspection showed varied service lives associated with the different coating systems. Some of the systems were in excellent condition after 20 years while others had completely broken down. In addition to the present condition of the test spans, the paper will review the historical performance of the various coating systems as well as the applied cost. Finally, several important implications for maintenance planners will be presented. These will include cost-benefit calculations and risk-reduction strategies.

**Bajat, J. B., Miskovic-Stankovic V.B., Bibic N., and Drazic D.M. "The influence of zinc surface pretreatment on the adhesion of epoxy coating electrodeposited on hot dip galvanized steel" Progress in Organic Coatings 58 2007 323 – 330.**

Author Abstract

The adhesion and electrochemical properties of epoxy coatings electrodeposited on hot-dip galvanized steel with and without passive films were investigated during exposure to 3% NaCl. The passive films were formed in hot air, in boiling water and by chromating. Adhesion was measured both by a standardized pull-off method and by swelling in N-methyl pyrrolidone. Pretreatment of hot-dip galvanized steel with passive film formed in hot air increases both dry and wet adhesion strength of the epoxy coating compared to pretreatment with passive film formed in boiling water and chromate coating. The overall increase of wet adhesion for this sample was maintained throughout the whole investigated time period. It was shown that the change in adhesion of epoxy coating on a chromate coating is smallest of all investigated samples, although the initial value of adhesion on this surface had the lowest value. The corrosion stability of coated Zn samples pretreated by different methods, was investigated by electrochemical impedance spectroscopy and in the initial time of exposure to NaCl the highest values of pore resistance were also obtained for the epoxy coating on Zn pretreated in hot air, whereas the epoxy coating on a HDG steel with a chromate coating showed the smallest change in electrochemical properties (pore resistance, coating capacitance, charge-transfer resistance) during prolonged exposure time.

**Chang, L., and Maged Georgy, Steel Bridge Protection Policy Volume III Metallization of Steel Bridges: Research and Practice, Indiana Department of Transportation, West Lafayette, IN, 1999**

Author Abstract

The study identifies various painting systems that are successfully used in Indiana's surrounding states and other industries. The identified systems are further screened and evaluated. After prudently comparing INDOT's inorganic zinc / vinyl system with the waterborne acrylic system, the moisture cure urethane coating system, and the 3-coat system of zinc-epoxy-urethane, the results show that the new 3-coat system fulfills INDOT's needs with the most benefits. Therefore, the 3-coat system is recommended to replace INDOT present inorganic zinc / vinyl system.

To deal with the problems facing the lead-based paint, a comparison between full-removal and over-coating alternatives is made. Results show that over-coating might provide a good protection for less than half the cost of full-removal; however, it delays the lead full-removal process and does not completely solve the environmental problem.

The metalization of steel bridges is seemingly a potential protection policy. After reviewing standards and specifications on metalization, it is shown that metalization jobs require a higher degree of control. It suits on-shop practices; however, the initial cost is considerably high.

This study also describes a life cycle cost analysis that was done to determine an optimal painting system for INDOT. Herein, a deterministic method of economic analysis and a stochastic method of Markov chains process are used. The analysis not only reconfirms that the 3-coat system is the comparatively better painting system, but also generates an optimal painting maintenance plan for INDOT.

To assure the quality of paint material and workmanship after substantial completion of the painting contract, the development of legally binding and dependable warranty clauses is initiated in this study. The developed painting warranty clauses were primarily derived from the painting warranty clauses used by IDOT, MDOT, and INDOT's pavement warranty clauses. A comparative study was conducted on, eleven essential categories. Among them, it was found that the warranty period, the definition of "defect", and the amount of the warranty, and all need further evaluation.

**D. Thierry, D. Persson, N. Le Bozec. (2018). Atmospheric Corrosions of Zinc and Zinc Alloyed Coated Steel. *Chemistry, Molecular Sciences and Chemical Engineering,* pp. 55-78**

Author Abstract

This article reviews the atmospheric corrosion of zinc and zinc alloyed coated steel. The influence of the main environmental factors on the atmospheric corrosion of zinc is discussed as well as their impacts on the type of corrosion and corrosion products formed both under laboratory and field exposures. The corrosion behavior of zinc and zinc alloyed steel under field exposure conditions is detailed and the mechanisms of corrosion of zinc and hot-dip galvanized steel are discussed. Finally, the role of addition of magnesium and aluminium in zinc coating on the corrosion behavior of zinc alloyed coated steel is given and the importance of the type of patina on the corrosion performance of these coatings is discussed.

**D. Tordonato. (2012). Laboratory Evaluation of Metalized Coatings for Use on Reclamation Infrastructure,** ***Burea of Reclamation Denver***

Author Abstract

Metalized/thermal spray coatings (TSCs) were investigated by the Bureau of Reclamation's (Reclamation) Materials Engineering and Research Laboratory. The goal of this study was to evaluate the feasibility of using TSCs for corrosion protection on Reclamation equipment. The focus of this study was on thermal spray materials that are anodic (corrode preferentially) to steel. This study includes a literature review of metalizing by others as well as laboratory test programs that evaluated five thermal spray alloys and two sealer systems.

**Dallin, G., Gagné, M, et al.,** ***Duplex Coatings for Corrosion Protection of Steel Structures,*** **TRB annual meeting, (2018).**

Author Abstract

Paint is the primary corrosion control strategy for large steel structures, requiring near constant maintenance. Metallic zinc coatings with a paint top-coat, or 'Duplex Coatings,' offer both barrier and sacrificial corrosion protection mechanisms, with improved impact and abrasion resistance, and much longer lifetimes between maintenance compared to paint only coatings. Duplex coatings provide more than twice the life of the corrosion protection provided by one coating system alone. A paint top-coat over a metallic zinc base layer protects the zinc from initial corrosion. The zinc base layer similarly protects the paint from under film corrosion at scratches and holes. The synergy between the two coatings provides protection far superior to either system used independently. Empirical evidence shows that, depending on the environment, duplex zinc coatings will provide 1.5 to 2.3 times the sum of the expected life of each system alone. Duplex zinc coating systems have decades of proven performance protecting steel infrastructure from corrosion.

**Dickie, R. (1994). Paint adhesion, corrosion protection, and interfacial chemistry.** ***Progress in Organic Coatings*****, 25(1), pp.3-22.**

Author Abstract

Maintenance of adhesion under environmental exposure is a key performance parameter used to evaluate the protective capability of corrosion-protective paint systems. Interfacial chemical reactions involved in the establishment of paint adhesion, in the suppression of corrosion processes, and in the degradation and loss of paint adhesion have been extensively studied using modern surface analytical techniques. This paper reviews some of the phenomenological and mechanistic conclusions obtained from surface analytical studies. The chemistry of the interface, and the composition of the paint resin, play especially important roles in the initial stages of corrosion-induced paint adhesion loss. Physical degradation processes and their interaction with interfacial chemical processes need to be considered in evaluating the long-term durability of corrosion protective paint systems. Research needs related to paint adhesion, interfacial chemistry, and mechanisms of adhesion loss are discussed.

**Duran, Bernardo (2022). Combining Thermal Spray Zinc and Hot-Dip Galvanizing To Achieve an All-Metallic Zinc Coating System. Paper No. 18207 presented at AMPP Annual Conference, March 2022.**

Author 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.

**Ellor, James A., John Repp, and Walter A. Young, Thermally Sprayed Metal Coatings to Protect Steel Piling: Final Report and Guide, NCHRP Report 528, Transportation Research Board, Washington, DC, 2004**

Author Abstract

Thermally sprayed metal coatings (TSMCs) are available as alloys of base metals such as aluminum and zinc. TSMCs can offer substantial advantages when compared with other types of coatings commonly used to protect steel pilings primarily because of their resistance to corrosion and handling damage. However, available publications do not provide sufficient guidance for highway agency personnel on TSMC materials and the use of TSMCs for steel pilings. Without this information, there is reluctance to use this technology. There has been a need for research on the use of TSMCs to protect steel pilings. Conclusions concerning the performance and potential benefits of TSMCs are needed as is a guide to assist state highway agencies in properly specifying and applying TSMCs. A guide can help highway agency personnel responsible for steel pilings to consider TSMCs and to make more rational decisions about the use of protective pile coatings.

Under NCHRP Project 24-10, Corrpro Companies, Inc., investigated the existing state of knowledge pertaining to TSMCs and developed a guide addressing the application of TSMCs for the protection of steel pilings. The guide was developed as the result of investigating existing standards and specifications, coating applicators, and widely used practices pertaining to TSMCs. Laboratory work was performed to refine critical areas not adequately addressed in current literature and practice such as abrasive mix, edge geometry, sealers, and steel hardness variations.

The final report for this project includes a literature review, a synthesis of existing practice, a presentation of laboratory results, and four supporting appendixes:

- Appendix A: List and Description of Existing TSMC Specifications,
- Appendix B: List and Description of Existing TSMC Guides,
- Appendix C: Literature Review References and Summaries, and
- Appendix D: Bibliography.

The Thermally Sprayed Metal Coating Guide, which is the primary product of this research, includes procedures for the application of TSMCs for corrosion control on piles used in highway construction. The guide provides information for a user to select, specify, and apply a metal coating for steel piles in freshwater, brackish, or seawater environments. The guide will significantly enhance the capabilities of highway agencies in using TSMCs to protect steel pilings from corrosion.

**Federal Highway Administration (FHWA) Study Tour for Bridge Maintenance Coatings, International Technology Research Institute, June 1996.**

Author Abstract

Regulatory impact in environmental impact and worker safety and changes in coating material technology have led to rapid changes in the bridge maintenance coating market. The FHWA commissioned a team to pursue technology transfer to the steel bridge maintenance coating methods with the European highway community. This report highlight the methods and materials identified during this technology transfer. Topics include contracting operations, surface preparation methods, worker health and safety, environmental considerations, agency-contractor relations, bridge management systems, and metallizing.

**Gagné, M., Knudsen, O.Ø., and Dahle, K. O. (2022). Life Cycle Costs for Thermal Spray Zinc Duplex Coatings on Long Lifetime Steel Constructions. Paper No. 17803 presented at AMPP Annual Conference, March 2022.**

Author Abstract

Public infrastructures like bridges typically have a design lifetime of 100 years or more. When selecting protective coatings in such a long term perspective, focus should be on life cycle costs and not only the costs in the construction phase, since the maintenance costs may be considerable and dominate the total cost of ownership. Coating selection standards like ISO 12944 are not intended for such a long timescale, and there is little documentation in the literature of coating performance with lifetimes of more than about 20 years. Owners of structures with very long lifetimes have little information to base their coating selection on, besides their own experiences. Thermal spray zinc (TSZ) duplex coatings have been shown to be highly durable, as evidenced by more than 50 years of successful use since first specified by the Norwegian Public Roads Administration (NPRA). The paper will summarize field examinations, maintenance costs, coating lifetime expectations and life cycle cost estimates for steel bridges as a function of the environmental corrosivity category (C1-C5) and make comparisons to alternative coatings that are less expensive to apply but that have shorter lifetime expectancy.

**Ghorbanpoor, A., Tabatabai, H., Leppi, Z., *Aesthetic Coatings for Steel Bridge Components*, Wisconsin DOT, (2013).**

Author Abstract

The effectiveness of aesthetic coating systems for steel bridges was studied. Twelve 2-coat, 3-coat, and duplex coating systems were selected and subjected to a series of accelerated weathering and mechanical tests to determine their performance. The performance evaluation was made by considering gloss and color retention, coating discontinuities, rust creepage, and coating adhesion. Surface preparation and coating application procedures were given significant consideration. The best color and gloss retention were achieved by the 3-coat fluoropolymer systems, but they required higher materials cost. One of the two 2-coat systems performed nearly the same as the 3-coat polyurethane coating systems and the other showed a poor performance with significant color fading. Duplex polyurethane systems showed comparable performance to that of the 3-coat fluoropolymer systems, but they performed better than the 3-coat polyurethane systems. This was primarily due to the added corrosion protection provided by the hot dip galvanization. It was found that proper adhesion in a duplex system can be achieved by following appropriate procedures for galvanization and surface preparation. Both duplex powder coated systems tested in this study experienced out-gassing problems during the initial application and did not show satisfactory performance.

**Hofman, R., Vreijling, M., Ferrari, G. and de Wit, J. (1998). Electrochemical Methods for Characterisation of Thermal Spray Corrosion Resistant Stainless-Steel Coatings.** ***Materials Science Forum*****, 289-292, pp.641-654.**

Author Abstract

The purpose of this thesis is to demonstrate the usefulness of electrochemical measurements for the characterization of the corrosion and corrosion protection properties of thermally sprayed coatings. The presented results are a selection of the data obtained during the investigation of thermally sprayed coatings over the period from spring 1994 to the summer of 1998 at the TNO Laboratories for Corrosion Prevention in Den Helder, The Netherlands. Inevitably, during a demonstration of the usefulness of a technique, also its limitations will become clear. A purely electrochemical investigation proved to be too limited for practical use. For this reason, also, other investigation techniques were used (e.g. mechanical tests and microscopy). Nonetheless, in some cases it became clear that it would be impossible to achieve a complete understanding of the corrosion reaction mechanisms. In fact, the in-depth study of some of the encountered phenomena could well result in new research projects. However, the usefulness of electrochemical measuring techniques was demonstrated clearly.

**Helsel, Jayson L. and Lanterman, Robert (2022). Expected Service Life and Cost Considerations for Maintenance and New Construction Protective Coating Work. Paper No. 17616 presented at AMPP Annual Conference, March 2022.**

Author Abstract

This paper is an update to "Expected Service Life and Cost Considerations for Maintenance and New Construction Protective Coating Work" by the authors in 2018.

Designed to assist the coatings engineer or specifier in identifying candidate protective coating systems for specific service environments applicable to a broad array of industries, this paper provides: 1) commonly used generic coating systems; 2) service life for each in specific environments; 3) current material costs; 4) current field and shop painting costs; and 5) guidelines for calculating approximate installed costs of the systems. Guidelines for developing long-term life-cycle costs and number of paintings for the expected life of the structure are included. The basic elements of economic analysis and justification are addressed together with guidance on the preparation of a Present Value Analysis. Examples are provided to aid the reader in the proper use of the information. Updates to the paper include revisions to the coating systems for atmospheric exposure, new discussion related to maintenance painting strategies and updated cost data.

**International Lead Zinc Research Organization, Galvanizing reactive steels, a guide for galvanizers and specifiers.**

Author Abstract

A hot dip galvanized coating on steel, produced under typical commercial conditions, is expected to be smooth, shiny and frequently with a crystalline 'spangle' pattern on the surface. The cross section of such a coating shows that it is made up of a series of largely coherent iron-zinc alloy layers, topped by a layer of unalloyed zinc. This structure provides the hot dip galvanized coating with its unique combination of toughness and corrosion resistance. However, from time to time all or part of the steel being galvanized reacts very rapidly with the zinc producing a coating which is dull grey in appearance, excessively thick, brittle and poorly adherent. Such coatings have two broad types of structures.

**Jordan, D., Franks, L. and Kallend, J.** ***Relative Contributions of Several Cathodic Reactions to the Anodic Dissolution of Electrogalvanized Steel.*** **CORROSION, 52(3), pp.187-193. (1996).**

<u>Author Abstract</u>

Zero-resistance ammeter (ZRA) measurements and a 23 full-factorial statistical experimental design were used to determine the effects of pH, oxygen, and red rust on the cathodic half-cell reaction on corroding electrogalvanized steel. Analysis of variance indicated that the red rust reduction reaction was dominant. The recently developed galvanic corrosion-mechanical wedging model for under film corrosion of painted galvanized steel was supported.

**Karlsson, J., Corrosion Mechanisms Under Organic Coatings, 2011**

<u>Author Abstract</u>

The demands on the corrosion protection in the automotive industry are very extensive. A car is subjected to various environments and there are many factors affecting the corrosion. There are thus high demands also on the corrosion testing. Many studies have been made concerning atmospheric corrosion but corrosion under a paint coating system is fairly unexplored. Such studies are important in understanding the corrosion mechanism possible in automotive corrosion. Phosphating is the pretreatment used in the automotive industry today and offer an excellent corrosion protection to the painted metal. However due to environmental aspects and possible legislation a need for new pretreatments, next generation pretreatments (NGPT) have developed and are under evaluation. Two types of NGPT´s are of greatest interest, a silane based one and a zirconium based one. The purpose of this project is to investigate corrosion under organic coating in an attempt to understand the corrosion mechanisms. The influence of different pretreatments in this context is also studied. The most existent corrosion product found was a zinc hydroxy chloride called simonkolleite [$Zn_5Cl_2(OH)_8{*}H_2O$] despite different pretreatments and exposure methods. This compound was found in a growth ring pattern on all materials from the cyclic corrosion test. The growth rings are related to the cycles in corrosion test chambers. The growth ring pattern is more distinct on the NGPT panels. The corrosion is spread in a circular manner from a small cathodic spot in the scribe. The scribe is applied to act as an initiation point for the corrosion. The analyses were preformed mainly with SEM/EDS and to some extent with optical microscopy and FTIR. The study shows a clear difference in morphology between the different pretreatments, however bending test shows no differences in adhesiveness to paint coating. The bending test showed that the fracture occurred within the pretreatment layer. In the cyclic corrosion test, however, the pretreatment layer is present on the paint side of the fracture.

**Knudsen, O., Matre, H., (2019). Experiences with Thermal Spray Zinc Duplex Coatings on Road Bridges.** ***MDPI Coatings,*** **371, pp.1-15**

<u>Author Abstract</u>

Road bridges are typically designed with a 100-year lifetime, so protective coatings with very long durability are desired. Thermal spray zinc (TSZ) duplex coatings have proven to be very durable. The Norwegian Public Roads Administration (NPRA) has specified TSZ duplex coatings for protection of steel bridges since 1965. In this study, the performance of TSZ duplex coatings on 61 steel bridges has been analyzed. Based on corrosivity measurements on five bridges, a corrosivity category was estimated for each bridge in the study. Coating performance was evaluated from pictures taken by the NPRA during routine inspections of the bridges. The results show that very long lifetimes can be achieved with TSZ duplex coatings. There are examples of 50-year old bridges with duplex coatings in good condition. Even in very corrosive environments, more than 40-year old coatings are still in good condition. While there are a few bridges in this study where the coating failed after only about 20 years, the typical coating failures are due to application errors, low paint film thickness and saponification of the paint. Modern bridge designs and improved coating systems are assumed to increase the duplex coating lifetime on bridges even further.

**Knudsen, O, Coating systems for long lifetime: Thermally Sprayed Duplex Systems, *SINTEF Final Report*, (2010)**

Author Abstract

Thermally sprayed zinc or aluminum in combination with organic coatings, TS Duplex Coating Systems, is a common method used for corrosion protection of bridges, ships and oil- and gas installations. These systems are supposed to provide a long lifetime (>20 years), and with that, be both cost effective and environment friendly. However, so far, the potential market for these protective systems has not been reached. Potential users of such systems may have become sceptical because of some reported cases with rapid degradation. Particularly for systems were TS aluminum has been used, there have been problems. The main goals of this project have been to solve these problems, and to find an optimal protective system, which combines thermally sprayed metals with paint, and still have a relatively low price.

**Kogler, R, J. Ault, J. and Farschon, C. Environmentally Acceptable Materials for the Corrosion Protection of Steel Bridges (Report No. FHWA-RD-96-058), Federal Highway Administration, Washington, DC, January 1997.**

Author Abstract

The recently promulgated environmental regulations concerning volatile organic compounds (VOC) and certain hazardous heavy metals have had a great impact on the bridge painting industry. As a response to these regulations, many of the major coaling manufacturers now offer "environmentally acceptable" alternative coating systems to replace those traditionally used on bridge structures. The Federal Highway Administration sponsored a 7-year study to determine the relative corrosion control performance of these newly available coating systems. A battery of accelerated laboratory tests were performed on candidate coating materials with a maximum VOC content of 340 g/L (2.8 lbs/gal). Accelerated tests included cyclic salt fog/ natural marine exposure, cyclic brine immersion/natural marine exposure, and natural marine exposure testing. Natural exposure test panels were exposed and evaluated for a total of 6.5 years. The most promising coating systems were selected for long-term field evaluation based on accelerated test performance.

The long-term exposure testing was conducted for 5 years in three marine locations. Panels were exposed on two bridges, one in New Jersey, and one in southern Louisiana. The third long-term exposure location was in Sea Isle City, New Jersey. Thirteen coating systems were included for long-term exposure testing. These Included 2 high-VOC controls and 11 test systems having a VOC level of 340 g/L (2.8 lbs/gal) or less. Five of the test systems contained high-solids primers, two of the test systems contained waterborne primers, one system was based on a powder coating, and three systems were metallizing.

The best performing systems were the three metallized coatings. These were initially less aesthetic than coating systems with high-gloss topcoats, but they displayed near-perfect corrosion performance after 5-to 6.5-year exposure periods. Of the traditional liquid applied coating systems, those incorporating inorganic zinc primers performed the best over near-white blasted and power-tool cleaned surfaces. High-solids epoxy coatings had a tendency to undercut at intentional scribes and rust worse than coatings with zinc-rich primers over less than ideal surface preparations.

Current bridge painting methodologies and corrosiveness of various bridge substructures were investigated. Various bridge maintenance painting options were evaluated on a life-cycle cost basis using data developed in the program. The analysis points to the potential advantages of long-term durable coatings such as metallizing and alternative painting practices such as zone painting.

**Kogler, R., Brydl, D., Highsmith, C. "Recent FHWA Experience in Testing and Implementing Metallzed Coatings for Steel Bridges," Corrosion 98, Paper no. 499, 1998.**

Author Abstract

Thermal sprayed metal coatings (metallizing) have been used for corrosion control on steel structures for many years in various industrial applications. The US Navy has used thermal sprayed aluminum (TSA) coatings for high and low temperature corrosion protection in some of the most severe shipboard applications since the 1970s, with excellent success. In addition, the offshore industry has used thermal sprayed coatings to protect steel for many years. Other good performance histories of using metallizing processes to protect steel have been well documented. In spite of the availability and good service history of thermal sprayed coatings in other industries, the use of metallizing to protect bridge steel has been limited in the U.S. For the most part, this limitation has been caused by the generic lack of emphasis on coating performance during the construction of most of the bridges in the U.S. highway system. Also, metallizing traditionally has posed a significant cost increase over paint application in the fabrication shop, particularly in field maintenance applications.

**Kogler, R., Mott, W. Environmentally Acceptable Materials for the Corrosion Protection of Steel Bridges: Task C, Laboratory Evaluation (Report No. FHWA-RD-91-060), Federal Highway Administration, Washington, DC, September 1992.**

Author Abstract

Environmental regulations concerning volatile organic compounds (VOCs) and certain hazardous heavy metals have had a large impact on the bridge painting industry. As a response to these regulations, many of the major coating manufacturers have begun to offer "environmentally acceptable" alternative coating systems to replace those traditionally used on bridge structures. In the interest of determining the relative corrosion control performance of these newly available coating systems, the Federal Highway Administration contracted for a seven-year study. As a precursor to long-term, natural exposure testing of various environmentally acceptable coating systems, a battery of accelerated laboratory screening tests were performed. These tests included 13 high solids or waterborne, conventionally applied coatings; 14 powder coating or metallized coatings; and 7 high VOC control coatings. The results of various tests were used to develop a matrix of test coatings to be used in the follow-on, long-term natural exposure testing. In the accelerated laboratory screening tests, several of the low VOC coating systems performed as well, or better than the high VOC controls. In general, the low VOC zinc-based systems (both inorganic and organic zinc) and the epoxy mastic type systems performed the best in the accelerated tests.

***KYTC- Kentucky Transportation Cabinet*, SHRP2 Solutions, (2015)**

Summary

This presentation shows KTC's Accelerated Bridge Construction Project in Knox County – KY 6 over Stewart's Creek. The replacement structure used a Duplex Coating System consisting of painted galvanizing. Steel was galvanized at AZZ's facility in Nashville, TN. Lessons learned included blast cleaning to SP-10 prior to galvanizing and specifying Si and P content of steel.

**Larsen, K. (2010). Modern Corrosion Control Adds More Life to 83-Year-Old Bridge, *NACE International Materials Performance*, Vol 49, pp. 26-30**

Author Abstract

After four years of extensive rehabilitation work that integrated the repair and replacement of components degraded by corrosion and wear, the 83-year-old Bridge of Lions in St. Augustine, Florida is once again open to travelers. Although the "new" look of the bridge mirrors its initial appearance with almost complete historical accuracy, the renovation merged original bridge parts with modern-day materials and technologies, including corrosion control, that are expected to give the reborn structure 100 years of additional service life.

**Langill, T., *Preparing Hot-Dip Galvanized Coating Surfaces for Painting*, SSPC, (2015).**

Author Abstract

Duplex systems, also known as painting over hot dip galvanized steel, are extremely effective corrosion protection systems. However, careful surface preparation techniques need to be used to alleviate potential coating failures. The age and characteristics of the galvanized coating should be used to determine what type of surface preparation is needed. Surface preparation should develop an anchor profile for the paint without removing the zinc coating.

**Lau, Kingsley, Corrosion Evaluation of Novel Coatings for Steel Components of Highway Bridges, Tallahassee, FL, 2015**

Author Abstract

The Florida Department of Transportation (FDOT) had expressed interest in gauging the available coating technologies that may have suitable applications for steel components in highway bridges. The motivation was to possibly identify coating systems that would provide corrosion durability of steel components in highway bridges and reduce costs associated with regular inspection and maintenance of the coating systems. Chemically bonded phosphate ceramics (CBPC) and the thermal diffusion galvanizing (TDG) process have been identified for further testing due to growing interest in the systems for possible corrosion mitigation, the lack of sufficient data to determine their effectiveness for corrosion protection of steel structures, and their commercial availability. An issue for further evaluation of long term durability and corrosion protection by CBPC coatings is the degree of deterioration of the ceramic coating in aggressive environments. Initial testing showed that the material was not durable in highly alkaline solutions (pH 13), and in exposure conditions that cycle between frequent high moisture contents and drying conditions. The rather short-term outdoor exposures investigated so far have produced some promising results, but the significant extent of undercoating surface oxidation that was observed may compromise long-term durability. The intermediate alloy layer was not consistently identified and its role in corrosion mitigation has not been elucidated. Although no severe steel corrosion was observed for TDG in outdoor exposure, degradation of the topcoat, when present, and subsequent consumption of the TDG would result in a shorter service life of the coating for corrosion mitigation. Variations in quality of the topcoats resulted in variations in coating performance. The findings suggest that sufficient application of the TDG and robust topcoats are required for long-term durability.

**Lee, H., Singh, J., et al. *Corrosion mechanism and kinetics of Al-Zn coating deposited by arc thermal spraying process in saline solution at prolong exposure periods*. Scientific Reports, 9(1). (2019).**

Author Abstract

Steel structures significantly degrades owing to corrosion especially in coastal and industrial areas where significant amounts of aggressive ions are present. Therefore, anodic metals such as Al and Zn are used to protect steel. In the present study, we provide insights for the corrosion mechanism and kinetics of Al-Zn pseudo alloy coating deposited on mild steel plate via an arc thermal spraying process in 3.5 wt.% NaCl solution in terms of its improved corrosion resistance properties at prolonged exposure durations. Electrochemical studies including open circuit potential (OCP) and electrochemical impedance spectroscopy (EIS) on the deposited coating at longer exposure durations revealed enhanced corrosion resistance properties while the morphology of corrosion products through field emission-scanning electron microscopy (FE-SEM) indicated their compactness and adherence. Furthermore, atomic force microscopy (AFM) confirmed reduced roughness when compared with that of unexposed coating. Additionally, X-ray diffraction (XRD) and Raman spectroscopy results confirmed the formation of protective, adherent, and sparingly soluble Simonkolleite ($Zn_5(OH)_8Cl_2 \cdot H_2O$) after 55 d of exposure in 3.5 wt.% NaCl solution. A schematic is proposed that explains the corrosion process of Al–Zn pseudo alloy coating in 3.5 wt.% NaCl solution from the deposition of coating and initiation of corrosion to longer exposure durations.

**Maeda, S. (1996). Surface chemistry of galvanized steel sheets relevant to adhesion performance. *Progress in Organic Coatings*, 28(4), pp.227-238.**

Author Abstract

A review is presented on the recent development of surface treatment technologies for hot-dip galvanized steels relevant to adhesion of organic coatings. Applications of surface analytical techniques have elucidated that the surface layers of the nanometer scale dramatically govern the adhesion performance of painting or adhesive bonding. Surface enrichment of aluminium in the zinc layer deteriorates paint adhesion due to the reduction in phosphatability on the galvanized steel sheets and decreases the adhesive strength of the epoxy/dicyandiamide-bonded sheets due to the loss of acid-base interaction at the adhesive-substrate interface. In addition, the co-segregation of Al and Pb into the surface layer is responsible for the intergranular corrosion of zinc and facilitates the formation of a weak boundary layer, resulting in poor bond durability in a wet atmosphere. Improved adhesion performance has been established by developing new technologies that reduce the surface enrichment of minor elements or impurities in the zinc layer on the galvanizing line or that adopt a surface conditioning process prior to pretreatment in subsequent coil coating lines.

**Mandeno, W., *Thermal Metal Spray: Successes, Failures and Lessons Learned,* Corrosion & Prevention, Paper 167, (2012).**

Author Abstract

Thermally sprayed metal (TSM) includes proven long-term protective coating systems for steelwork in a marine environment such as thermal sprayed zinc (TSZ) and thermal sprayed aluminum (TSA); however, specifiers have been slow to adopt these in Australia. This paper reviews the technology then looks at several projects in New Zealand and overseas, somewhere a premature failure has occurred, and discusses these and the lessons that should be learned. It concludes with recommendations as to how coating specifications could be improved so that TSM's potential long-life performance can be achieved.

**Mansfeld, F., Kendig, M. and Tsai, S. (1982). Evaluation of Corrosion Behavior of Coated Metals with AC Impedance Measurements. *CORROSION*, 38(9), pp.478-485.**

<u>Author Abstract</u>

AC impedance measurements have been performed in 0.5 N NaCI for coated steel and aluminum alloys which had been subjected to different surface treatment procedures. These procedures included phosphating for steel and exposure to a conversion coating for the Al alloys. A polybutadiene coating of 8 ± 2μm thickness was applied by spin coating. The AC impedance measurements made it possible to follow the penetration of electrolyte into the coating and to detect the initiation of corrosion at the metal/coating interface. A general model has been used to analyze the impedance data in terms of reactions occurring during the interaction of the coated metals with the environment. Based on this analysis the different pretreatment procedures have been ranked in terms of their efficiency in providing corrosion protection by the organic coating. A comparison between impedance results and visual observation over several days of the corroded and the delaminated areas under the coating confirm that AC impedance data can be used to characterize organic coating/metal systems.

**Marty Wilson, Christopher Howard, Aaron Speisman, and Greg Richards, "SR 292 Over Perdido Key—Challenges to Field Metallizing of Steel Superstructure," SSPC 2018.**

<u>Author Abstract</u>

The Florida Department of Transportation (FDOT) undertook recoating of the superstructure steel components of the SR 292 high-level bridge over the Intracoastal Water Way (ICWW) in Perdido Key, Florida, which carries one lane of traffic in each direction and is the only connection between Perdido Key and the mainland. Due to the significant impact to businesses and the public, including tourists, from any proposed lane closures, FDOT looked for other means to address the deteriorating paint system, provide for a longer service life, and complete the work without any lane closures on the bridge. This paper describes the project's repair design and highlights the design issues, particularly the restrictions on having no lane closures and all work being completed from below deck; the design decision to use field metalizing on the superstructure steel components to reduce future maintenance needs and rehabilitation; replacement of deteriorated steel components; modifications to the FDOT specifications to address the metalizing work; and the decisions made during construction to allow for the timely completion of the project. The paper includes typical metalizing processes applied to the project to assure a successful installation.

**McMahon, M. (2019). Development of new criteria for evaluating the effectiveness of Zn-rich primers in protecting Al-Mg alloys. *Science Direct*, 135, pp. 392-409**

<u>Author Abstract</u>

One inorganic and three organic Zn rich primers (ZRPs) without a pretreatment or a top coat we reevaluated on highly sensitized aluminum alloy 5456-H116 in 0.6 MNaCl for their ability to suppress intergranular corrosion (IGC) and intergranular stress corrosion cracking (IG-SCC) based on the achievement and maintenance of protective potentials under simulated galvanic coupling conditions. These evaluations utilized a combination of existing criteria (e.g. the need to establish an intermediate cathodic potential) and additional new criteria based on fast anodic response and low polarizability. Ethyl silicate, epoxy, epoxy polyamide, and polyurethane resins were considered. Accelerated electrochemical cycle testing in full 0.6M NaCl immersion demonstrated that anodic charge usage in the candidate ZRPs had a greater dependence on the pore resistance than on theoretical anodic charge capacity. Electrochemical impedance spectroscopy modeling of cycle testing data demonstrated that the ZRPs with low pore resistance also had the fastest anodic response time. Galvanostatic pulse testing demonstrated that the ZRPs with the highest anodic charge usage and low pore resistance were also the least polarizable. These analyses propose relevant metrics to evaluate the effectiveness of Zn-rich primers in a complex challenge heretofore not considered: suppressing IGC/IG-SCC on highly sensitized 5456-H116 in aggressive alternate immersion environments.

**Meade, B., *Duplex Coatings on Transportation Cabinet Bridges,* JPCL, (2017).**

Author Abstract

The 2016 U.S. bridge inventory lists almost 610,000 highway bridges. Industry experts believe that the cost of maintaining these bridges for repairs due to corrosion is at least $30 billion annually. New bridges are being constructed nationally at the rate of approximately 3,000 each year and these new bridges must not pose additional maintenance burdens on already inadequate bridge maintenance budgets. Bridges have been historically designed for a theoretical 50-year service life but in most cases remain in service in excess of 75 years, and the Federal Highway Administration (FHWA) has long sought a 100-year bridge design. To seek design service lives of 100 years implies that the foreseeable service lives will actually exceed 100 years. One tool that bridge designers can employ in seeking this goal is the use of hot-dip galvanizing (HDG) and duplex coatings for bridges where appropriate.

**Mittal, K., Adhesion Aspects of Polymeric Coatings," 1983**

Author Abstract

This volume documents the proceedings of the "Second International Symposium on Adhesion Aspects of Polymeric Coatings" held in Newark, New Jersey, May 25-26, 2000. Since the first symposium, held in 1981, there had been tremendous research activity relative to the adhesion aspects of polymeric coatings. Polymeric coatings are used for a variety of purposes. Irrespective of the intended purpose of the coating, it must adequately adhere to the underlying substrate, otherwise delamination and other undesirable phenomena occur. So the need to understand the factors which influence adhesion of polymeric coatings and to control it to a desirable level is quite patent. This volume contains a total of 13 papers, which were all properly peer reviewed, revised and edited before inclusion. Furthermore, the authors were asked to update their manuscripts, so the information contained in this book should be current and fresh. The topics covered in this book include: factors influencing adhesion of polymeric coatings; ways to improve adhesion; formation and relevance of interphase in practical adhesion; adhesion/cohesion in painted plastics; imaging of polymer surfaces; effect of substrate residue (smut) on coating process; surface treatment of metals and glass by silanes; surface modification of polyphenylene sulfide plastics; resin bonding in dentistry; measurement of internal stresses in polymeric coatings; effect of steel surface composition on adhesion of paint; wet adhesion of coatings on wood; and modified tape test to measure adhesion of coatings.

**Nazarov, A., Olivier, M. and Thierry, D. (2012). SKP and FT-IR microscopy study of the paint corrosion de-adhesion from the surface of galvanized steel.** ***Progress in Organic Coatings*****, 74(2), pp.356-364.**

Author Abstract

Scanning Kelvin Probe (SKP) and FTIR microscopy were applied to study the atmospheric corrosion of galvanized steel coated by electrophoretic epoxy resin (ED) at a defect.

The SKP was useful to determine the spatial separation of the electrochemical reactions at a defect and surrounding metal/paint interface and to evaluate the formation of the galvanic cells. FT-IR microscopy was helpful to identify the composition and distribution of the corrosion products in the galvanic cells.

It was shown that the cathodic delamination of coating takes place after deposition of a thick water electrolyte film in the defect. The anodic undermining of the coating is favoured in case of atmospheric corrosion under thin electrolyte films. The anodic de-adhesion starting from defect reaching the zinc layer and from the non-protected cut edge in case of exposure in the salt spray conditions was also determined.

The role of the formation of confined volume underneath the delaminated paint on the rate of anodic undermining is discussed.

**Ocel, Slip and Creep of Thermal Spray Coatings, Report FHWA-HRT-14-083, Federal Highway Administration, 2014**

Excerpts from the paper

All steel bridge systems and their components need some level of corrosion protection to assure a serviceable life. One of two approaches is typically used: either the bridge component is fabricated from a corrosion-resistant alloy, or the steel is coated for protection. The most common coating practice is use of a multilayered paint system over a zinc-rich primer. Other coating alternatives for corrosion protection are hot-dip zinc galvanization and thermal spray coatings (TSC). Both galvanization and TSCs offer better long-term corrosion protection than zinc-bearing paint systems in severe environments. For this reason, these alternative-coating systems need to be mainstreamed for the protection of steel bridges.

In addition to corrosion resistance, the coating must be compatible with use in high-strength bolted connections. The American Association of State Highway and Transportation Officials (AASHTO) Load and Resistance Factor Design (LRFD) Bridge Design Specifications require bolted connections be designed as “slip-critical” if the connection is subjected to “…stress reversal, heavy impact loads, severe vibration or located where stress and strain due to joint slippage would be detrimental to the serviceability of the structure…”(1) Slip-critical connections rely on the clamping force from the bolts to develop frictional shear stresses as the means to transfer force from one element to the next. This construction is in contrast to bearing connections, in which the individual connection elements bear on the bolt and the force is transferred through shear stresses in the bolt itself. In the design of a slip-critical connection, the engineer must select a “frictional slip coefficient” between the layers of a connection to calculate the slip resistance. AASHTO refers to this frictional value as a “surface condition factor,” although in this TechBrief, it will be referred to as the “slip coefficient.” The engineer does not specify an exact slip coefficient; rather, the AASHTO LRFD Bridge Design Specifications provide three different categories (Class A, B, and C) from which the engineer can choose.

Coatings applied over blast-cleaned surfaces must be demonstrated through testing to achieve either Class A or B slip resistance and be certified as such. From the perspective of the bridge fabricator, there may be advantages to using slip-certified coatings in the faying surfaces of slip-critical connections. For instance, if the bridge will be painted, then it will have to be blast-cleaned prior to paint application, and primers should be applied shortly after blast-cleaning before the steel can flash rust. If the primer has been certified to provide a certain slip coefficient, then the entire piece can be primed without masking off the areas of the faying surfaces, a time-consuming step that adds cost to the overall fabrication of the bridge. The AASHTO LRFD Bridge Design Specifications say nothing about the use of TSCs on the faying surface. That is not to say they cannot be used, but because they are not directly referenced, there may be an aversion to specifying their use because of their unknown slip resistance.

This TechBrief introduces limited data on the slip coefficients developed by both sealed and unsealed TSCs.

Because of their rough textures, unsealed zinc and zinc/aluminum alloy TSCs had no problems passing Class B slip performance requirements in accordance with the RCSC specification. However, once the surface was sealed, neither coating system could meet the RCSC criteria for failing the creep test (despite achieving Class A short-term slip resistance). Until further research can demonstrate slip-critical performance of sealed TSCs, it is recommended that slip-critical faying surfaces be either masked off in fabrication or assembled before application of TSC sealers.

**Persson, D., Thierry, D. and Karlsson, O. (2017). Corrosion and corrosion products of hot dipped galvanized steel during long term atmospheric exposure at different sites world-wide. *Corrosion Science*, 126, pp.152-165.**

Author Abstract

The atmospheric corrosion of hot dipped galvanized steel was studied in a wide-world exposure in Europe, East Asia and USA. The corrosion product composition, morphology and surface distribution was investigated after 0.5, 1, and 2 years exposure. The corrosion was localized for all exposure conditions with sulfate and chloride containing corrosion products $(Zn(OH)_2)_3 \cdot ZnSO_4 \cdot nH_2O$,$NaZn_4(SO_4)(OH)_6Cl \cdot 6H_2O$ and $Zn_5(OH)_8Cl_2 \cdot H_2O$ formed at the anodic sites in corrosion pits and $Zn_5(OH)_6(CO_3)_2$ mainly in the outer parts of the corrosion products and cathodic areas outside the pits. The content of the sulfate containing corrosion products increased in the order marine < marine/urban, marine/industrial<Industrial/urban.

**Rossi, B., Marquart, S. and Rossi, G. (2017). Comparative life cycle cost assessment of painted and hot-dip galvanized bridges. Journal of Environmental Management, 197, pp.41-49.**

Author Abstract

The study addresses the life cycle cost assessment (LCCA) of steel bridges, focusing on the maintenance activities and the maintenance scenario. Firstly, the unit costs of maintenance activities and the irdurability (i.e. the time between two activities) are evaluated. Pragmatic data are provided for the environment category C4 and for three activities: Patch Up, Overcoating and Remove & Replace. A comparative LCCA for a typical hypothetic steel girder bridge is carried out, either painted or hot-dip galvanized (HDG), in the environmental class C4. The LCC versus the cumulated life is provided for both options. The initial cost of the steel unpainted option is only 50.3% of the HDG option. It is shown that after ‘Overcoating’ occurring at 18.5 years, the total Net Present Value (NPV) of the painted option surpasses that of the HDG option. A sensitivity analysis of the NPV to the cost and service life parameters, the escalation and discount rates is then performed. The discount and escalation rate, considerably influences the total LCC, following a non-linear trend. The total LCC decreases with the discount rate increasing and, conversely, increases with the escalation rate increasing. Secondly, the influence of the maintenance scenario on the total LCC is assessed based on a probabilistic approach. A permutation of the three independent maintenance activities assumed to occur six times over the life of the bridge is considered and a probability of occurrence is associated to each unique scenario. The most probable scenarios are then classified according to their NPV or achieved service life. This approach leads to the definition of a cost-effective maintenance scenario i.e. the scenario, within all the considered permutations, that has the minimum LCC in a range of lifespan. Besides, the probabilistic analysis also shows that, whatever the scenario, the return on investment period ranges between 18.5 years and 24.2 years. After that period, the HDG option becomes economic.

**Saarimaa, V., Kaleva, A., Nikkanen, J., Heinonen, S., Levänen, E., Väisänen, P., Markkula, A. and Juhanoja, J. (2017). Supercritical carbon dioxide treatment of hot dip galvanized steel as a surface treatment before coating. *Surface and Coatings Technology*, 331, pp.137-142.**

Author Abstract

Supercritical carbon dioxide ($scCO_2$) treatment was employed for rapid formation of a zinc patina layer on hot dip galvanized (HDG) steel. In the presence of $H_2O$ and a Cu precursor, an artificial patina consisting of two distinctive phases was formed: a dense ~ 1 μm layer of anhydrous $ZnCO_3$ adjacent to native zinc coating, and a needle-like porous structure showing resemblance to hydrozincite ($Zn_5(CO_3)_2(OH)_6$). The artificial patina layer significantly decreased the surface free energy of HDG, which was evidenced also by good wettability by a polyester melamine coating. Furthermore, the needle-like patina surface structure stayed intact through the coating process, indicating improved coating adhesion. $ScCO_2$ treatment facilitates rapid and impurity-free surface treatment of hot dip galvanized steel and could be used to tailor novel adhesion and corrosion promoting surface morphologies.

**Taheri, P., Wielant, J., Hauffman, T., Flores, J., Hannour, F., de Wit, J., Mol, J. and Terryn, H. (2011). A comparison of the interfacial bonding properties of carboxylic acid functional groups on zinc and iron substrates. *Electrochimica Acta*, 56(4), pp.1904-1911.**

Author Abstract

The present work investigates the molecular interfacial bonds between carboxylic functional groups and zinc and iron substrates. Succinic acid models the functionality of many commonly used adhesives and organic coatings. On the other hand, iron and zinc form the major surface composition of galvanized steel. Consequently, studying the interfacial properties of the polymer functional groups and zinc or iron substrates illuminates the correlation of the polymer bonding characteristics and surface chemical properties of galvanized steel. In this work, X-ray photoelectron spectroscopy (XPS) and fourier transform infrared reflection absorption spectroscopy (FTIR-RAS) are combined to evaluate the surface compositions, the amount of adsorbed molecules and the interaction mechanism between the succinic acid functionalities and the differently pretreated surfaces. The results show that variation of the treatments prior to succinic molecule adsorption results in different adsorption properties, which are related to the changes in chemistry and composition of the oxide layer.

**Van Eijnsbergen, J. F. H. "Duplex Systems – Hot-dip Galvanizing Plus Painting," Elsevier, Amsterdam, Netherlands,1994.**

Author Abstract

The use of duplex systems is based on the synergistic effect of galvanizing and organic coatings. They offer a long service life in environment where galvanized steel without coatings does not resist against corrosion for the required period of time. Since former adhesion problems can be avoided by using duplex systems due to the choice of suitable paint systems and surface pretreatment, duplex systems are nowadays in widespread use.

**P. Vinik. (2008). Coating Failures on Galvanized Mast Arms. *Cases from the F-Files*, pp. 20-26**

Author Abstract

The next time you pull up to an intersection with traffic signals look for the mast arms that support them. Are the arms galvanized, concrete, aluminum, or painted? Painted mast arms may have had the coating system applied directly to blast cleaned steel or over hot-dip galvanized steel (a duplex system). This article dis-cusses the failure of coatings applied to galvanized mast arms for the Florida Department of Transportation (FDOT); analysis of the failure, including key background information on galvanizing; the findings; and the approach FDOT implemented to correct failing galvanized mast arms exhibiting corrosion.

**Wang, K., Wang, S., Xiong, T., Wen, D., Wang, G., Liu, W. and Du, H. (2019). Effect of Mg and Nano-TiO2 on the Marine Protective Properties of Zn-Al Coatings. *Coatings*, 9(5), p.339.**

Author Abstract

According to research, we have learned that Mg and TiO2 are new types of material of marine protective coatings. We found that the addition of Mg can improve the performance of Zn-Al coating passivation film, and TiO2 has excellent photocatalytic self-cleaning performance. In this paper Zn-Al pseudo alloy coating was prepared by cold spray technique, and Zn-Al-Mg-TiO2, pseudo alloy composite coating was prepared by adding Mg and nano-TiO2 wire. The effects of Mg and TiO2 to the marine protective properties of Zn-Al coatings were studied by friction and wear test, dynamic salt water corrosion test, electrochemical test, scanning electron microscope (SEM), energy dispersive spectrometer (EDS) and super deep scene 3D microscope. The results show that the addition of Mg and nano-TiO2 not only fills the gap of the coating and improves the density of the coating, but also generates grid-like flocculent corrosion products on the surface of the coating which can gather other corrosion products to improve the density of corrosion products, reduce the friction coefficient, and corrosion rate of the coating surface, effectively prevent the invasion of Cl in solution and improve the wear and corrosion resistance of the coating.

**Wang, X, Li X, et al, *Influence of Temperature and Relative Humidity on the Atmospheric Corrosion of Zinc in Field Exposures and Laboratory Environments by Atmospheric Corrosion Monitor*, International Journal of Electrochemical Science, 8361-8373, (2015).**

Author Abstract

In the present work, the effect of temperature and relative humidity on the corrosion rate of zinc in field exposures for nearly one year or in laboratory corrosion environments was investigated by zinc-graphite coupling type atmospheric corrosion monitor (ACM) sensor. During the field exposure, the temperature, relative humidity and corrosion rate were monitored continuously at the same time. The results showed that using the time of wetness (TOW) alone to estimate the corrosion rate of zinc had some limitations. To address this problem, ACM was also used in laboratory corrosion tests, which were performed in the chamber with controlled temperature and humidity. It was found that both temperature and relative humidity could affect the corrosion rate of zinc, and there was a coupling effect between the temperature and relative humidity on the corrosion rate. Based on the data from the laboratory corrosion tests, a new equation was proposed to describe the correlation of corrosion rate with temperature and relative humidity, which also considered the coupling effect between temperature and relative humidity. This equation better reflected the atmospheric corrosion rate of Zn during field exposures compared to the TOW.

**Williams, T., Olsen, A., *Application and Evaluation of Coating Over Hot-Dipped Galvanizing,* SSPC, (2015).**

Author Abstract

Duplex coatings are used to protect galvanizing in harsh environments, provide aesthetics, and enhance corrosion protection. Surface preparation is critical to achieving long term performance, and abrasive blasting was found to be the most effective surface preparation technique. Epoxy/polyurethane coatings are commonly used as duplex coatings in highly corrosive environments, and these coatings were benchmarked against high-build polyaspartic coatings. Polyaspartic coatings were found to perform as well as epoxy/polyurethane coatings in cyclic prohesion and wet adhesion evaluations over blasted hot-dipped galvanizing substrates.

**Worsley, D., McMurray, H., Sullivan, J. and Williams, I. (2004). Quantitative Assessment of Localized Corrosion Occurring on Galvanized Steel Samples Using the Scanning Vibrating Electrode Technique. CORROSION, 60(5), pp.437-447.**

Author Abstract

Zinc and zinc alloy galvanized steel is used increasingly for structural cladding, automotive, and domestic appliance applications. In assessing the different galvanizing coatings, it is important to understand the nature of corrosion reactions occurring on the metal surfaces. To this end, the scanning vibrating electrode technique (SVET) has been used to study the effect of variation in metallic coating on the localization and intensity of corrosion reactions occurring on the BareMetal surfaces when immersed in aerated 0.1% sodium chloride (NaCl). The samples used comprised pure zinc and galvanized steel substrates, namely electro-zinc (EZ), hot dip galvanized steel (HDG), iron (9%) zinc intermetallic (IZ),5% aluminum zinc alloy (Galan†), and 55% aluminum zinc alloy (Alunite†). The SVET has the resolution and sensitivity to enable the number and intensity of active anodes to be quantified. Zinc galvanized materials show anodes, which do not deactivate within the 24 h of the test whereas zinc aluminum alloy anodes display typical anode lifetimes of 6 h -12 h. The SVET data has been calibrated and integrated to provide a total current per scan and subsequently con-verted to zinc loss using Faraday's law. The total average mass losses obtained from 10-mm by 10-mm exposed areas were measured using the SVET: 1.133, 0.601, 0.432, 0.615,0.264, and 0.051 mg for zinc, EZ, HDG, IZ, Galfan, and Zalutite, respectively, and these values were confirmed using inductively coupled plasma mass spectrometry (ICP-MS). The SVET data for zinc loss obtained over 24 h has been compared to external weathering data obtained after 2, 6, and 12 months of external exposure. There is an excellent correlation between metal runoff in initial external exposure and24-h SVET experiments. In longer-term exposure, however, the IZ coating becomes covered in a metal hydr(oxide) layer, reducing runoff, and penetrative defects to the iron substrate in EZ lead to elevated runoff rates within 12 months.

**Yang, S., Lee, K., Lu, C., Mirville, M. and Parham, A. (2017). Adhesion Evaluation of Duplex Paint System for Sustainable Infrastructure. *Journal of Materials in Civil Engineering*, 29(9)**

Author Abstract

Organic paints are applied to galvanized or metalized steel surfaces in a duplex system, which is potentially more sustainable than the zinc-rich primer/steel system. A series of experimental tests were performed to measure and investigate adhesion strengths on three different types of roughened zinc surfaces. The contact angles were also measured for freshly formulated liquid paints on the roughened zinc surfaces to test if there is a correlation between the paint wetting property and the adhesive strengths. By comparing duplex system and zinc-rich primer/steel qualified North East Protective Coating (NEPCOAT) panels, it was found that the paint adhesion of the duplex system is as strong as the zinc primer/steel panels test results. The results also showed that adhesive strengths depend on the match between the paint and type of roughened zinc surfaces. The measurement of liquid paint wetting properties indicates small contact angles correlate with stronger pull-off adhesive strength. The authors of this study suggest that contact angle/strength correlation could be useful as a tool for optimizing the match between the paints and the profiled zinc surface.

**Yasakau, K., Giner, I., Vree, et. al (2016). Influence of stripping and cooling atmospheres on surface properties and corrosion of zinc galvanizing coatings. *Applied Surface Science*, 389, pp.144-156.**

Author Abstract

In this work the influence of stripping/cooling atmospheres used after withdrawal of steel sheet from Zn or Zn-alloy melt on surface properties of Zn (Z) and Zn-Al-Mg (ZM) hot-dip galvanizing coatings has been studied. The aim was to understand how the atmosphere (composed by nitrogen (N2) or air) affects adhesion strength to model adhesive and corrosive behaviour of the galvanized substrates. It was shown that the surface chemical composition and Volta potential of the galvanizing coatings prepared under the air or nitrogen atmosphere are strongly influenced by the atmosphere. The surface chemistry Z and ZM surfaces prepared under N2 contained a higher content of metal atoms and a richer hydroxide density than the specimens prepared under air atmosphere as assessed by X-ray photoelectron spectroscopy (XPS). The induced differences on the microstructure of the galvanized coatings played a key role on the local corrosion induced defects as observed by means of in situ Atomic force microscopy (AFM). Peel force tests performed on the substrates coated by model adhesive films indicate a higher adhesive strength to the surfaces prepared under nitrogen atmosphere. The obtained results have been discussed in terms of the microstructure and surface chemical composition of the galvanizing coatings.

**Yıldız, R. and Dehri, İ. (2015). Investigation of the cut-edge corrosion of organically-coated galvanized steel after accelerated atmospheric corrosion test. *Arabian Journal of Chemistry*, 8(6), pp. 821-827.**

Author Abstract

The cut edge of corrosion of organically coated (epoxy, polyurethane, and polyester) galvanized steel was investigated using electrochemical impedance spectroscopy (EIS). Measurements were performed on specimens that had been tested in an accelerated atmospheric corrosion test. The samples were subjected to 10 s of fogging and 1 h awaiting cycles in an exposure cabinet (120 and 180 days) with artificial acid rain solution. According to the investigation, the coatings were damaged from the cut edge into the sheet. This distance was about 0.8 cm. These defects were more pronounced at after 180 days in proportion to after 120 days.

**Zapponi, M., Pérez, T., Ramos, C. and Saragovi, C. (2005). Prohesion and outdoors tests on corrosion products developed over painted galvanized steel sheets with and without Cr(VI) species. *Corrosion Science*, 47(4), pp.923-936.**

Author Abstract

Galvanized steel sheets pre-treated with a new product and then painted with a polyester topcoat without primer were submitted to Prohesion G-85 test (PT) and to outdoor marine exposure test (OT). The new product that replaces standard inorganic chromium pre-treatment + primer consists in a water based resin which applied directly to the properly cleaned metal substrate is then dried in place. This scheme sets aside Cr (VI) compounds which cause severe damages on human health.

Goethite, lepidocrocite, magnetite, akaganeite and silicates were found in OT samples coinciding with the usual corrosion products obtained for conventional painting schemes (with Cr(VI)).

Surprisingly in PT samples greigite was detected, showing that the new painting scheme is susceptible to microbiological corrosion. Goethite, lepidocrocite, pyrite, magnetite and akaganeite were also found.

This study allows the conclusion that in the PT the corrosion mechanism is different from that in the OT for the analyzed samples and should not be used to predict the performance of this kind of outdoor exposed materials.

**Zoller, J. (2014). The Memorial Bridge, Design Innovations and Fabrication Challenges. Presented at the Mid-Atlantic States QA Workshop, February 5, 2014.**

Summary

This PowerPoint presentation describes the rehabilitation of Memorial Bridge which carries US Route 1 over Piscataqua River from Portsmouth, NH to Kittery, Maine. Of particular note to this project, the bridge was entirely metallized in the shop using zinc wire arc spray. The metallizing was applied at 10 ±2 mils over 10 feet above the roadway and 14±2 mils below 10 foot above the roadway. All metallizing had a clear seal coat applied. The bridge was opened to traffic on August 3, 2013. The presentation mentions four other metallized bridges in New England – the Providence River Bridge in Rhode Island (2005), the Lake Champlain Bridge (2011), the Pawtucket River Bridge in Rhode Island (2012) and I-95 Whittier Bridge in Massachusetts (2014). At the end of the presentation, metallizing was included as a design option for the Sarah Mildred Long Bridge Replacement, though further research revealed that it was constructed as a precast segmental concrete bridge.

**Zoller, J. (2022). The NH-ME Metallized Memorial Bridge. Paper No. 17837 presented at AMPP Annual Conference, March 2022.**

Author Abstract

This is the story of the largest movable bridge replacement in NH's history, a compelling account of new ideas to match and exceed an historically significant 90-year old lift bridge in design, style, and innovation with today's unique high-performance features designed to last a century. These bridge features include a first-in-the-world structural design, and the first use of thermal spray zinc coating in New Hampshire and Maine, whose pewter-colored finish blends with the naval and marine river setting, and whose success has encouraged the growth of metallizing in shops and on bridges in New England over the past decade.

**Zoller, J. (2022). Metallizing Steel Bridges in New England - It's Growing! Paper No. 17836 presented at AMPP Annual Conference, March 2022.**

Author Abstract

The use of metallized coating on bridges in New Hampshire years ago was limited to small special strategic steel locations. The metallizing option was severely limited by lack of shop applicators. Rhode Island pioneered duplex metallized bridges, research, and interest. The past two decades have seen a rapid growth of industry facility investment for application and Owner selection of the metallizing coating. This paper presents signature New England bridges and several New Hampshire bridges with metallized coating representing the growing popularity of thermal spray coating for steel bridges.

# Appendix B: Details of Metallic Coating Process

## Attachment 1 – Test Panel Preparation for Studies 1 through 5

Hot-rolled carbon steel (Nucor Multigrade) test panels measuring ¼” x 4” x 6” (Mill Certification 4/29/19, appended) containing a ¼” diameter hanging hole and cold-rolled carbon steel (AISI 1018, ASTM A108) test panels measuring 5/8" x 4" x 4" and 5/8" x 4" x 7" (Mill Certification 2/21/18, appended) with 1” diameter holes were obtained from Alro Steel Corporation (Imperial, PA).[1] A total of 315 – 4" x 6" test panels, 70 – 4" x 4" test panels, and 42 – 4" x 7" test panels were included in Studies 1-5. Additionally, 24 – ¼" x 1" x 5.5" test panels were cut from the 4" x 6" hot-rolled steel panels. These “strips” were fabricated for Study 5 (Segmented Cell Testing). These strips were abrasive blast cleaned and sealed to protect from corrosion (they remained uncoated).

All test panels were solvent cleaned in accordance with SSPC-SP 1, Solvent Cleaning prior to abrasive blast cleaning. Subsequently all test panels were abrasive blast cleaned with steel grit to achieve a “white metal” cleanliness in accordance with SSPC-SP 5, White Metal Blast, yielding a nominal 3-mil angular surface profile. Actual surface profile measurements were obtained from representative test panels according to ASTM D4417, Standard Test Methods for Field Measurement of Surface Profile of Blast Cleaned Steel, Method C (Replica Tape). Testex X-Coarse replica tape was used in conjunction with a calibrated spring micrometer. Actual surface profile measurements ranged from 2.7 to 3.3 mils. The test panels were preserved in a heated oven after surface preparation and prior to transportation to the shops performing the thermal spray applications and hot-dip galvanizing. While abrasive blast cleaning was not required for the test panels designated for hot-dip galvanizing, the steel contained 0.19% (1/4" steel) and 0.28% (5/8" steel) Silicon. Abrasive blast cleaning was performed to control excessive zinc build while the test panels were in the bath.

### Thermal Spray Coating (TSC) Application

A total of 225 – 4" x 6" test panels, 50 – 4" x 4" panels for slip coefficient testing and 30 – 4" x 7" panels for tension creep testing (Study 4) were transported to Ohio Structures, Inc. (Berlin Center, Ohio) for application of thermal spray coatings.[2] Ohio Structures, Inc. is an AISC certified shop and maintains a Sophisticated Painting Endorsement from AISC. The panels for slip and creep testing were preloaded in special racks that permitted application to both faces but no edges.[1] All test panels remained in a “white metal” condition prior to application.

Thermal spray application to all test panels was performed on December 5, 2019. William Corbett, a NACE Level 3 and SSPC Level 3 certified coatings inspector, and an SSPC Protective Coating Specialist was on-site during all thermal spray application. Mr. Corbett segregated test panels for the applicator, monitored ambient conditions and surface temperature using a calibrated DeFelsko Dew Point Meter (S/N 229129), and vacuum sealed the test panels after ambient cooling. All test panels were handled with gloves. The applicator was Mr. John Boyles; the Paint Shop Supervisor directing the work was Mr. Larry Culver. Mr. Boyles has over 20-years of experience with TSC. All application was performed using Thermion

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[1] The cold-rolled panel material and configuration meets the requirements set forth in Appendix A of the *Specification for Structural Joints Using High-Strength Bolts*, prepared by the Research Council on Structural Connections (December 31, 2009).

[2] Transportation time was approximately one hour, during which time the panels were in a climate-controlled vehicle and protected from corrosion using corrosion inhibitive paper.

electric arc spray equipment located in a ventilated spray booth equipped with four thermal spray coating apparatus'. The shop is enclosed and heated.

The zinc wire was applied first. Zinc TSC was applied to 30 test panels designated for slip coefficient testing and18 test panels designated for tension creep testing (Study 4). The same wire was applied to 75 – 4" x 6" test panels designated for Studies 1, 2, 3, and 5. The wire, supplied by Non-Ferrous Traders, Inc. was 0.1875" diameter and contained 99.99% zinc. A Certificate of Analysis was provided (appended). There were no lot/batch numbers listed on the wire barrels. Barrel No's 52551141 and 52551142 contained the zinc wire used for application. The purity of the Zn TSC was later confirmed to be 99.97% using a Thermo Scientific Niton XL3t GOLDD + XRF unit. The required thickness range was 8-12 mils (confirmed on-site with spot checks). The applicator monitored the thickness during application; coating thickness was spot checked prior to vacuum sealing the test panels using a calibrated PosiTector 6000 (S/N 190593) verified for accuracy prior to use (using DeFelsko traceable coated standards) and adjusted over the abrasive blast cleaned steel surface using a 10.1-mil measured shim. The application commenced at 0700 hours and was completed at 0910 hours. All test panels were vacuum sealed in 3-mil bags after application and cooling (in the shop).

***Zinc Wire Application***

| Equipment Setting/Condition | Value |
|---|---|
| Amperage | 400A |
| Voltage | 27V |
| Air Temperature | 68°F |
| Relative Humidity | 32% |
| Dew Point Temperature | 37°F |
| Surface Temperature | 56°F |

The aluminum wire was applied second. Aluminum TSC was applied to 75 – 4" x 6" test panels designated for Studies 1, 2, 3, and 5. The wire, supplied by TMS Metalizing Systems, Ltd. was 3/16" diameter and contained 99.50% aluminum. A Certificate of Analysis was provided (appended). The Lot# was RB16420464. The required thickness range was 8-12 mils (confirmed on-site with spot checks). The applicator monitored the thickness during application; coating thickness measurements were spot checked prior to vacuum sealing the test panels using a calibrated PosiTector 6000. The application commenced at 1015 hours and was completed at 1245 hours (including a 45-minute lunch break for the applicator). All test panels were vacuum sealed in 3-mil bags after application and cooling (in the shop).

***Aluminum Wire Application***

| Equipment Setting/ Condition | Value |
|---|---|
| Amperage | 370A |
| Voltage | 27-31V |
| Air Temperature | 81°F |
| Relative Humidity | 16% |
| Dew Point Temperature | 31°F |
| Surface Temperature | 66°F |

The 85% zinc/15% aluminum alloy wire was applied last. Zinc/Aluminum TSC was applied to 20 test panels designated for slip coefficient testing and 12 test panels designated for tension creep testing (Study 4), and 75 – 4" x 6" test panels designated for Studies 1, 2, and 3. The wire, supplied by Non-Ferrous Traders, Inc. was 0.1875" diameter. A Certificate of Analysis was provided (appended). The Lot/Batch# was 16236. The required thickness range was 8-12 mils (confirmed on-site with spot checks). The applicator monitored the thickness during application; coating thickness measurements were spot checked prior to vacuum sealing the test panels using a calibrated PosiTector 6000 (S/N 190593). The application commenced at 1335 hours and was completed at 1435 hours. All test panels were vacuum sealed in 3-mil bags after application and cooling (in the shop).

***Zinc/Aluminum Alloy Wire Application***

| Equipment Setting/Condition | Value |
|---|---|
| Amperage | 400A |
| Voltage | 28V |
| Air Temperature | 75°F |
| Relative Humidity | 23% |
| Dew Point Temperature | 34°F |
| Surface Temperature | 88°F |

### Hot Dip Galvanizing (HDG)

A total of 90 – 4" x 6" test panels (Studies 1, 2, 3, 5), and 20 – 4" x 4" panels for slip coefficient testing and 12 – 4" x 7" panels for tension creep testing (Study 4) were transported to AZZ Galvanizing (Canton, Ohio) for pickling and hot dip galvanizing.[3] The test panels were suspended from a large, moveable frame using ¼” wire through the holes in the panels to facilitate the dipping process. It should be noted that the blast-cleaned panels were exposed to light rain during the hanging process. Any surface rusting was removed by the pickling process.

Hot dip galvanizing was performed on December 9, 2019. William Corbett, a NACE Level 3 and SSPC Level 3 certified coatings inspector, and an SSPC Protective Coating Specialist, and Ryan Wilson, Laboratory Technician were on-site and witnessed the dipping process.

All work was coordinated through Aaron Dillon, Plant Manager. Kyle Nannah (also with AZZ Galvanizing) advised KTA on December 6, 2019 that Bismuth (approximately 300#) was scheduled to be added to the zinc bath the morning of December 9, 2019. Bismuth aids the fluidity of the zinc. The addition of Bismuth is considered common practice and does not adversely affect the deposition of the zinc.

---

[3] Transportation time was approximately two hours, during which time the panels were in a climate-controlled vehicle and protected from corrosion using corrosion inhibitive paper.

*Figure 1-1. Test panels being removed from the galvanizing bath.*

The test panels were suspended from the frame starting at 1200 hours. The panels were pickled in ambient hydrochloric acid, then dipped in an 834°F zinc bath at 1335 hours. The dwell time in the zinc bath was 3 1/2 minutes. The test panels were not post-quenched. The shop is open at both ends, making it subject to outside air temperatures. The outside air temperature was approximately 50°F with a steady rain.

The panels were air cooled for approximately 1-hour inside the galvanizing shop. The main suspension wires were subsequently cut, and the panels (on wire "branches") were loaded into the back of the SUV on plywood covered with flame retardant paper. Test panels were handled using heat-resistant gloves and were loaded into the vehicle under cover to prevent exposure to rain. The panels were transported back to the KTA Laboratory (approximate 2-hour transit time). The panels were unloaded, cut from the suspension wires, and the bottom edge of several panels ground to remove sharp drips that would puncture the vacuum seal bags. Gloves were worn by all personnel to prevent surface contamination. All test panels were vacuum sealed in 3-mil bags within 2-hours after returning to the KTA Laboratory. The maximum lapsed time between galvanizing and vacuum sealing was approximately 5-hours (1335-1830 hours).

Once cooled, coating thickness measurements were spot checked prior to vacuum sealing the test panels using a calibrated PosiTector 6000. The coating thicknesses ranged from 3.9 to 4.8 mils. This is consistent with the ASTM A123/AASHTO M111 requirement for a minimum average thickness of 3.9 mils for substrates thicker than ¼-inch.

Each test panel was uniquely identified to coincide with the panel numbers on the test matrices and the coating thickness measured and documented prior to testing.

TMS METALIZING SYSTEMS, LTD.
*"The Metalizing Source"*

August 21, 2019

**Ohio Structures, Inc.**
535 N. Broad St. Suite 5
Canfield, OH 44406

## CERTIFICATION

TMS Metalizing Systems, Ltd - INVOICE # 15967

This is to certify that the 60 pounds of 3/16" diameter material shipped August 21, 2019 is Alloy #1350-O Aluminum Metalizing Wire and has the following composition:

Lot # RB16420464

Chemical Composition Limits:

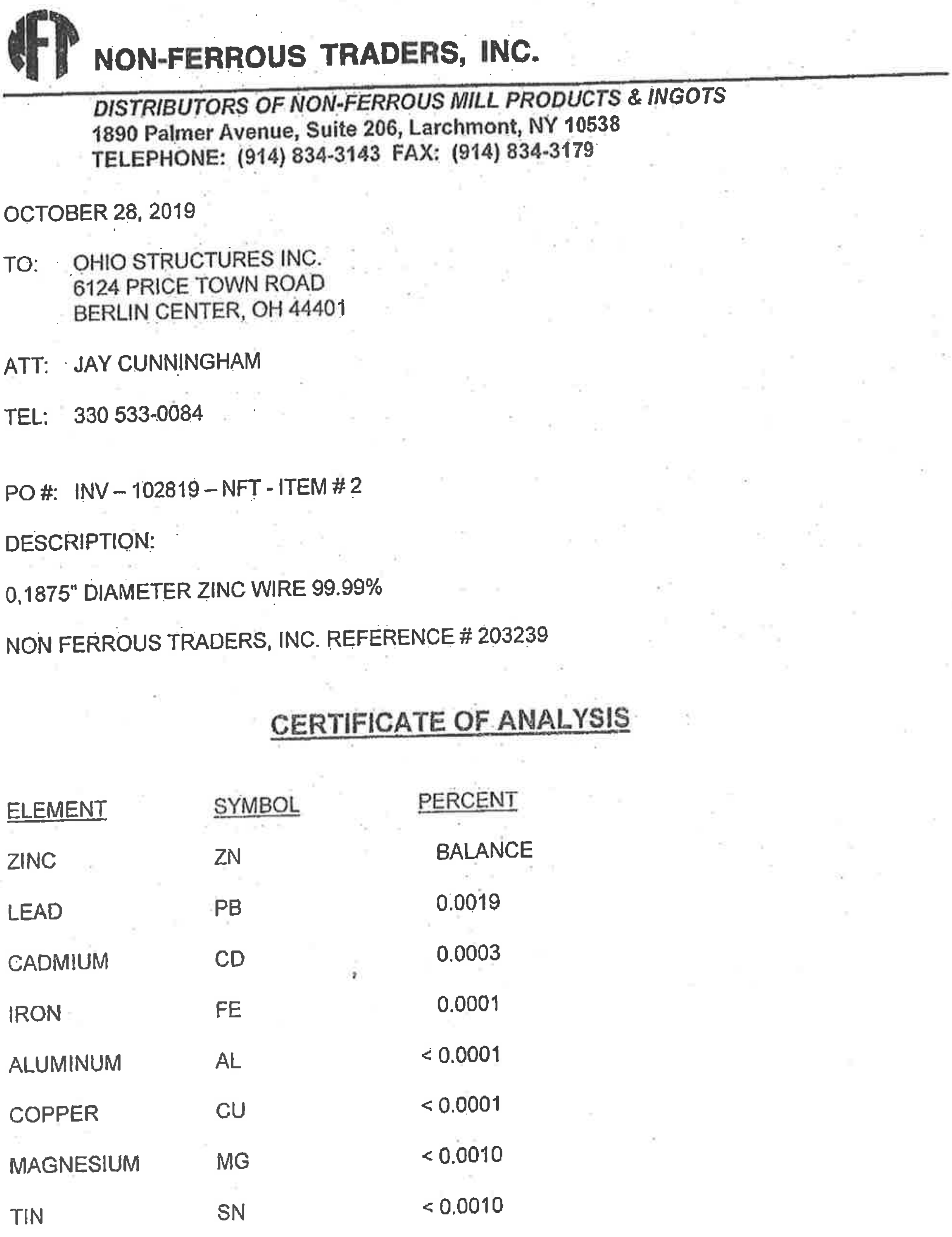
| Element | Minimum % | Maximum % |
|---|---|---|
| Silicon | --- | 0.10 |
| Iron | --- | 0.40 |
| Copper | --- | 0.05 |
| Manganese | --- | 0.01 |
| Chromium | --- | 0.01 |
| Zinc | --- | 0.05 |
| Gallium | --- | 0.03 |
| Boron | --- | 0.05 |
| Titanium + Vanadium | --- | 0.02 |
| Other Each | --- | 0.03 |
| Other Total | --- | 0.10 |
| Aluminum | 99.50 | |

Material complies with the chemical and compositional limits of MIL-W-6712C.

Product Made in USA

Dave Wixson
TMS Metalizing Systems, Ltd.
www.tmsmetalizing.com

TMS Metalizing Systems, Ltd.
P.O. Box 2136, Silverdale, WA 98383-2136
Phone: (360) 692-6656 Fax: (360) 698-1539
www.tmsmetalizing.com



**NON-FERROUS TRADERS, INC.**

*DISTRIBUTORS OF NON-FERROUS MILL PRODUCTS & INGOTS*
1890 Palmer Avenue, Suite 206, Larchmont, NY 10538
TELEPHONE: (914) 834-3143 FAX: (914) 834-3179

OCTOBER 28, 2019

TO: OHIO STRUCTURES INC.
6124 PRICE TOWN ROAD
BERLIN CENTER, OH 44401

ATT: JAY CUNNINGHAM

TEL: 330 533-0084

PO #: INV – 102819 – NFT - ITEM # 2

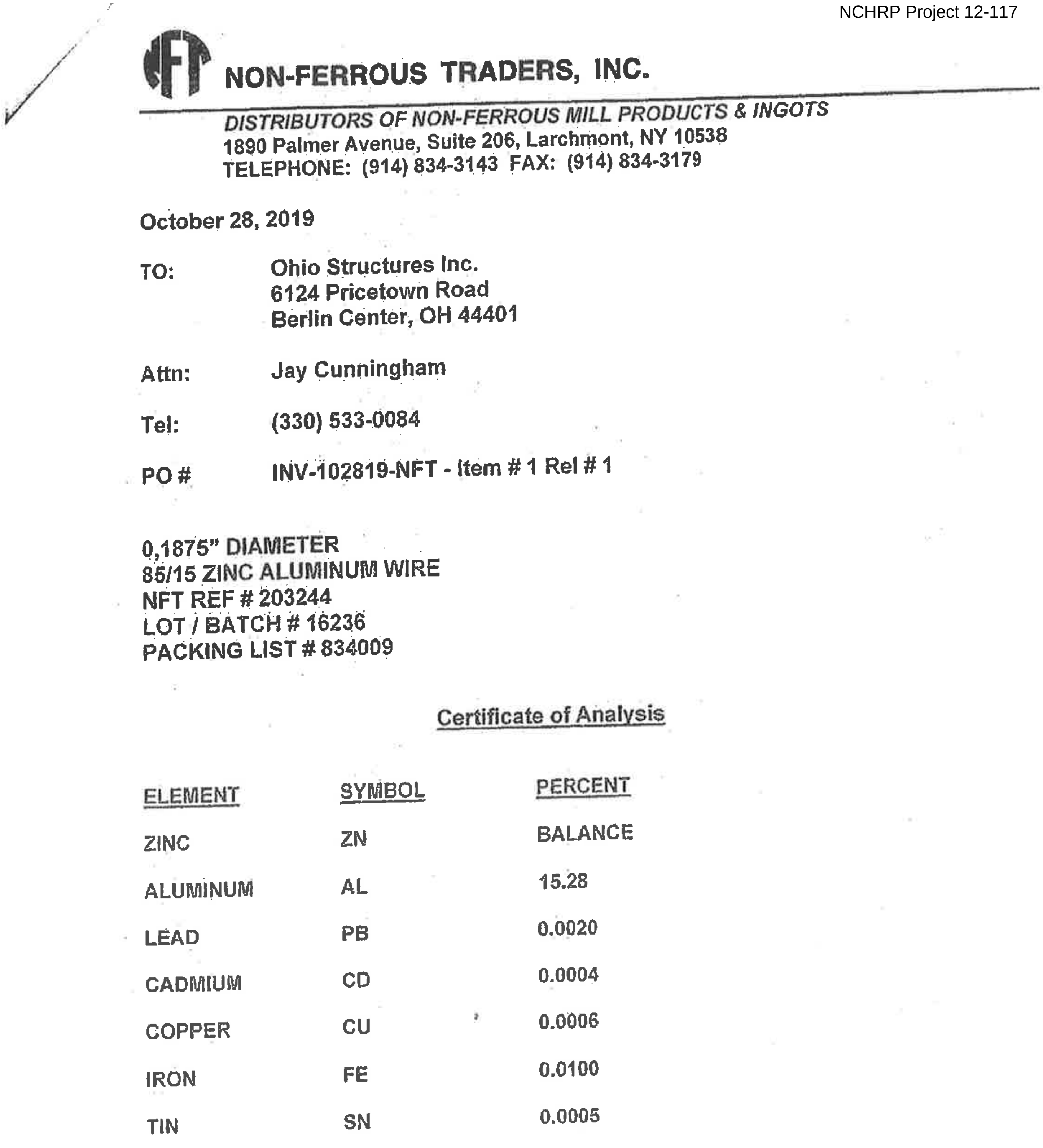
DESCRIPTION:

0,1875" DIAMETER ZINC WIRE 99.99%

NON FERROUS TRADERS, INC. REFERENCE # 203239

## CERTIFICATE OF ANALYSIS

| ELEMENT | SYMBOL | PERCENT |
|---|---|---|
| ZINC | ZN | BALANCE |
| LEAD | PB | 0.0019 |
| CADMIUM | CD | 0.0003 |
| IRON | FE | 0.0001 |
| ALUMINUM | AL | < 0.0001 |
| COPPER | CU | < 0.0001 |
| MAGNESIUM | MG | < 0.0010 |
| TIN | SN | < 0.0010 |



**NON-FERROUS TRADERS, INC.**
*DISTRIBUTORS OF NON-FERROUS MILL PRODUCTS & INGOTS*
1890 Palmer Avenue, Suite 206, Larchmont, NY 10538
TELEPHONE: (914) 834-3143 FAX: (914) 834-3179

October 28, 2019

TO: Ohio Structures Inc.
6124 Pricetown Road
Berlin Center, OH 44401

Attn: Jay Cunningham

Tel: (330) 533-0084

PO # INV-102819-NFT - Item # 1 Rel # 1

0,1875" DIAMETER
85/15 ZINC ALUMINUM WIRE
NFT REF # 203244
LOT / BATCH # 16236
PACKING LIST # 834009

## Certificate of Analysis

| ELEMENT | SYMBOL | PERCENT |
|---|---|---|
| ZINC | ZN | BALANCE |
| ALUMINUM | AL | 15.28 |
| LEAD | PB | 0.0020 |
| CADMIUM | CD | 0.0004 |
| COPPER | CU | 0.0006 |
| IRON | FE | 0.0100 |
| TIN | SN | 0.0005 |

**NUCOR**

***NUCOR CORPORATION***
***NUCOR STEEL SOUTH CAROLINA***

MTR #: C1-466464
300 Steel Mill Road
DARLINGTON, SC 29540
(843) 393-5841
Fax: (843) 395-8701

# Mill Certification

4/29/2019

Sold To:
ALRO STEEL CORP
PO BOX 927
JACKSON, MI 49204-0927
(517) 787-5500

Ship To:
ALRO PITTSBURGH
140 SOLAR DR
IMPERIAL, PA 15126
(412) 279-1660

| | | | |
|---|---|---|---|
| Customer P.O. | PT14100992 | Sales Order | 312445.1 |
| Product Group | Merchant Bar Quality | Part Number | 5325040024010W0 |
| Grade | NUCOR MULTIGRADE | Lot # | DL1910141203 |
| Size | 1/4x4" Flat | Heat # | DL19101412 |
| Product | 1/4x4" Flat 20' NUCOR MULTIGRADE | B.L. Number | C1-784585 |
| Description | NUCOR MULTIGRADE | Load Number | C1-466464 |
| Customer Spec | | Customer Part # | 06502320 |

I hereby certify that the material described herein has been manufactured in accordance with the specifications and standards listed above and that it satisfies those requirements.

**Roll Date: 3/11/2019** **Melt Date: 3/5/2019** **Qty Shipped LBS: 20,416** **Qty Shipped Pcs: 300**

**Melt Date: 3/5/2019**

| C | Mn | P | S | Si | Cu | Ni | Cr | Mo | V | Cb | Sn |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.13% | 0.76% | 0.005% | 0.025% | 0.19% | 0.43% | 0.10% | 0.09% | 0.022% | 0.0040% | 0.012% | 0.016% |
| Ti | CE4020 | CEA529 | | | | | | | | | |
| 0.001% | 0.32% | 0.35% | | | | | | | | | |

CE4020: C. E. CSA G4020, AASHTO M270
CEA529: A529 CARBON EQUIVALENT

**Roll Date: 3/11/2019**

| | | |
|---|---|---|
| Yield 1: 58,000psi | Tensile 1: 74,000psi | Elongation: 31% in 8"(% in 203.3mm) |
| Yield 2: 58,000psi | Tensile 2: 74,000psi | Elongation 30% in 8"(% in 203.3mm) |

Specification Comments: NUCOR MULTIGRADE MEETS THE REQUIREMENTS OF: ASTM A36/A36M-14, A529/529M-05(2009) GR50(345), A572/572M-13A GR50(345), A709/709M-13A GR36(250) & GR50(345), CSA G40.21-04 GR44W(300W) & GR50W(350W) AASHTO M270/M270M-10 GR36(270) & GR50(345), ASME SA36/SA36M-07, QQ-S-741D PRODUCED TO A FULLY KILLED, FINE GRAIN PRACTICE

1. WELDING OR WELD REPAIR WAS NOT PERFORMED ON THIS MATERIAL
2. MELTED AND MANUFACTURED IN THE USA
3. MERCURY, RADIUM, OR ALPHA SOURCE MATERIALS IN ANY FORM HAVE NOT BEEN USED IN THE PRODUCTION OF THIS MATERIAL

James H. Blew
Division Metallurgist

c r flat 1018 5/8 x 4 x 1

# Mill Certification

2/21/2018

MTR #: X1-102163
555 Collins Blvd
ORRVILLE, OH 44667
(330) 682-5555

NUCOR
NUCOR RIGHT BAR ORRVILLE

Sold To:
A RO STEEL CORP
P O BOX 927
J CKSON, MI 49204-0927

Ship To:
ALRO METAL SERVICE CTR.
4787 STATE RD
CUYAHOGA FALLS, OH 44223

| | | | |
|---|---|---|---|
| Customer P.O. | PT13265193 | Sales Order | 112810.1 |
| Product Group | Cold Finish Bar | Part Number | 320930 |
| Grade | 1018 ASTM A108 | Lot # | X1101640 |
| Size | Flat 0.6250x4.0000 (.0060) | Heat # | NF100887514 |
| Product | FL 0.625x4.000 1018 12-R CD | B.L. Number | X1-102334 |
| Description | CF Grade 1018 | Load Number | X1-102163 |
| Customer Spec | | Customer Part # | 00125200 |

I hereby certify that the material described herein has been manufactured in accordance with the specifications and standards listed above and that it satisfies those requirements.

Part Detail: FL 0.625x4.000 1018 12-R Cold Drawn
Process: Cold Drawn

| C | Mn | P | S | Si | Cu | Cr | Ni | Mo | Sn | V | Cb |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.16% | 0.82% | 0.019% | 0.024% | 0.28% | 0.29% | 0.17% | 0.10% | 0.030% | 0.011% | 0.0040% | 0.004% |
| Al | Pb | | | | | | | | | | |
| 0.000% | 0.000% | | | | | | | | | | |

Melting Mill: Nucor Bar NE

Country of Melting: USA

Reduction Ratio 16.2 :1

Country of Rolling: USA

Rolling Mill: Nucor Bar NE

Specification Comments: ASTM A108

1. Material certifies to ASTM A108 - 13 (unless otherwise noted) for Standard Cold Finished Bars
2. No welding or weld repair was performed on this material.
3. Mercury, radium, or alpha source materials in any form have not been used in the production of this material This document is in compliance with EN 10204 "type 3.1"

ALRO STEEL/METAL
RT09156973

Chris Kelly

Chris Kelly
DIVISION METALLURGIST

NBMG-10 ctober 1, 2017

# Appendix C: Test Panel Matrices for Studies 1 through 5

## Test Panel Matrices

| Test Panel No. | HDG and Vacuum Seal | Zinc TSC and Vacuum Seal | Zn/Al TSC and Vacuum Seal | Alum TSC and Vacuum Seal | DFT | Outdoor Exposure | Baseline pH & Tape Test | 100% Humidity 24 Hours | 100% Humidity 14 Days | 100% Humidity 7 Additional Days | Visual Eval. Photo[1] | pH & Tape Test[1] Demarcate Area | Coat 1/2[2] Test Adh | Resulting Oxide Formation Level | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | None | Light | Intermediate | Heavy |
| HDG-1 | X | | | | X | X | | | | | | | | | | | |
| HDG-2 | X | | | | X | | X | | X | X | | X | X | | | | X |
| HDG-3 | X | | | | X | | | | X | | X | | X | | | X | |
| HDG-4 | X | | | | X | | | | X | | X | | X | | | X | |
| HDG-5 | X | | | | X | | | | X | | | X | X | | | | X |
| HDG-6 | X | | | | X | | | | X | X | X | | X | | | | |
| HDG-7 | X | | | | X | | | | | | X | | X | X | | | |
| HDG-8 | X | | | | X | | | X | | | X | | X | | X | | |
| HDG-9 | X | | | | | | | | | | | | | | | | |
| HDG-10 | X | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| TSC-Zn-1 | | X | | | X | X | | | | | | | | | | | |
| TSC-Zn-2 | | X | | | X | | X | | X | X | | X | X | | | | X |
| TSC-Zn-3 | | X | | | X | | | | X | | X | | X | | | X | |
| TSC-Zn-4 | | X | | | X | | | | X | | X | | X | | | X | |
| TSC-Zn-5 | | X | | | X | | | | X | X | X | X | X | | | | X |
| TSC-Zn-6 | | X | | | X | | | | | | X | | X | X | | | |
| TSC-Zn-7 | | X | | | X | | | | | | X | | X | | X | | |
| TSC-Zn-8 | | X | | | | | | | | | | | | | | | |
| TSC-Zn-9 | | X | | | | | | | | | | | | | | | |
| TSC-Zn-10 | | X | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| TSC-ZnAl-1 | | | X | | X | X | | | | | | | | | | | |
| TSC-ZnAl-2 | | | X | | X | | X | | X | X | | X | X | | | | X |
| TSC-ZnAl-3 | | | X | | X | | | | X | | X | | X | | | X | |
| TSC-ZnAl-4 | | | X | | X | | | | X | | X | | X | | | X | |
| TSC-ZnAl-5 | | | X | | X | | | | X | X | X | X | X | | | | X |
| TSC-ZnAl-6 | | | X | | X | | | | | | X | | X | X | | | |
| TSC-ZnAl-7 | | | X | | X | | | X | | | X | | X | | X | | |
| TSC-ZnAl-8 | | | X | | | | | | | | | | | | | | |
| TSC-ZnAl-9 | | | X | | | | | | | | | | | | | | |
| TSC-ZnAl-10 | | | X | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| TSC-Al-1 | | | | X | X | X | | | | | | | | | | | |
| TSC-Al-2 | | | | X | X | | X | | X | X | | X | X | | | | X |
| TSC-Al-3 | | | | X | X | | | | X | | X | | X | | | X | |
| TSC-Al-4 | | | | X | X | | | | X | | X | | X | | | X | |
| TSC-Al-5 | | | | X | X | | | | X | X | | X | X | | | | X |
| TSC-Al-6 | | | | X | X | | | | | | | | X | X | | | |
| TSC-Al-7 | | | | X | X | | | X | | | X | | X | | X | | |
| TSC-Al-8 | | | | X | | | | | | | | | | | | | |
| TSC-Al-9 | | | | X | | | | | | | | | | | | | |
| TSC-Al-10 | | | | X | | | | | | | | | | | | | |

[1] Evaluate and photograph after cumulative 8-hours, 1-day, 2-days, 3-days, 4-days, 7-days, 10-days, and 14-days exposure (8x)

[2] No surface preparation. Coated with epoxy (brush application). After 7-day cure, performed tape adhesion

## Test Panel Matrices

| Test Panel No. | HDG and Vacuum Seal | Zinc TSC and Vacuum Seal | Zn/Al TSC and Vacuum Seal | Alum TSC and Vacuum Seal | Surface Prep | Sealer | | | Epoxy | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | SSPC-SP 16 | Rustbond | Interbond 600 | Pre-prime 920 | Carboguard 893 | Intergard 475HS | Macropoxy 646 | Cure 7-10 days | 30 Thermal Cycles | Duplicate D3359 | Duplicate D4541 |
| HDG-11 | X | | | | X | | | | X | | | X | X | X | X |
| HDG-12 | X | | | | X | | | | X | | | X | X | X | X |
| HDG-13 | X | | | | X | | | | X | | | X | X | X | X |
| HDG-14 | X | | | | X | | | | | X | | X | X | X | X |
| HDG-15 | X | | | | X | | | | | X | | X | X | X | X |
| HDG-16 | X | | | | X | | | | | X | | X | X | X | X |
| HDG-17 | X | | | | X | | | | | | X | X | X | X | X |
| HDG-18 | X | | | | X | | | | | | X | X | X | X | X |
| HDG-19 | X | | | | X | | | | | | X | X | X | X | X |
| | | | | | | | | | | | | | | | |
| TSC-Zn-11 | | X | | | NA | X | | | X | | | X | X | X | X |
| TSC-Zn-12 | | X | | | NA | X | | | X | | | X | X | X | X |
| TSC-Zn-13 | | X | | | NA | X | | | X | | | X | X | X | X |
| TSC-Zn-14 | | X | | | NA | | X | | | X | | X | X | X | X |
| TSC-Zn-15 | | X | | | NA | | X | | | X | | X | X | X | X |
| TSC-Zn-16 | | X | | | NA | | X | | | X | | X | X | X | X |
| TSC-Zn-17 | | X | | | NA | | | X | | | X | X | X | X | X |
| TSC-Zn-18 | | X | | | NA | | | X | | | X | X | X | X | X |
| TSC-Zn-19 | | X | | | NA | | | X | | | X | X | X | X | X |
| | | | | | | | | | | | | | | | |
| TSC-ZnAl-11 | | | X | | NA | X | | | X | | | X | X | X | X |
| TSC-ZnAl-12 | | | X | | NA | X | | | X | | | X | X | X | X |
| TSC-ZnAl-13 | | | X | | NA | X | | | X | | | X | X | X | X |
| TSC-ZnAl-14 | | | X | | NA | | X | | | X | | X | X | X | X |
| TSC-ZnAl-15 | | | X | | NA | | X | | | X | | X | X | X | X |
| TSC-ZnAl-16 | | | X | | NA | | X | | | X | | X | X | X | X |
| TSC-ZnAl-17 | | | X | | NA | | | X | | | X | X | X | X | X |
| TSC-ZnAl-18 | | | X | | NA | | | X | | | X | X | X | X | X |
| TSC-ZnAl-19 | | | X | | NA | | | X | | | X | X | X | X | X |
| | | | | | | | | | | | | | | | |
| TSC-Al-11 | | | | X | NA | X | | | X | | | X | X | X | X |
| TSC-Al-12 | | | | X | NA | X | | | X | | | X | X | X | X |
| TSC-Al-13 | | | | X | NA | X | | | X | | | X | X | X | X |
| TSC-Al-14 | | | | X | NA | | X | | | X | | X | X | X | X |
| TSC-Al-15 | | | | X | NA | | X | | | X | | X | X | X | X |
| TSC-Al-16 | | | | X | NA | | X | | | X | | X | X | X | X |
| TSC-Al-17 | | | | X | NA | | | X | | | X | X | X | X | X |
| TSC-Al-18 | | | | X | NA | | | X | | | X | X | X | X | X |
| TSC-Al-19 | | | | X | NA | | | X | | | X | X | X | X | X |

## Test Panel Matrices

| Test Panel No. | HDG and Vacuum Seal | Zinc TSC and Vacuum Seal | Zn/Al TSC and Vacuum Seal | Alum TSC and Vacuum Seal | Preliminary Exposure | | | Surface Preparation | | | | | | Sealer | Epoxy | Urethane | Testing | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | None | Humidity | Prohesion | None | SP 1 | Pressure Wash/Blow Dry | Wash primer | Power Sand | SP 16 | From Study 2 | From Study 2 | Added due to UV component of exposure | Cure 7-10 days | 1,008 hours D5894 exposure | Duplicate D3359 | Duplicate D4541 |
| HDG-20-22 | X | | | | 3 | | | X | | | | | | | X | X | X | X | X | X |
| HDG-23-25 | X | | | | | 3 | | X | | | | | | | X | X | X | X | X | X |
| HDG-26-28 | X | | | | | | 3 | X | | | | | | | X | X | X | X | X | X |
| HDG-29-31 | X | | | | 3 | | | | X | | | | | | X | X | X | X | X | X |
| HDG-32-34 | X | | | | | 3 | | | X | | | | | | X | X | X | X | X | X |
| HDG-35-37 | X | | | | | | 3 | | X | | | | | | X | X | X | X | X | X |
| HDG-38-40 | X | | | | 3 | | | | | | X | | | | X | X | X | X | X | X |
| HDG-41-43 | X | | | | | 3 | | | | | X | | | | X | X | X | X | X | X |
| HDG-44-46 | X | | | | | | 3 | | | | X | | | | X | X | X | X | X | X |
| HDG-47-49 | X | | | | 3 | | | | | | | X | | | X | X | X | X | X | X |
| HDG-50-52 | X | | | | | 3 | | | | | | X | | | X | X | X | X | X | X |
| HDG-53-55 | X | | | | | | 3 | | | | | X | | | X | X | X | X | X | X |
| HDG-56-58 | X | | | | 3 | | | | | | | | X | | X | X | X | X | X | X |
| HDG-59-61 | X | | | | | 3 | | | | | | | X | | X | X | X | X | X | X |
| HDG-62-64 | X | | | | | | 3 | | | | | | X | | X | X | X | X | X | X |
| | | | | | | | | | | | | | | | | | | | | |
| TSC-Zn-20-22 | | X | | | 3 | | | X | | | | | | X | X | X | X | X | X | X |
| TSC-Zn-23-25 | | X | | | | 3 | | X | | | | | | X | X | X | X | X | X | X |
| TSC-Zn-26-28 | | X | | | | | 3 | X | | | | | | X | X | X | X | X | X | X |
| TSC-Zn-29-31 | | X | | | 3 | | | | X | | | | | X | X | X | X | X | X | X |
| TSC-Zn-32-34 | | X | | | | 3 | | | X | | | | | X | X | X | X | X | X | X |
| TSC-Zn-35-37 | | X | | | | | 3 | | X | | | | | X | X | X | X | X | X | X |
| TSC-Zn-38-40 | | X | | | 3 | | | | | X | | | | X | X | X | X | X | X | X |
| TSC-Zn-41-43 | | X | | | | 3 | | | | X | | | | X | X | X | X | X | X | X |
| TSC-Zn-44-46 | | X | | | | | 3 | | | X | | | | X | X | X | X | X | X | X |
| TSC-Zn-47-49 | | X | | | 3 | | | | | | | X | | X | X | X | X | X | X | X |
| TSC-Zn-50-52 | | X | | | | 3 | | | | | | X | | X | X | X | X | X | X | X |
| TSC-Zn-53-55 | | X | | | | | 3 | | | | | X | | X | X | X | X | X | X | X |
| | | | | | | | | | | | | | | | | | | | | |
| TSC-ZnAl-20-22 | | | X | | 3 | | | X | | | | | | X | X | X | X | X | X | X |
| TSC-ZnAl-23-25 | | | X | | | 3 | | X | | | | | | X | X | X | X | X | X | X |
| TSC-ZnAl-26-28 | | | X | | | | 3 | X | | | | | | X | X | X | X | X | X | X |
| TSC-ZnAl-29-31 | | | X | | 3 | | | | X | | | | | X | X | X | X | X | X | X |
| TSC-ZnAl-32-34 | | | X | | | 3 | | | X | | | | | X | X | X | X | X | X | X |
| TSC-ZnAl-35-37 | | | X | | | | 3 | | X | | | | | X | X | X | X | X | X | X |
| TSC-ZnAl-38-40 | | | X | | 3 | | | | | X | | | | X | X | X | X | X | X | X |
| TSC-ZnAl-41-43 | | | X | | | 3 | | | | X | | | | X | X | X | X | X | X | X |
| TSC-ZnAl-44-46 | | | X | | | | 3 | | | X | | | | X | X | X | X | X | X | X |
| TSC-ZnAl-47-49 | | | X | | 3 | | | | | | | X | | X | X | X | X | X | X | X |
| TSC-ZnAl-50-52 | | | X | | | 3 | | | | | | X | | X | X | X | X | X | X | X |
| TSC-ZnAl-53-55 | | | X | | | | 3 | | | | | X | | X | X | X | X | X | X | X |
| | | | | | | | | | | | | | | | | | | | | |
| TSC-Al-20-22 | | | | X | 3 | | | X | | | | | | X | X | X | X | X | X | X |
| TSC-Al-23-25 | | | | X | | 3 | | X | | | | | | X | X | X | X | X | X | X |
| TSC-Al-26-28 | | | | X | | | 3 | X | | | | | | X | X | X | X | X | X | X |
| TSC-Al-29-31 | | | | X | 3 | | | | X | | | | | X | X | X | X | X | X | X |
| TSC-Al-32-34 | | | | X | | 3 | | | X | | | | | X | X | X | X | X | X | X |
| TSC-Al-35-37 | | | | X | | | 3 | | X | | | | | X | X | X | X | X | X | X |
| TSC-Al-38-40 | | | | X | 3 | | | | | X | | | | X | X | X | X | X | X | X |
| TSC-Al-41-43 | | | | X | | 3 | | | | X | | | | X | X | X | X | X | X | X |
| TSC-Al-44-46 | | | | X | | | 3 | | | X | | | | X | X | X | X | X | X | X |
| TSC-Al-47-49 | | | | X | 3 | | | | | | | X | | X | X | X | X | X | X | X |
| TSC-Al-50-52 | | | | X | | 3 | | | | | | X | | X | X | X | X | X | X | X |
| TSC-Al-53-55 | | | | X | | | 3 | | | | | X | | X | X | X | X | X | X | X |

## Test Panel Matrices

| Test Panel No. | Design/No. | HDG and Vacuum Seal | Zinc TSC and Vacuum Seal | Zn/Al TSC and Vacuum Seal | Organic Zinc Primer | Test No. | DISPOSITION - SLIP COF | | | DISPOSITION - CREEP | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Left | Center | Right | Left | Center | Right |
| 1-15 | Slip (15) | | X | | | 1 | 1-5 | 6-10 | 11-15 | | | |
| 16-24 | Creep (9) | | X | | | 1 | | | | 16-18 | 19-21 | 22-24 |
| 25-29 | Slip (5) | | X | | | 2 | | 25-29 | | | | |
| 30-32 | Creep (3) | | X | | | 2 | | | | | 30-32 | |
| 33-37 | Slip (5) | | X | | | 3 | | 33-37 | | | | |
| 38-40 | Creep (3) | | X | | | 3 | | | | | 38-40 | |
| 41-45 | Slip (5) | | X | | | 4 | | 41-45 | | | | |
| 46-48 | Creep (3) | | X | | | 4 | | | | | 46-48 | |
| | | | | | | | | | | | | |
| 49-58 | Slip (10) | X | | | | 3 | 49-53 | | 54-58 | | | |
| 59-64 | Creep (6) | X | | | | 3 | | | | 59-61 | | 62-64 |
| 65-69 | Slip (5) | X | | | | 5 | | 65-69 | | | | |
| 70-72 | Creep (3) | X | | | | 5 | | | | | 70-72 | |
| 73-77 | Slip (5) | X | | | | 6 | | 73-77 | | | | |
| 78-80 | Creep (3) | X | | | | 6 | | | | | 78-80 | |
| | | | | | | | | | | | | |
| 81-90 | Slip (10) | | | X | | 2 | 81-85 | | 86-90 | | | |
| 91-96 | Creep (6) | | | X | | 2 | | | | 91-93 | | 94-96 |
| 97-106 | Slip (10) | | | X | | 5 | 97-101 | | 102-106 | | | |
| 107-112 | Creep (6) | | | X | | 5 | | | | 107-109 | | 110-112 |
| | | | | | | | | | | | | |
| 113-122 | Slip (10) | | | | X | 4 | 113-117 | | 118-122 | | | |
| 123-128 | Creep (6) | | | | X | 4 | | | | 123-125 | | 126-128 |
| 129-138 | Slip (10) | | | | X | 6 | 129-133 | | 134-138 | | | |
| 139-144 | Creep (6) | | | | X | 6 | | | | 139-141 | | 142-144 |

## Test Panel Matrices

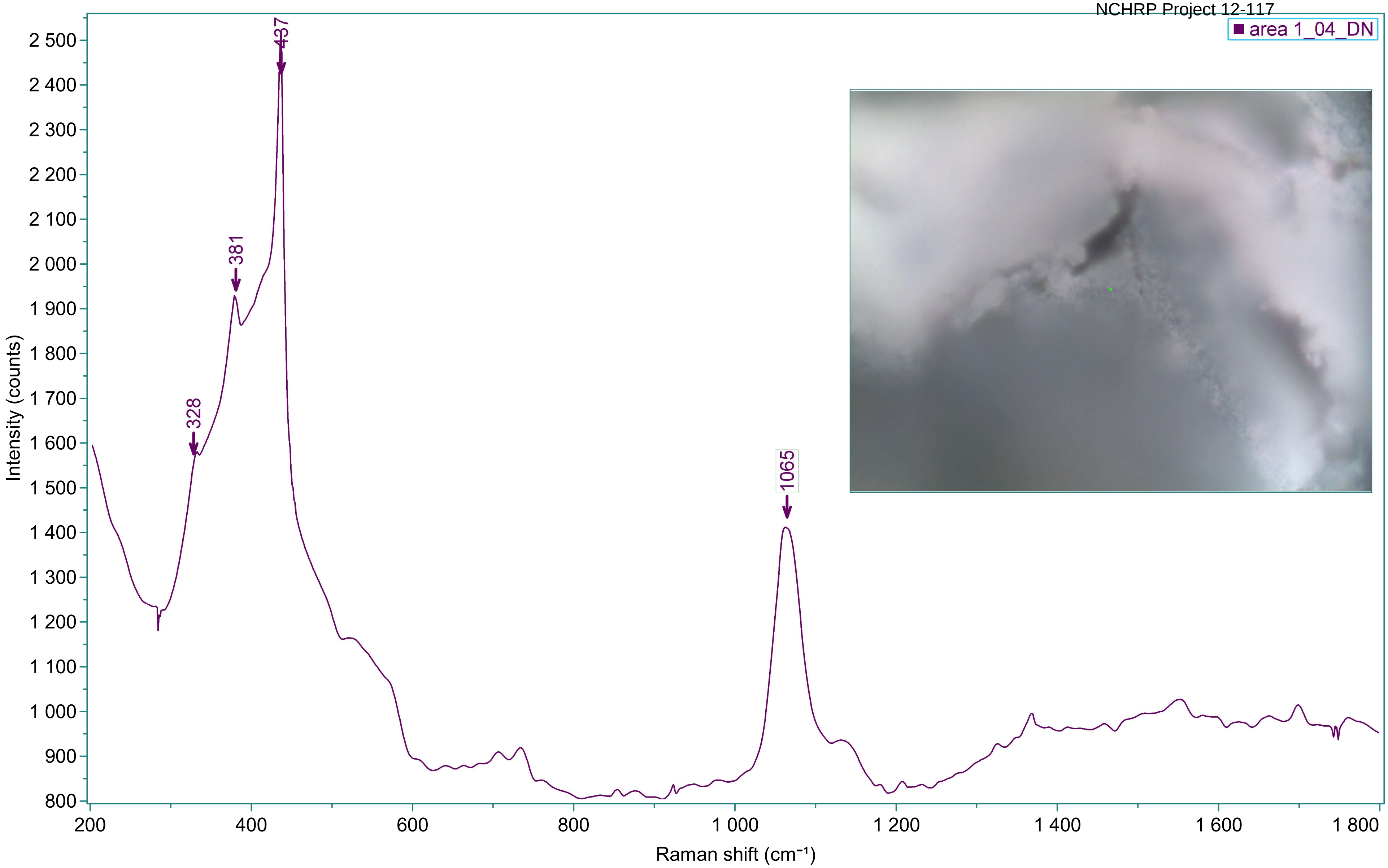
| Test Panel No. | No. of Coupons | Size[2] | Abrasive Blast | HDG and Vacuum Seal | Zinc TSC and Vacuum Seal | Al TSC and Vacuum Seal | Wet Storage Stain[1] | Send to Elzly | Return to KTA | Rustbond | Carboguard 893 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| HDG-65 | 4 | 1/4" x 1" x 5.5" | X | | | | | X | | | |
| HDG-66 | 4 | 1/4" x 1" x 5.5" | X | | | | | X | | | |
| HDG-67-70 | 24 | 1/4" x 1" x 1.75" | X | X | | | | X | X | | X |
| HDG-71-74 | 24 | 1/4" x 1" x 1.75" | X | X | | | X | X | X | | X |
| | | | | | | | | | | | |
| TSC-Zn-56 | 4 | 1/4" x 1" x 5.5" | X | | | | | | | | |
| TSC-Zn-57 | 4 | 1/4" x 1" x 5.5" | X | | | | | X | | | |
| TSC-Zn-58-61 | 24 | 1/4" x 1" x 1.75" | X | | X | | | X | X | | X |
| TSC-Zn-62-65 | 24 | 1/4" x 1" x 1.75" | X | | X | | | X | X | X | X |
| | | | | | | | | | | | |
| TSC-Al-56 | 4 | 1/4" x 1" x 5.5" | X | | | | | | | | |
| TSC-Al-57 | 4 | 1/4" x 1" x 5.5" | X | | | | | X | | | |
| TSC-Al-58-61 | 24 | 1/4" x 1" x 1.75" | X | | | X | | X | X | | X |
| TSC-Al-62-65 | 24 | 1/4" x 1" x 1.75" | X | | | X | | X | X | X | X |

[1] Return to KTA after cutting into coupons for exposure to create wet storage stain

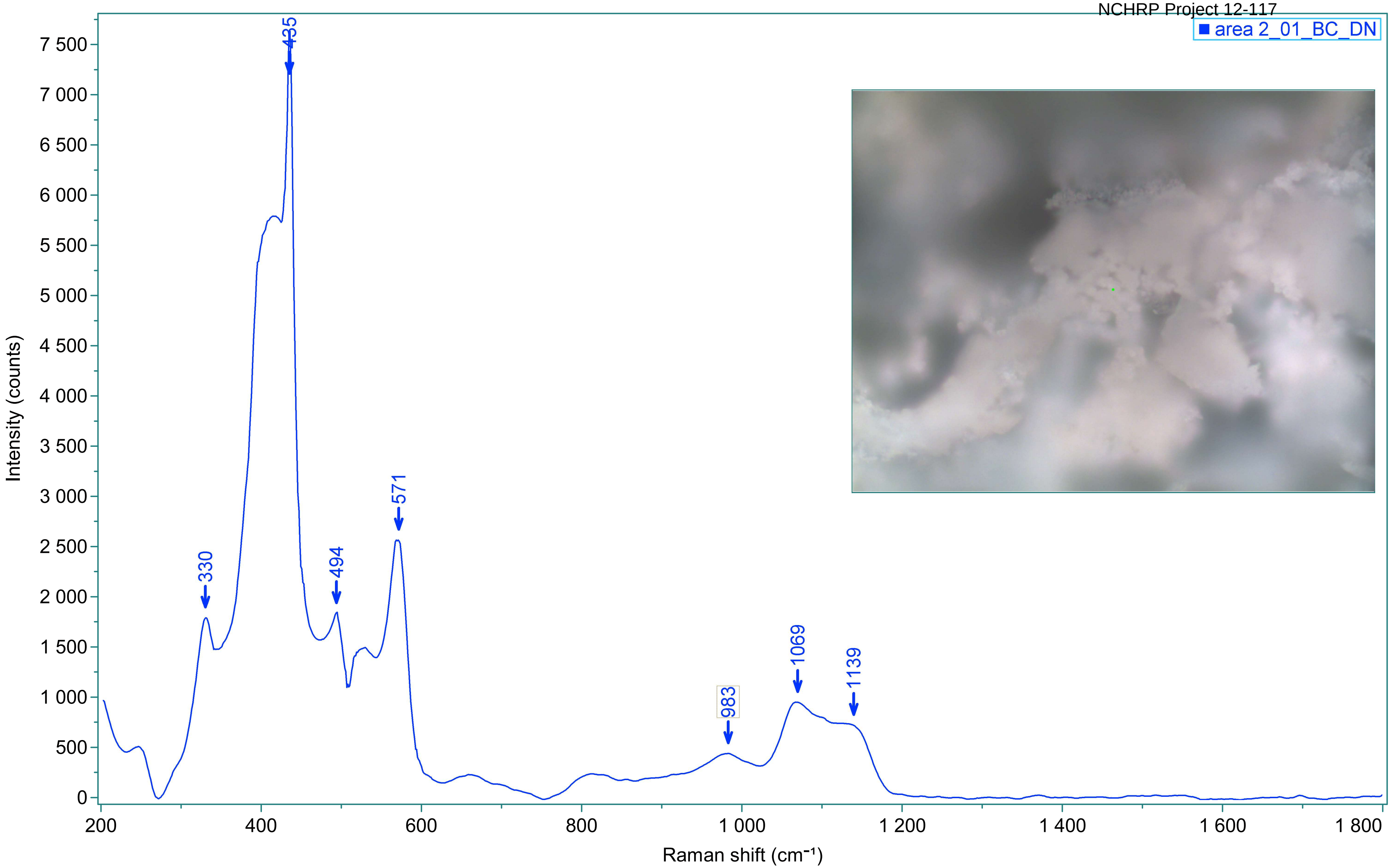
[2] *Process: To create 1" x 1.75" coupons, the HDG and TSC are applied to 4" x 6" panels. Panels are shipped to Elzly to be cut into coupons. 6 coupons per panel*

*The 1/4" x 1" x 5.5" will be cut to size pre-blast, since no post-blast coatings will be applied*

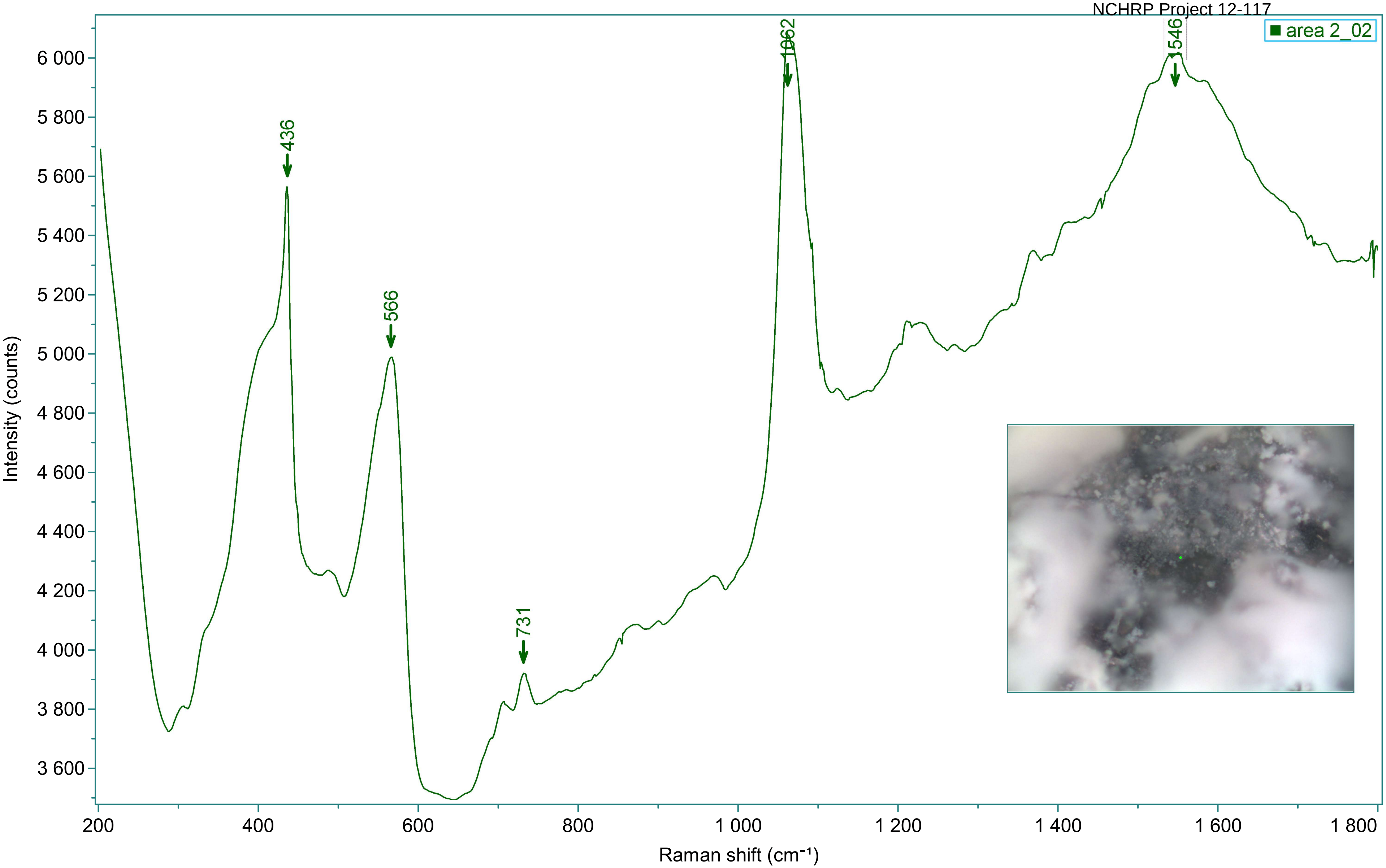
# Appendix D: Summary of Raman Spectra



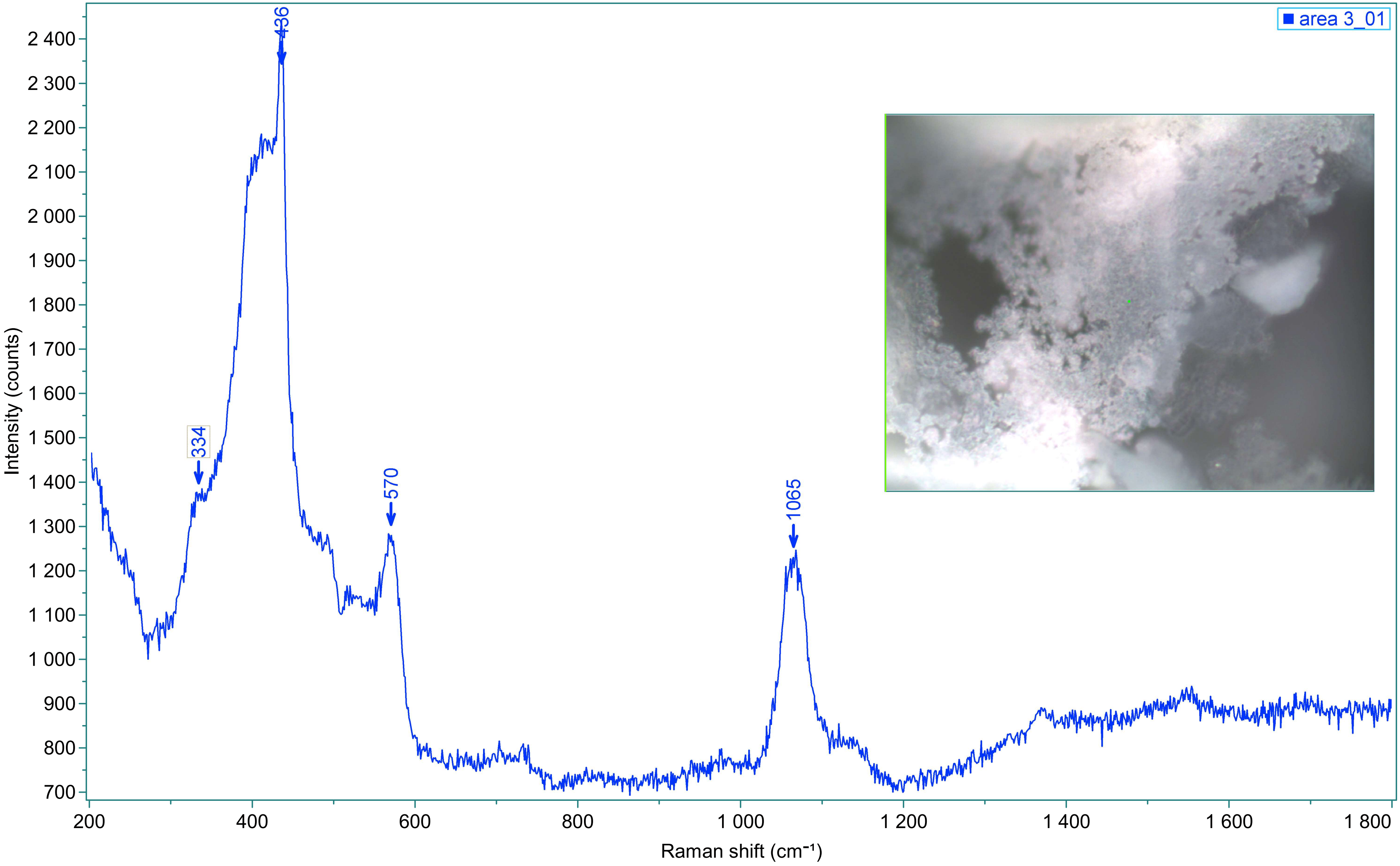
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Date | 04.12.2019 10:... | Acq. time (s) | 20 | Accumulations | 3 | Laser (nm) | 632.81 |
| Hole | 150.001 | Grating | 600 gr/mm | ND Filter | 100% | Delay time (s) | 0 |



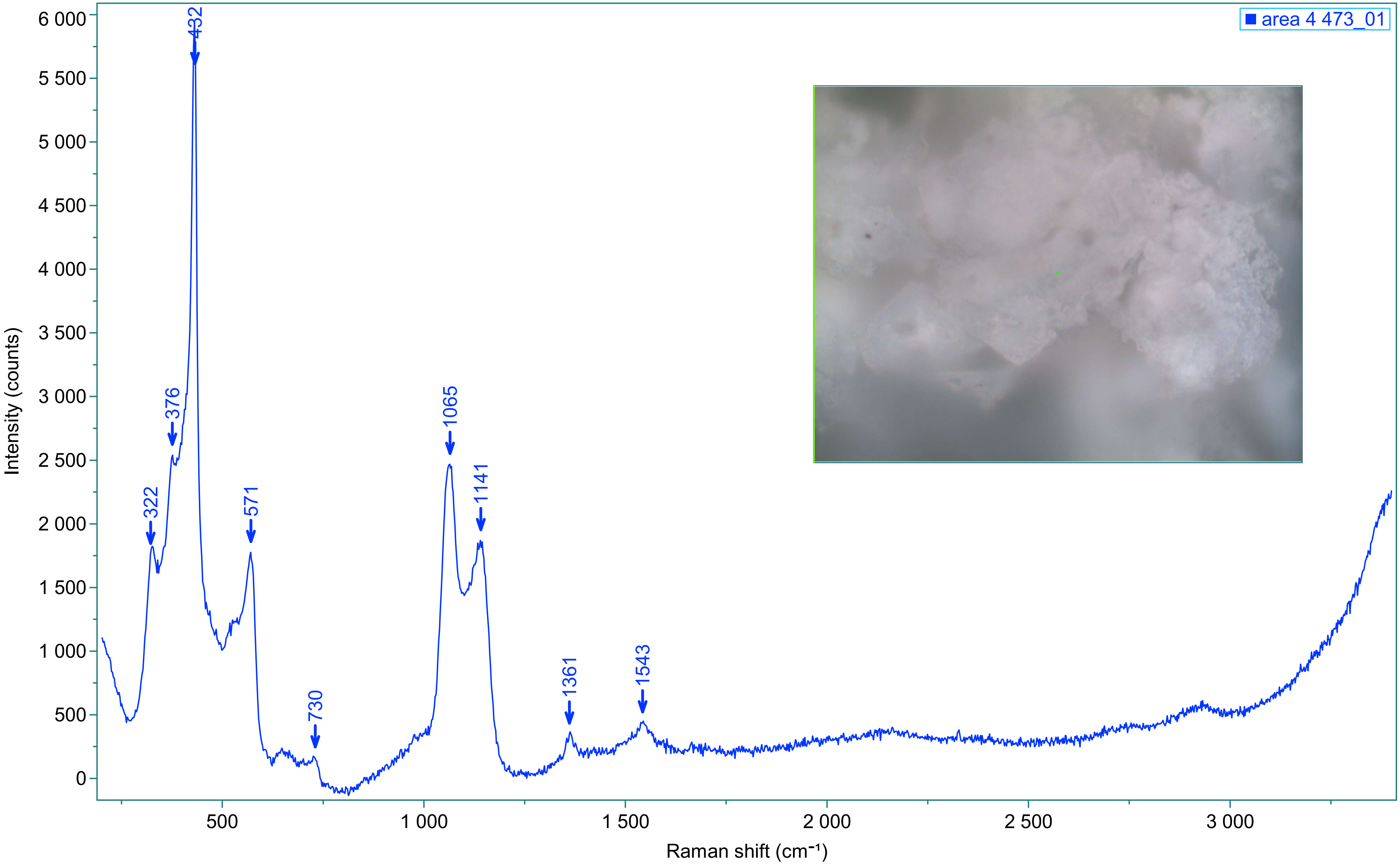
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Date | 04.12.2019 10:... | Acq. time (s) | 20 | Accumulations | 3 | Laser (nm) | 632.81 |
| Hole | 150.001 | Grating | 600 gr/mm | ND Filter | 100% | Delay time (s) | 0 |



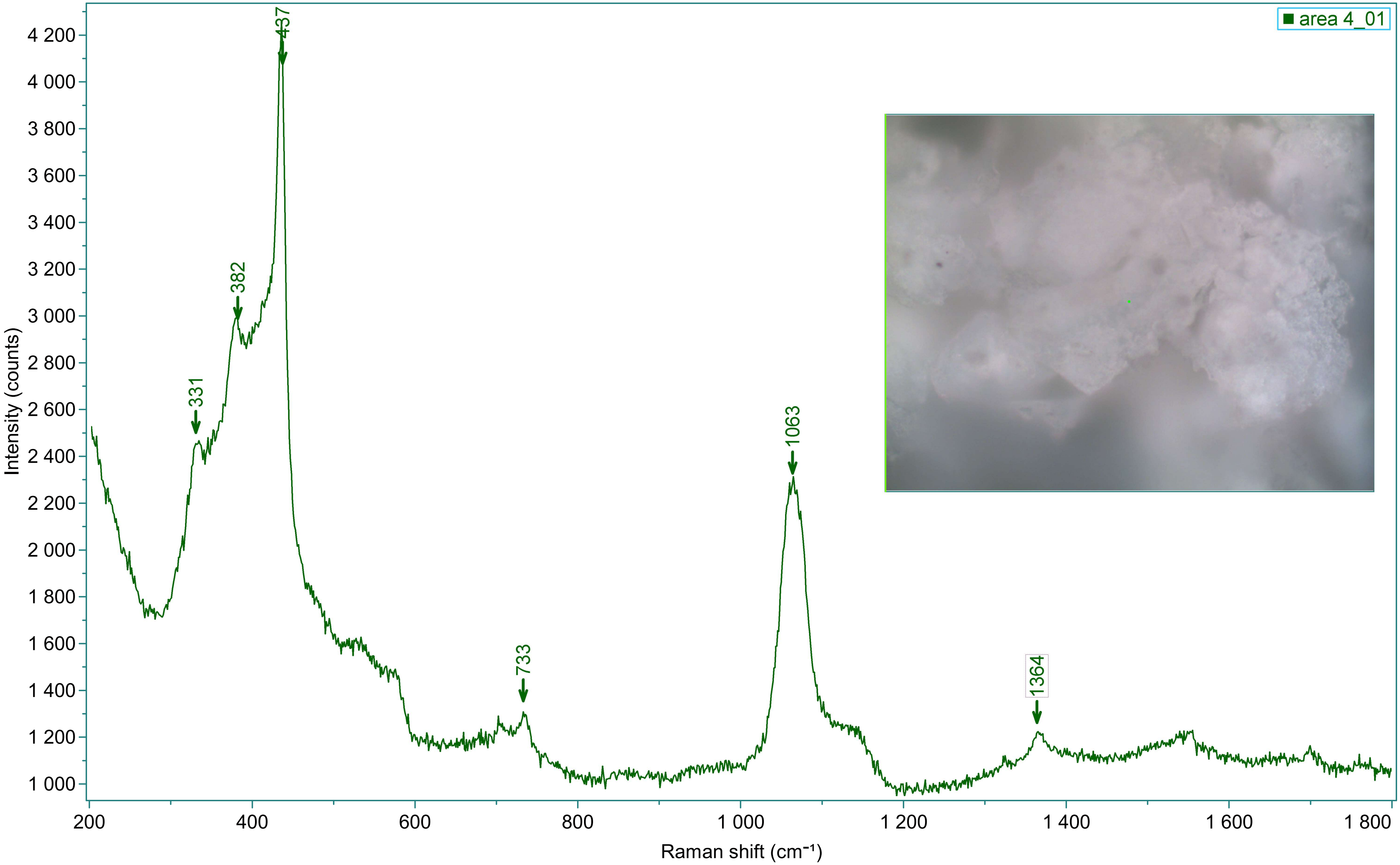
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Date | 04.12.2019 11:05 | Acq. time (s) | 20 | Accumulations | 3 | Laser (nm) | 632.81 |
| Hole | 150.001 | Grating | 600 gr/mm | ND Filter | 100% | Delay time (s) | 0 |



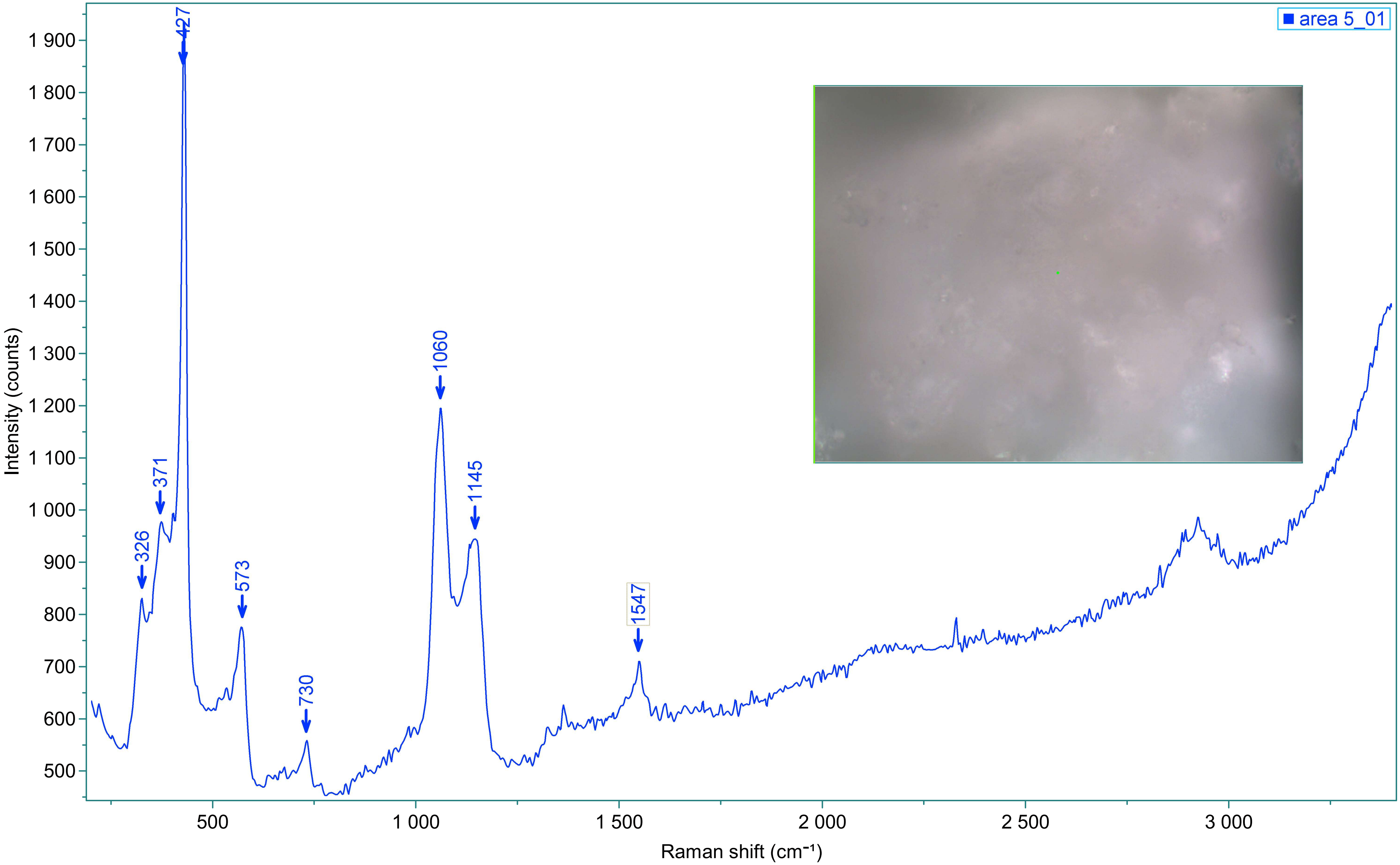
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Date | 04.12.2019 11:11 | Acq. time (s) | 20 | Accumulations | 3 | Laser (nm) | 632.81 |
| Hole | 150.001 | Grating | 600 gr/mm | ND Filter | 100% | Delay time (s) | 0 |



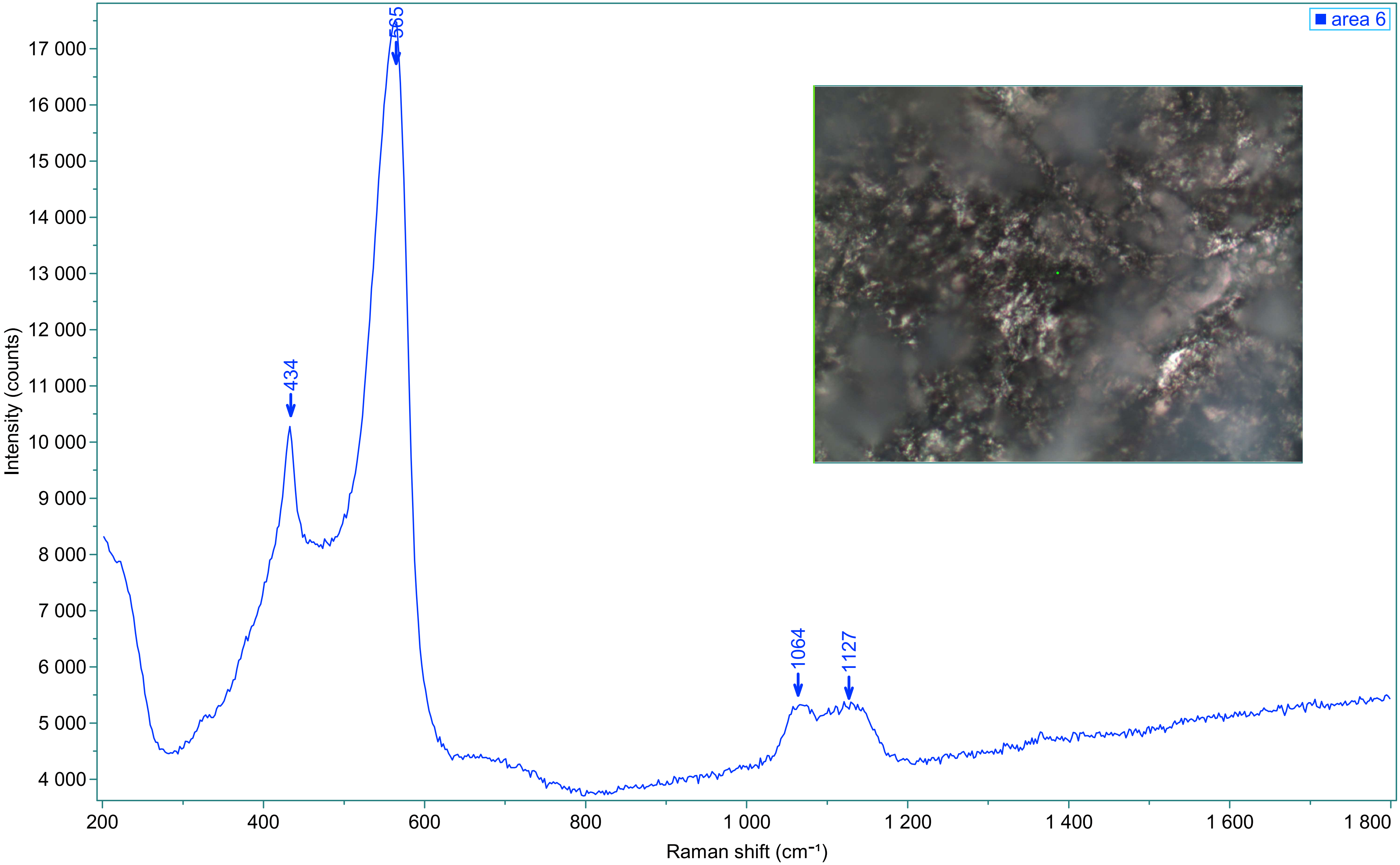
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Date | 04.12.2019 11:28 | Acq. time (s) | 10 | Accumulations | 3 | Laser (nm) | 473.06 |
| Hole | 150.001 | Grating | 600 gr/mm | ND Filter | 100% | Delay time (s) | 0 |



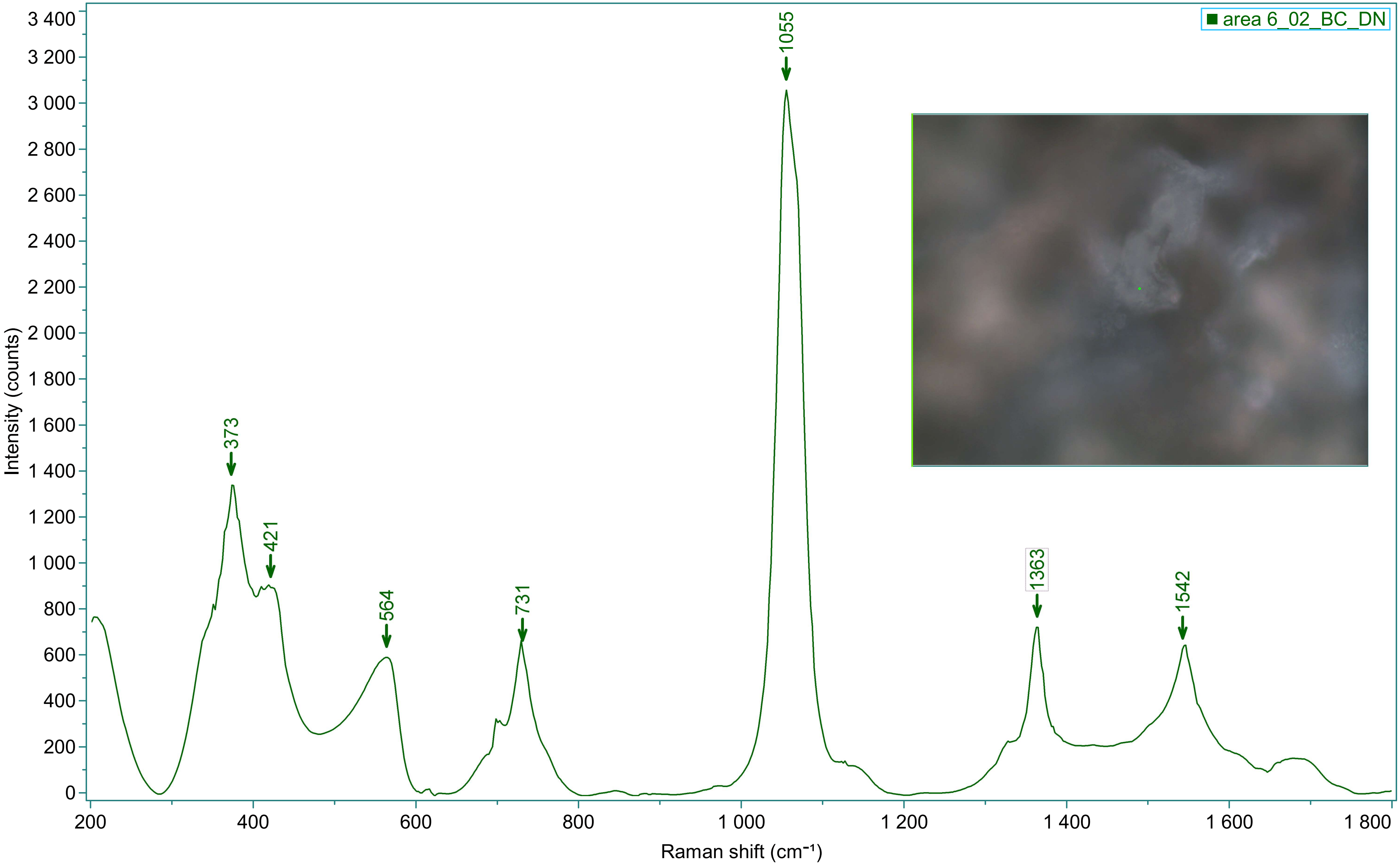
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Date | 04.12.2019 11:21 | Acq. time (s) | 20 | Accumulations | 3 | Laser (nm) | 632.81 |
| Hole | 150.001 | Grating | 600 gr/mm | ND Filter | 100% | Delay time (s) | 0 |



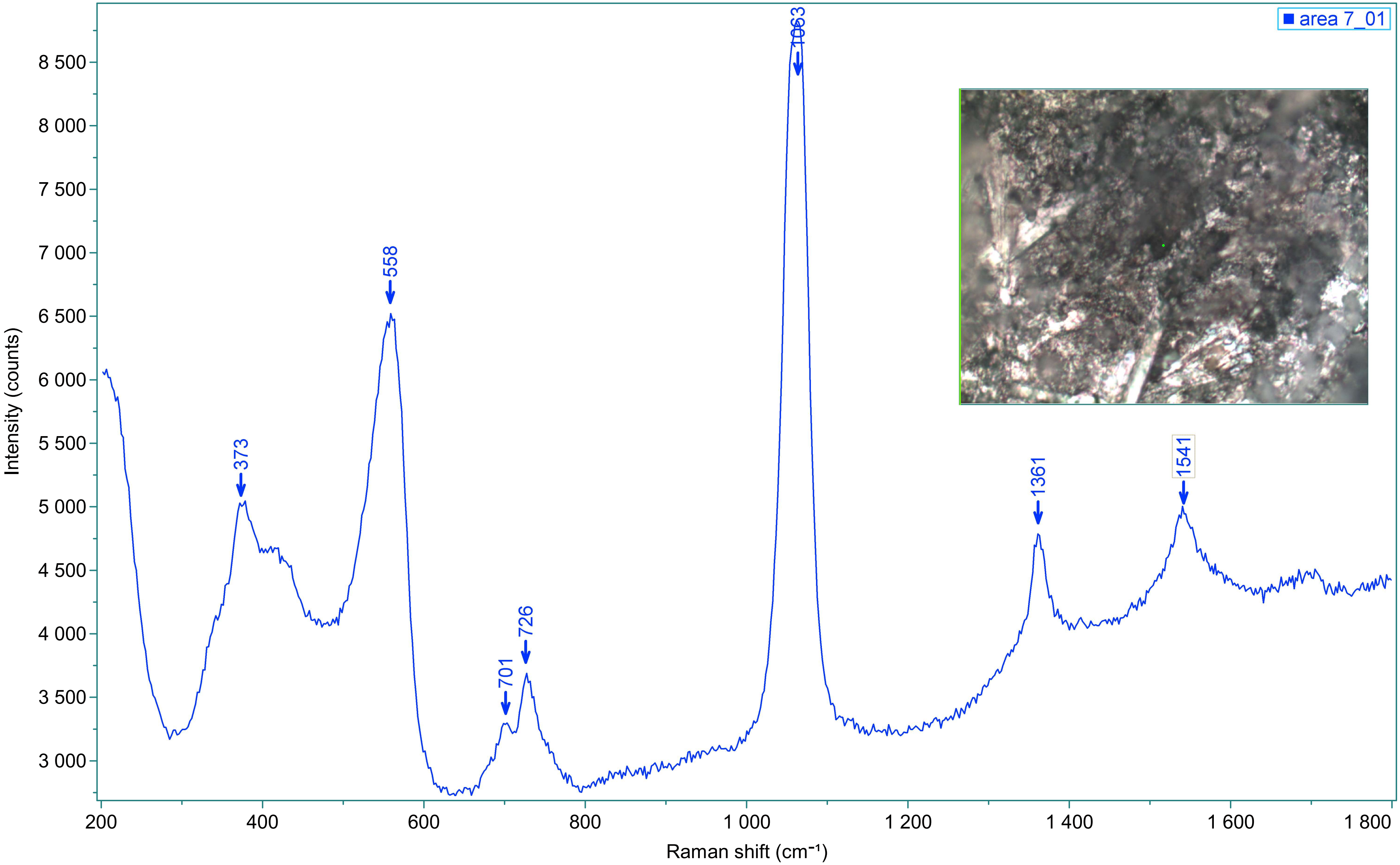
|  |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|
| Date | 04.12.2019 11:37 | Acq. time (s) | 10 | Accumulations | 3 | Laser (nm) | 473.06 |
| Hole | 150.001 | Grating | 600 gr/mm | ND Filter | 100% | Delay time (s) | 0 |



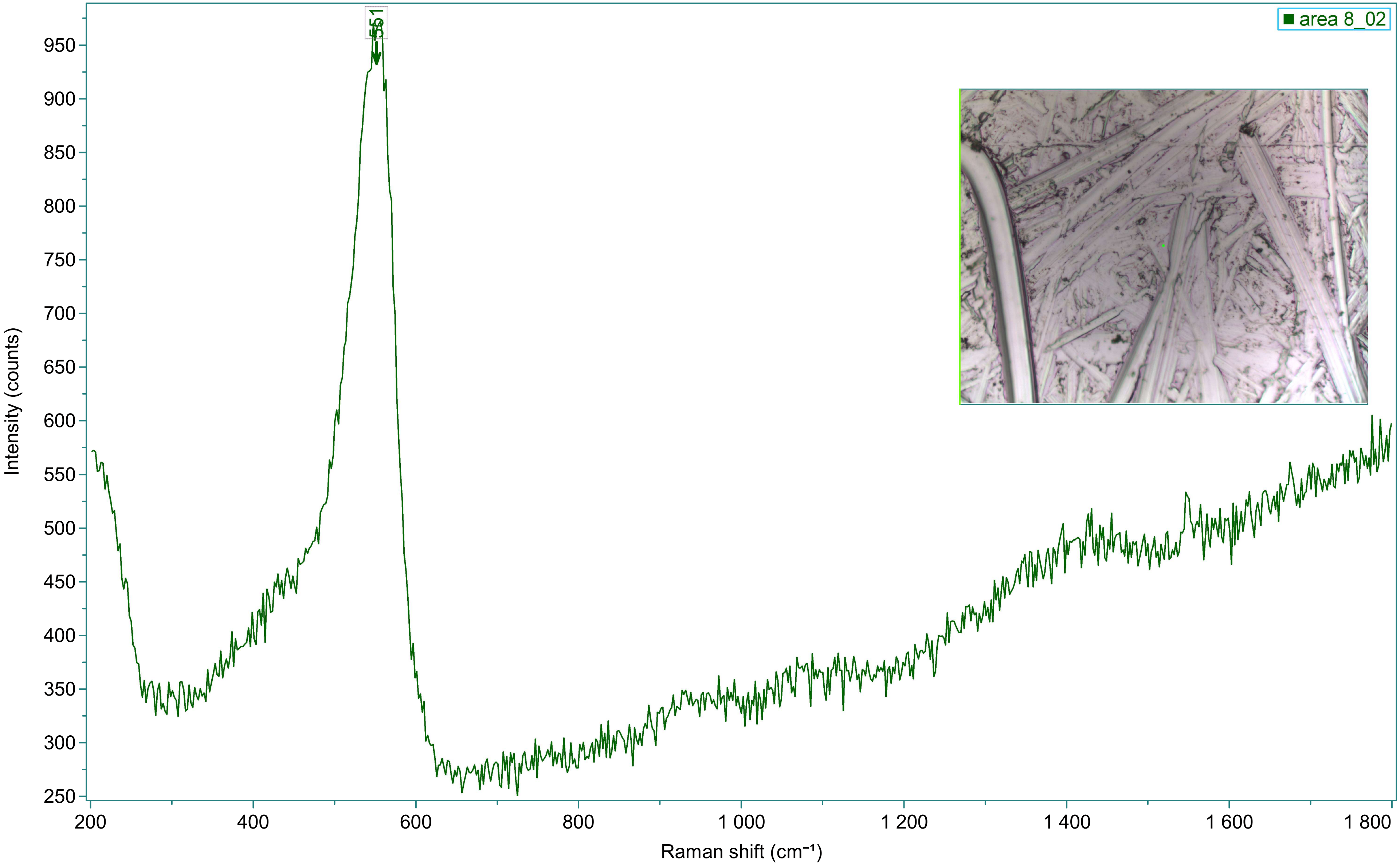
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Date | 04.12.2019 11:43 | Acq. time (s) | 20 | Accumulations | 3 | Laser (nm) | 473.06 |
| Hole | 150.001 | Grating | 600 gr/mm | ND Filter | 100% | Delay time (s) | 0 |



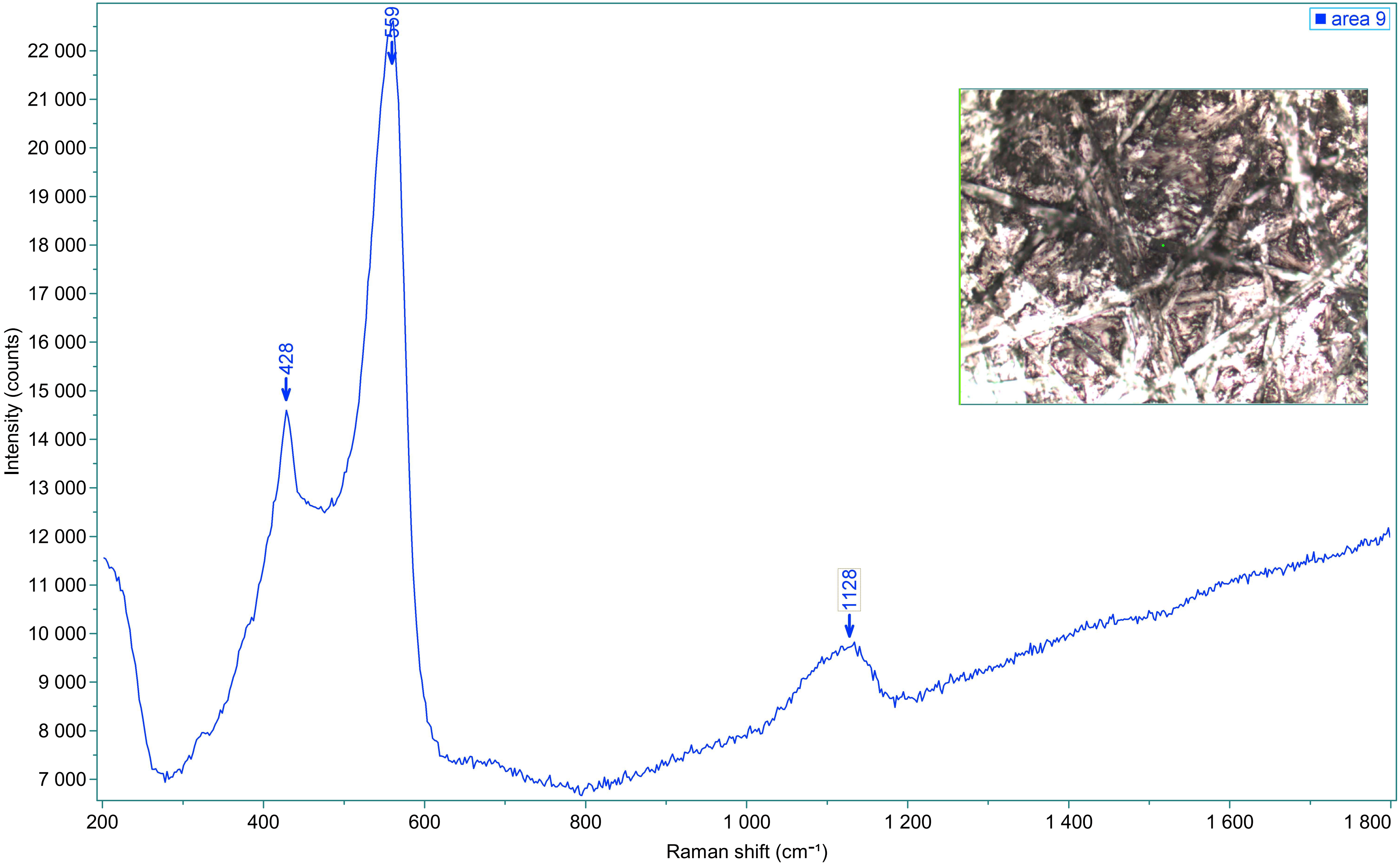
|  |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|
| Date | 04.12.2019 11:47 | Acq. time (s) | 20 | Accumulations | 3 | Laser (nm) | 473.06 |
| Hole | 150.001 | Grating | 600 gr/mm | ND Filter | 100% | Delay time (s) | 0 |



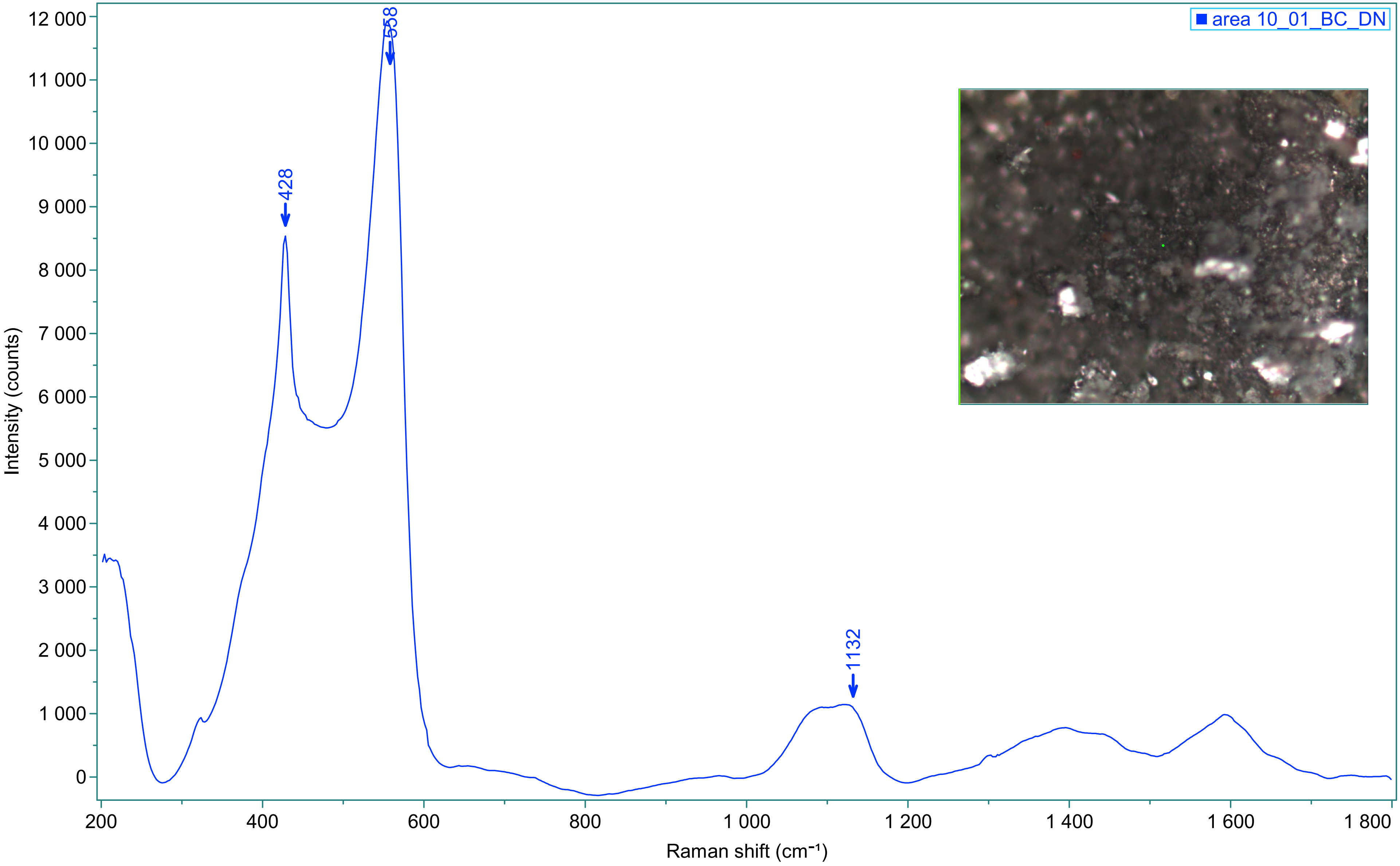
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Date | 04.12.2019 11:54 | Acq. time (s) | 20 | Accumulations | 3 | Laser (nm) | 473.06 |
| Hole | 150.001 | Grating | 600 gr/mm | ND Filter | 100% | Delay time (s) | 0 |



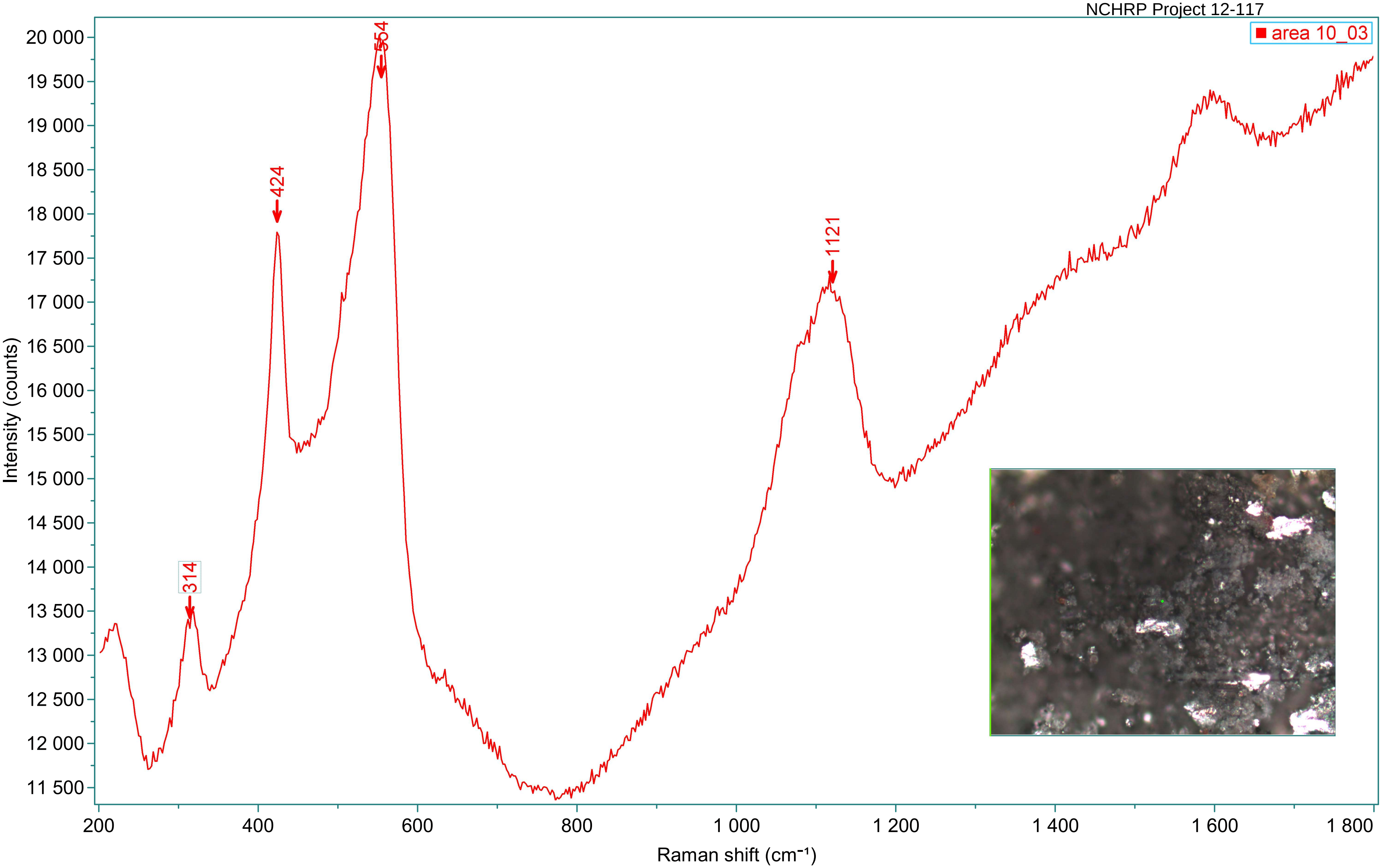
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Date | 04.12.2019 12:... | Acq. time (s) | 20 | Accumulations | 3 | Laser (nm) | 473.06 |
| Hole | 150.001 | Grating | 600 gr/mm | ND Filter | 100% | Delay time (s) | 0 |



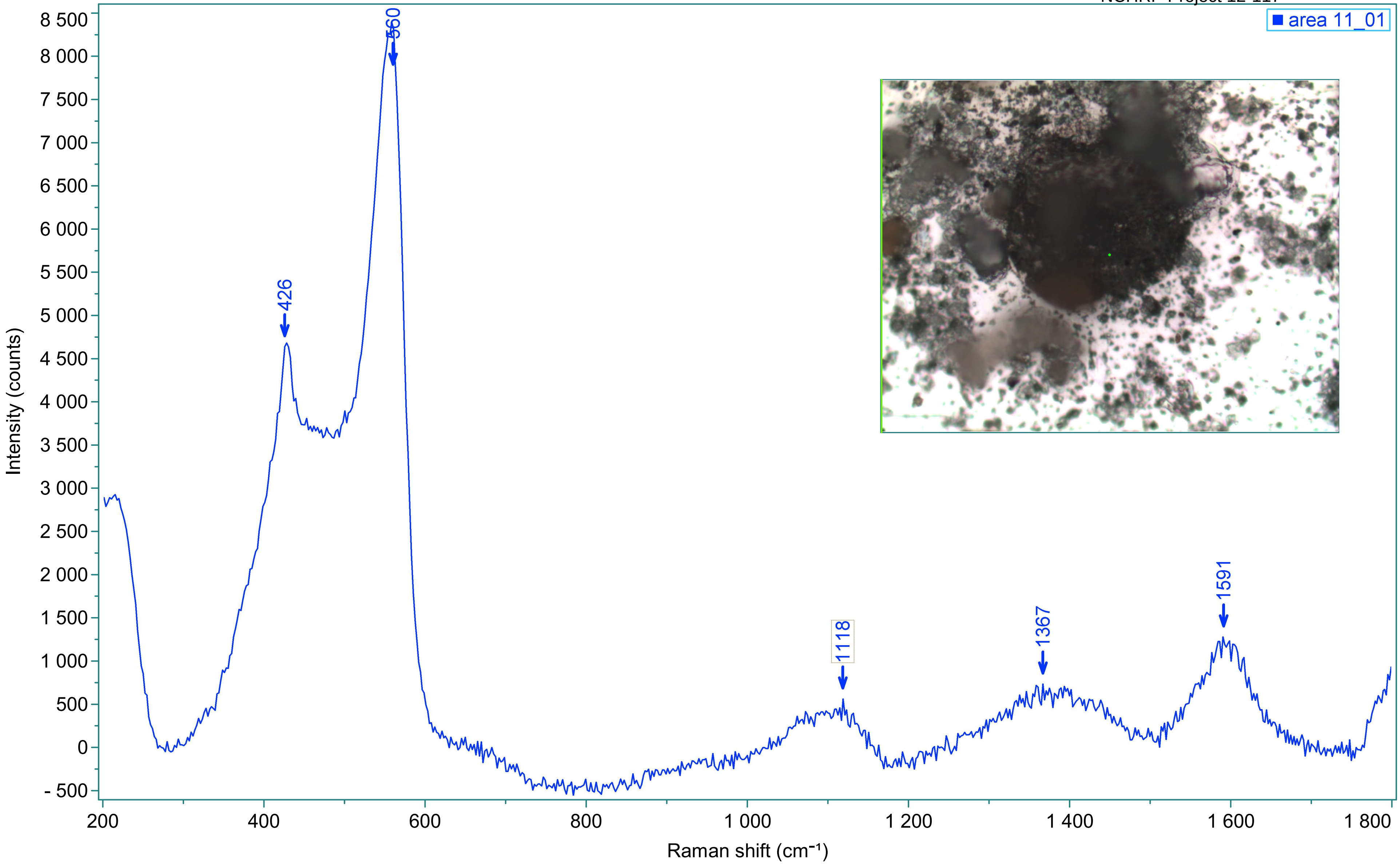
|  |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|
| Date | 04.12.2019 12:... | Acq. time (s) | 20 | Accumulations | 3 | Laser (nm) | 473.06 |
| Hole | 150.001 | Grating | 600 gr/mm | ND Filter | 100% | Delay time (s) | 0 |



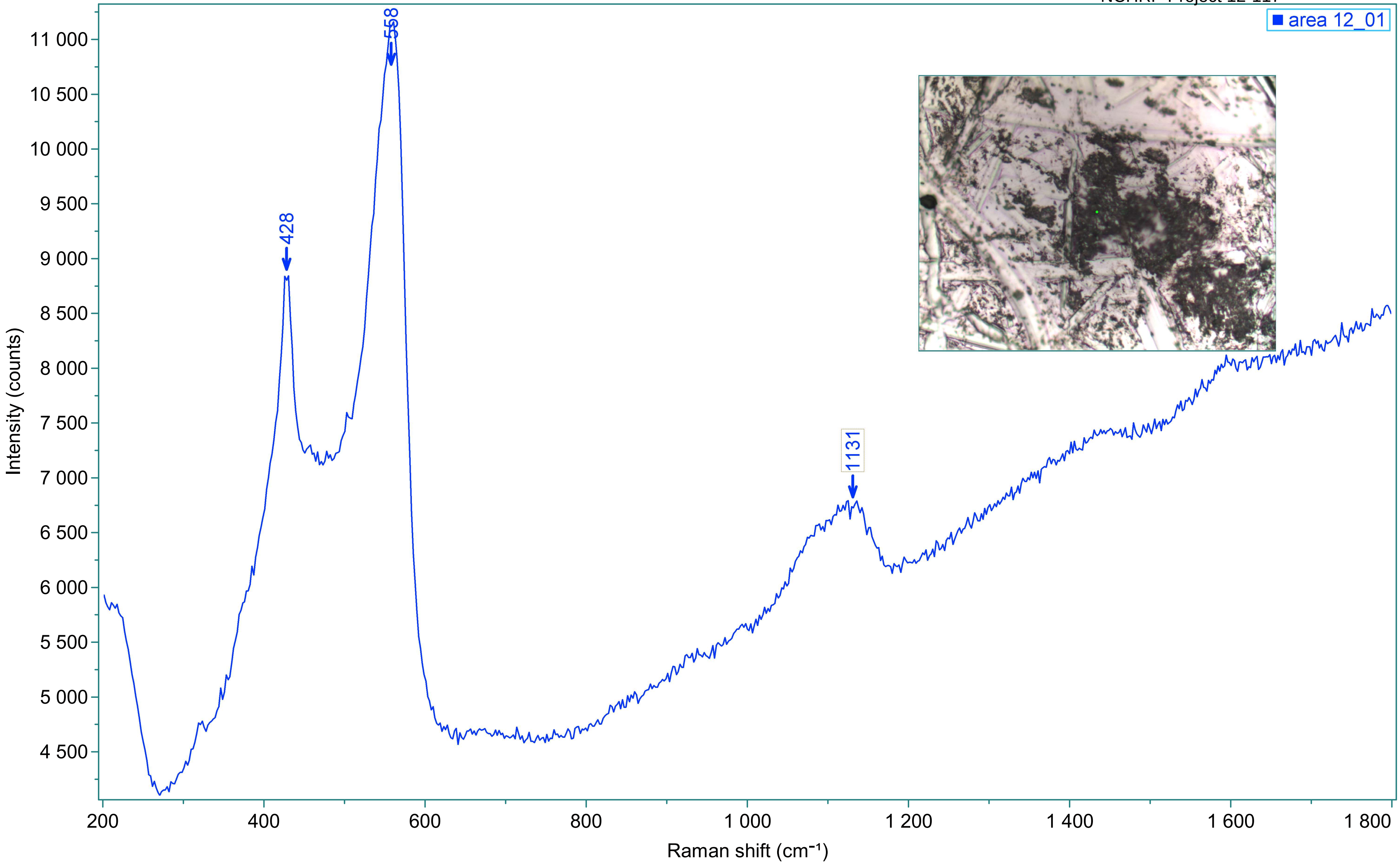
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Date | 04.12.2019 12:... | Acq. time (s) | 20 | Accumulations | 3 | Laser (nm) | 473.06 |
| Hole | 150.001 | Grating | 600 gr/mm | ND Filter | 100% | Delay time (s) | 0 |



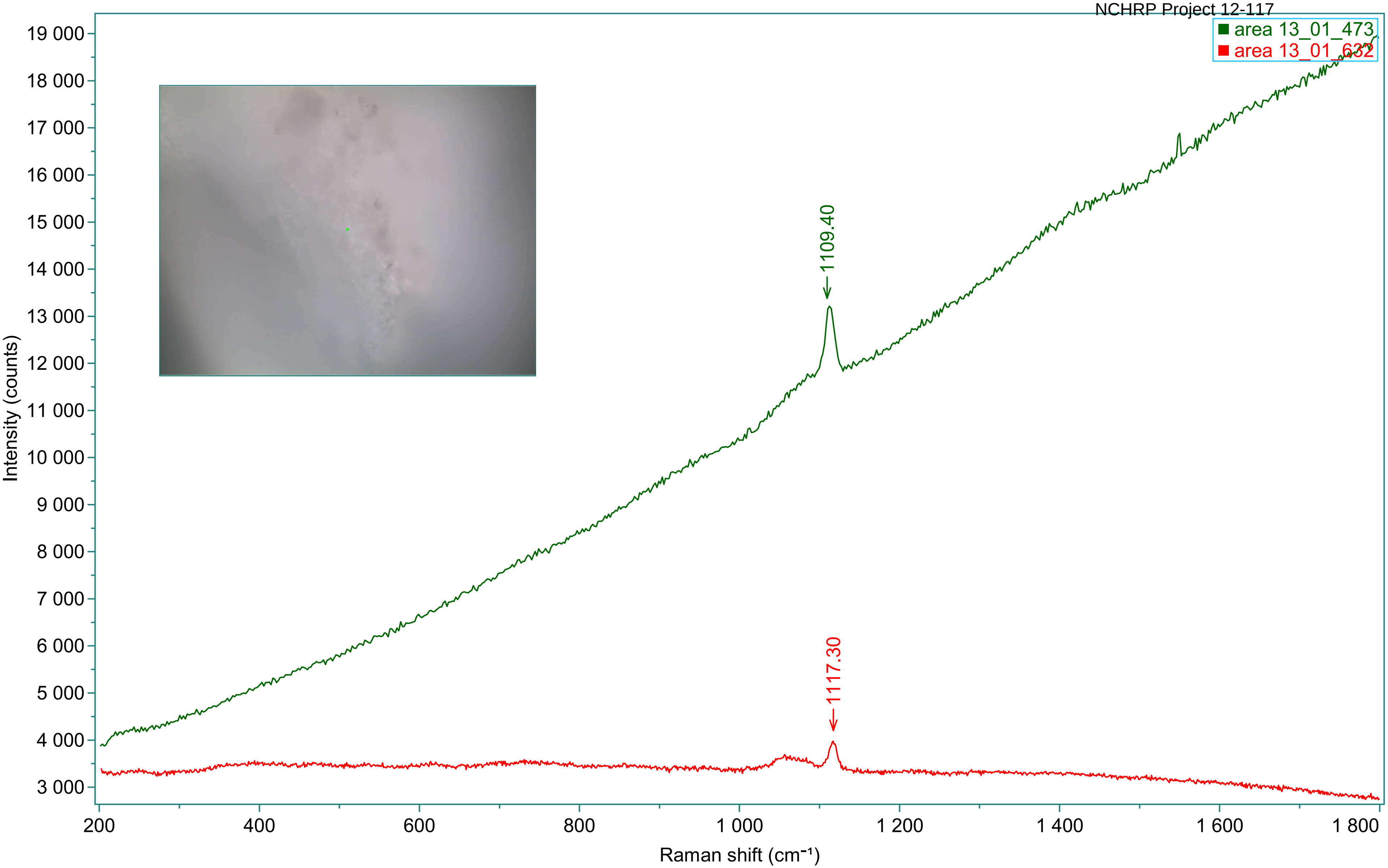
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Date | 04.12.2019 12:... | Acq. time (s) | 10 | Accumulations | 3 | Laser (nm) | 473.06 |
| Hole | 150.001 | Grating | 600 gr/mm | ND Filter | 100% | Delay time (s) | 0 |



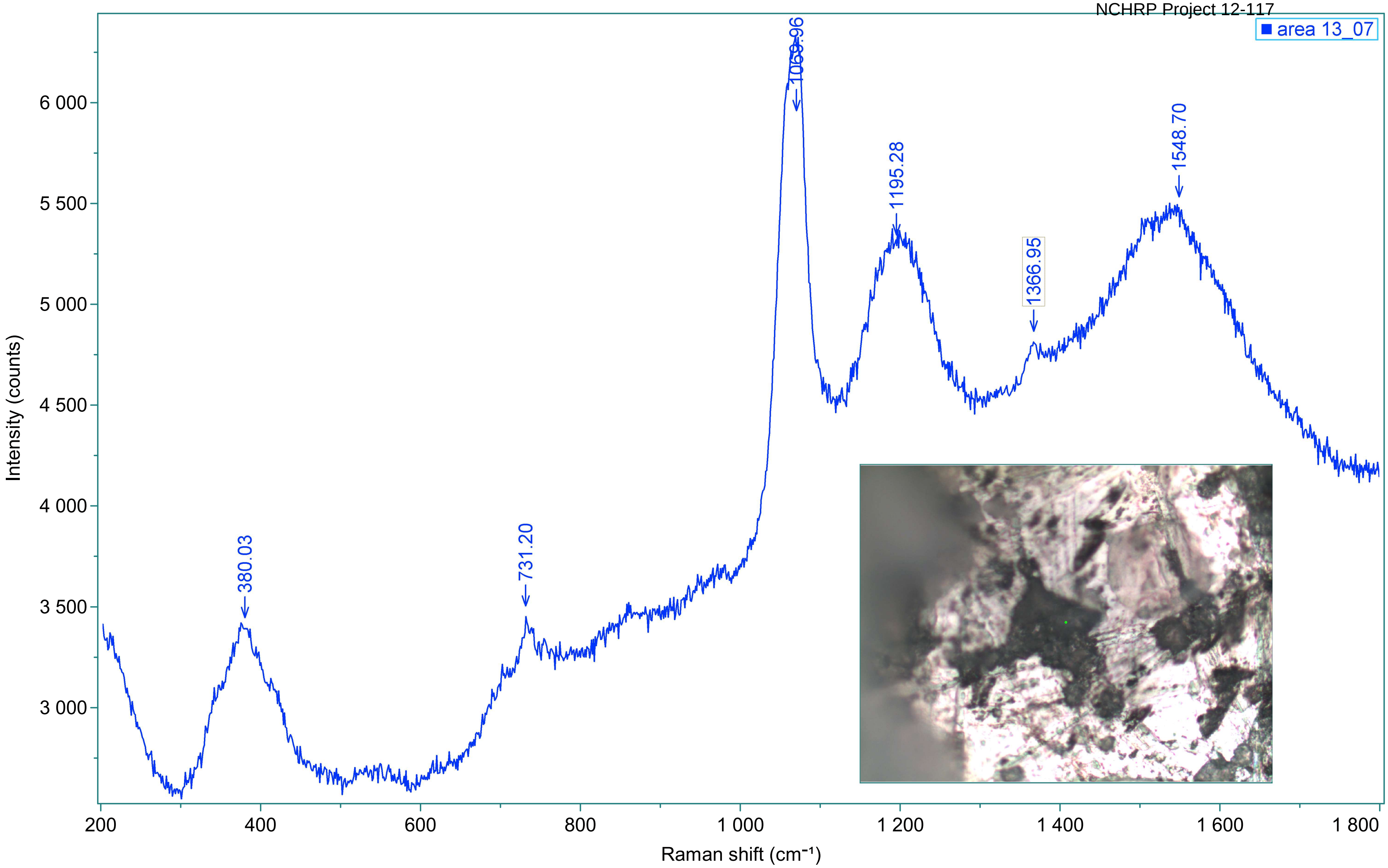
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Date | 04.12.2019 13:... | Acq. time (s) | 10 | Accumulations | 3 | Laser (nm) | 473.06 |
| Hole | 150.001 | Grating | 600 gr/mm | ND Filter | 100% | Delay time (s) | 0 |



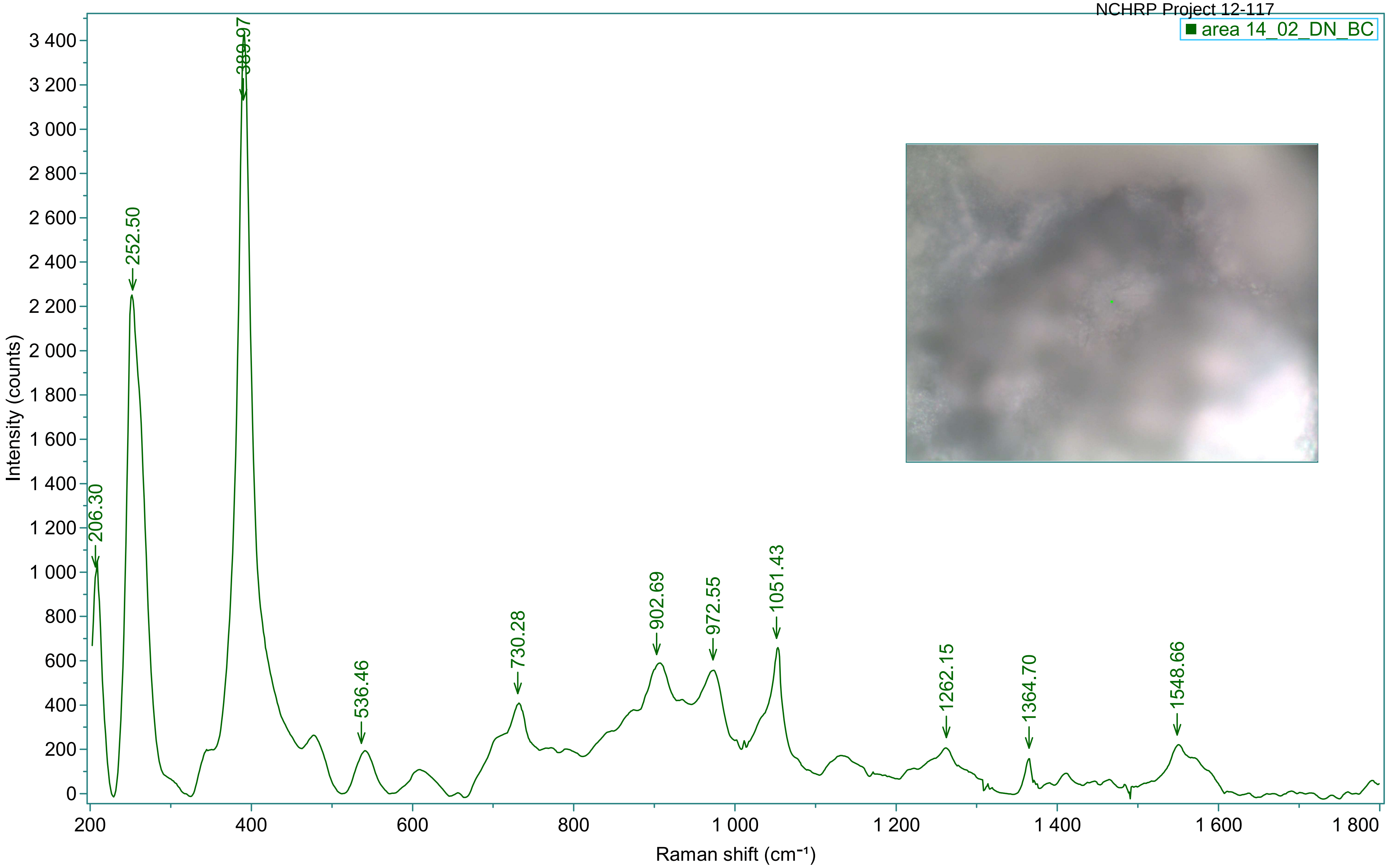
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Date | 04.12.2019 13:... | Acq. time (s) | 10 | Accumulations | 3 | Laser (nm) | 473.06 |
| Hole | 150.001 | Grating | 600 gr/mm | ND Filter | 100% | Delay time (s) | 0 |



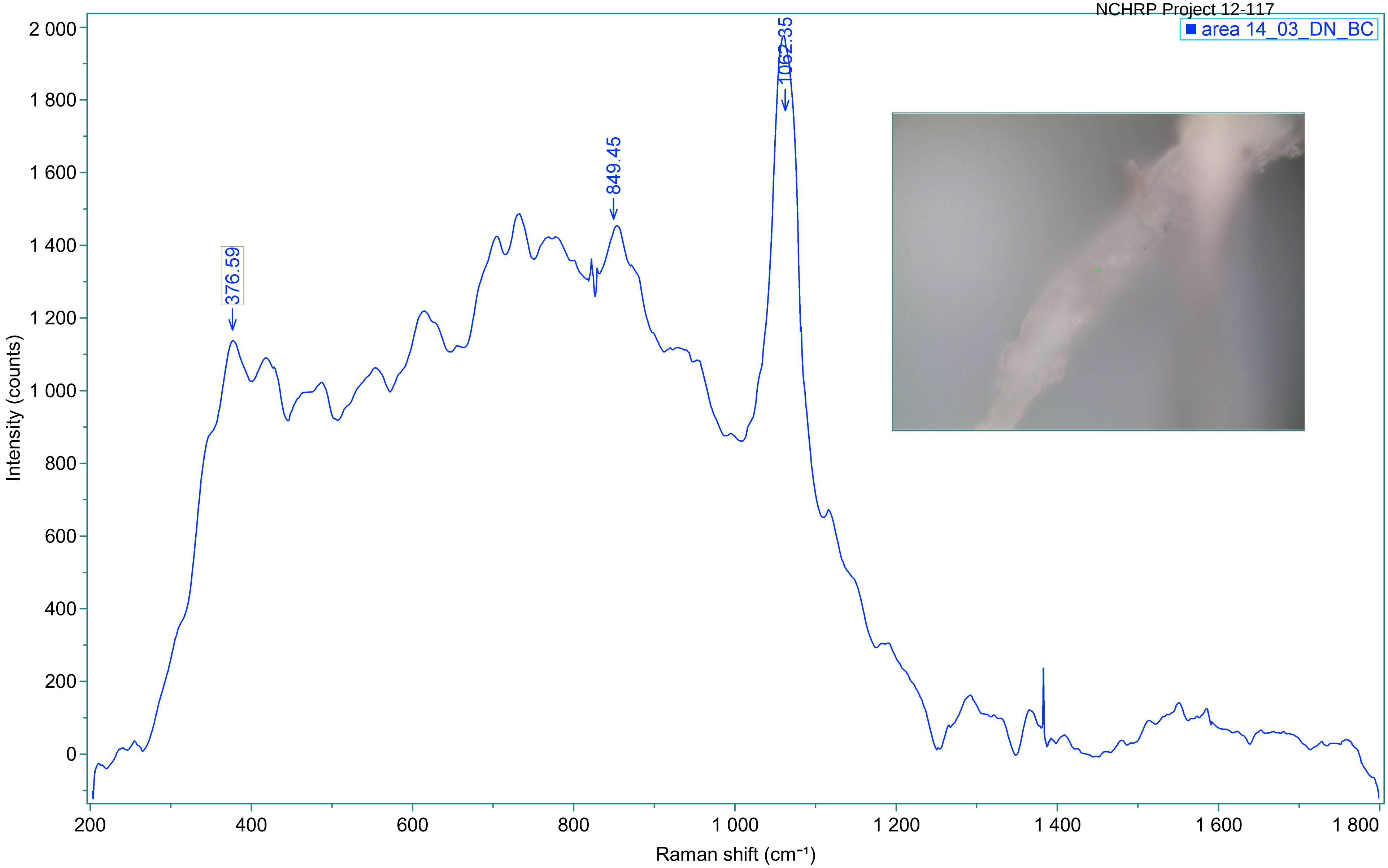
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Date | 04.12.2019 13:... | Acq. time (s) | 5 | Accumulations | 3 | Laser (nm) | 473.06 |
| Hole | 150.001 | Grating | 600 gr/mm | ND Filter | 100% | Delay time (s) | 0 |



| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Date | 04.12.2019 13:... | Acq. time (s) | 10 | Accumulations | 3 | Laser (nm) | 632.81 |
| Hole | 150.001 | Grating | 600 gr/mm | ND Filter | 100% | Delay time (s) | 0 |



| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Date | 04.12.2019 13:... | Acq. time (s) | 10 | Accumulations | 3 | Laser (nm) | 632.81 |
| Hole | 150.001 | Grating | 600 gr/mm | ND Filter | 100% | Delay time (s) | 0 |



| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Date | 04.12.2019 14:... | Acq. time (s) | 10 | Accumulations | 3 | Laser (nm) | 632.81 |
| Hole | 150.001 | Grating | 600 gr/mm | ND Filter | 100% | Delay time (s) | 0 |

# APPENDIX E: STUDY 1, REPRESENTATIVE TEST PANEL PHOTOGRAPHS

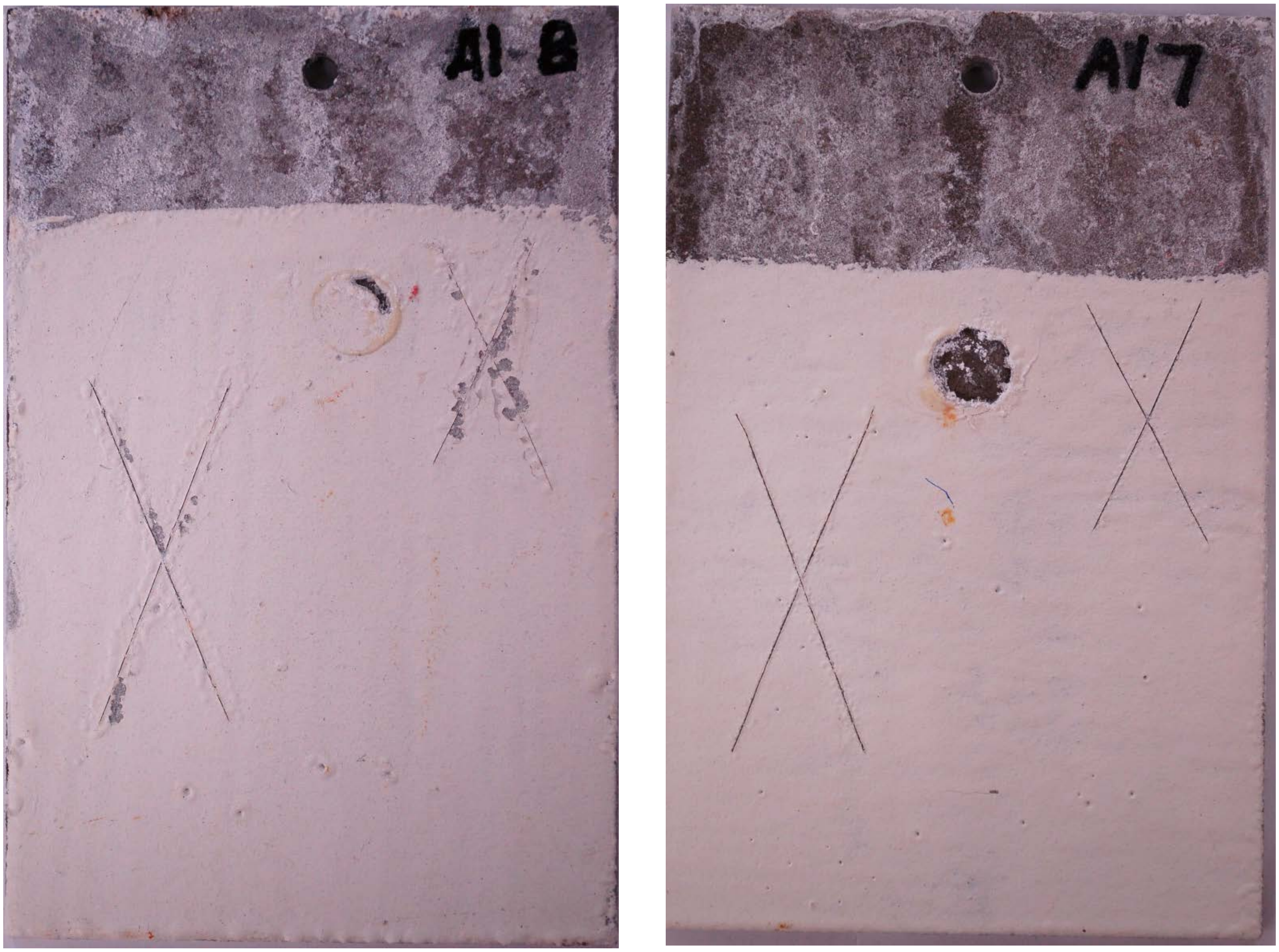


*Figure 1. Blistering of coating at X-cut incisions on Al TSC panels: no oxidation (L), 1 day exposure (R)*

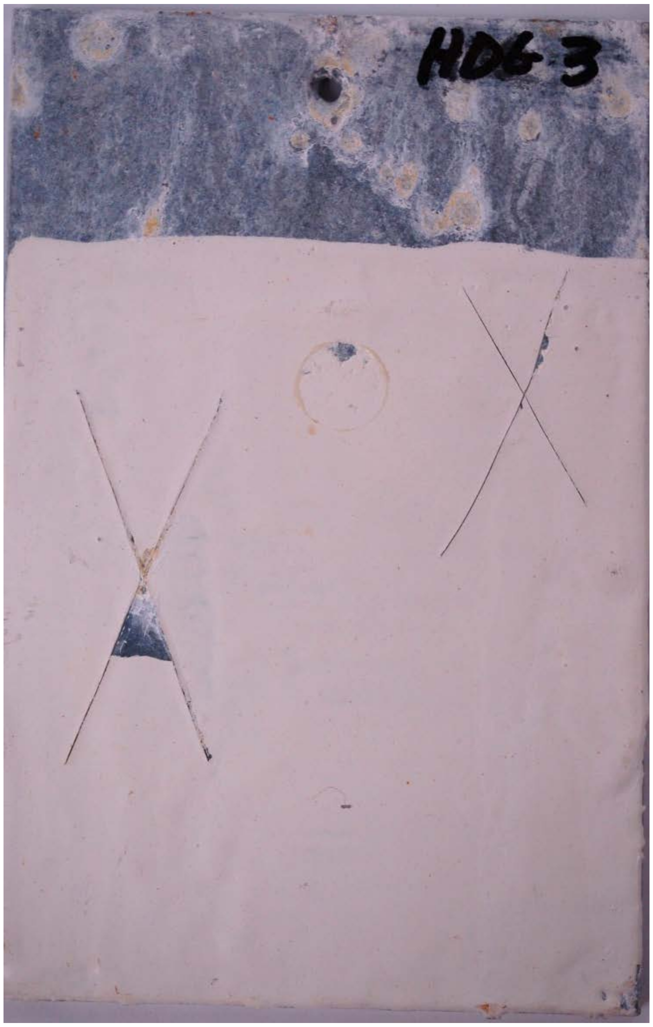


*Figure 2. X-cut tape adhesion rating of 2A (L) and 4A (R)*

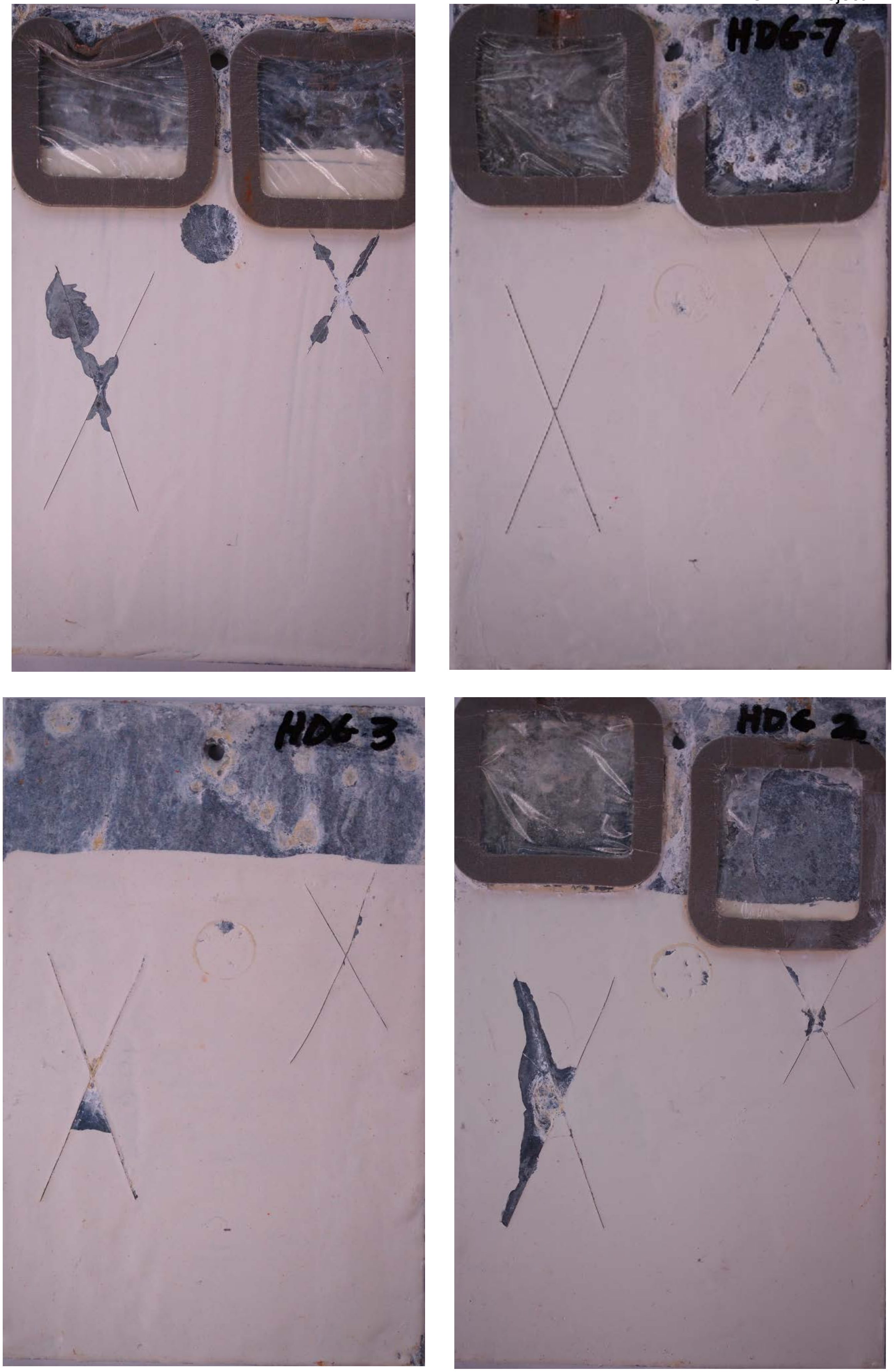


***Figure 3. HDG panels following X-cut tape adhesion testing for each of the four oxide conditions: no oxidation (top L), 1 day exposure (top R), 14 days exposure (bottom L), 21 days exposure (bottom R).***

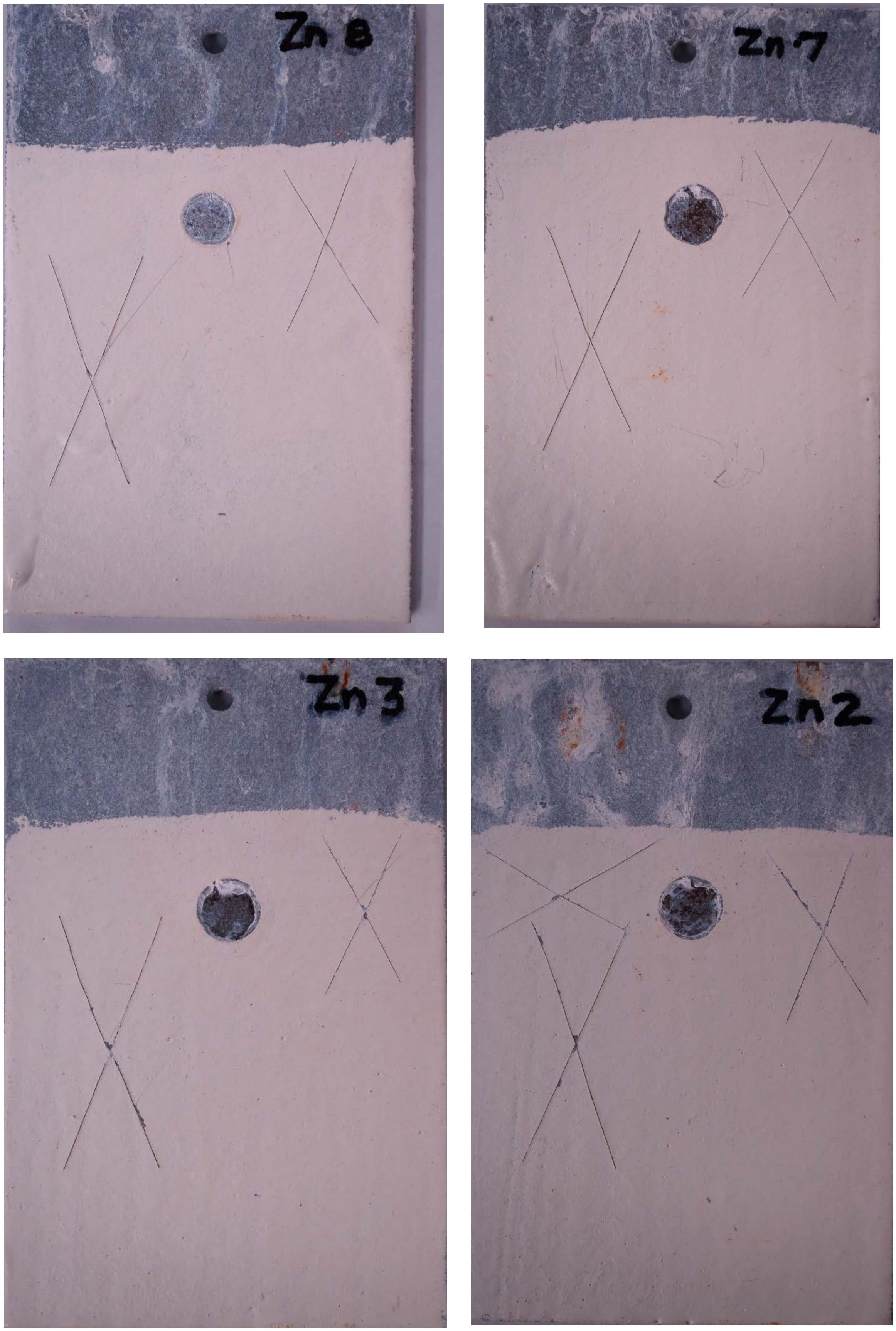


***Figure 4. Zn TSC panels following X-cut tape adhesion testing for each of the four oxide conditions: no oxidation (top L), 1 day exposure (top R), 14 days exposure (bottom L), 21 days exposure (bottom R).***

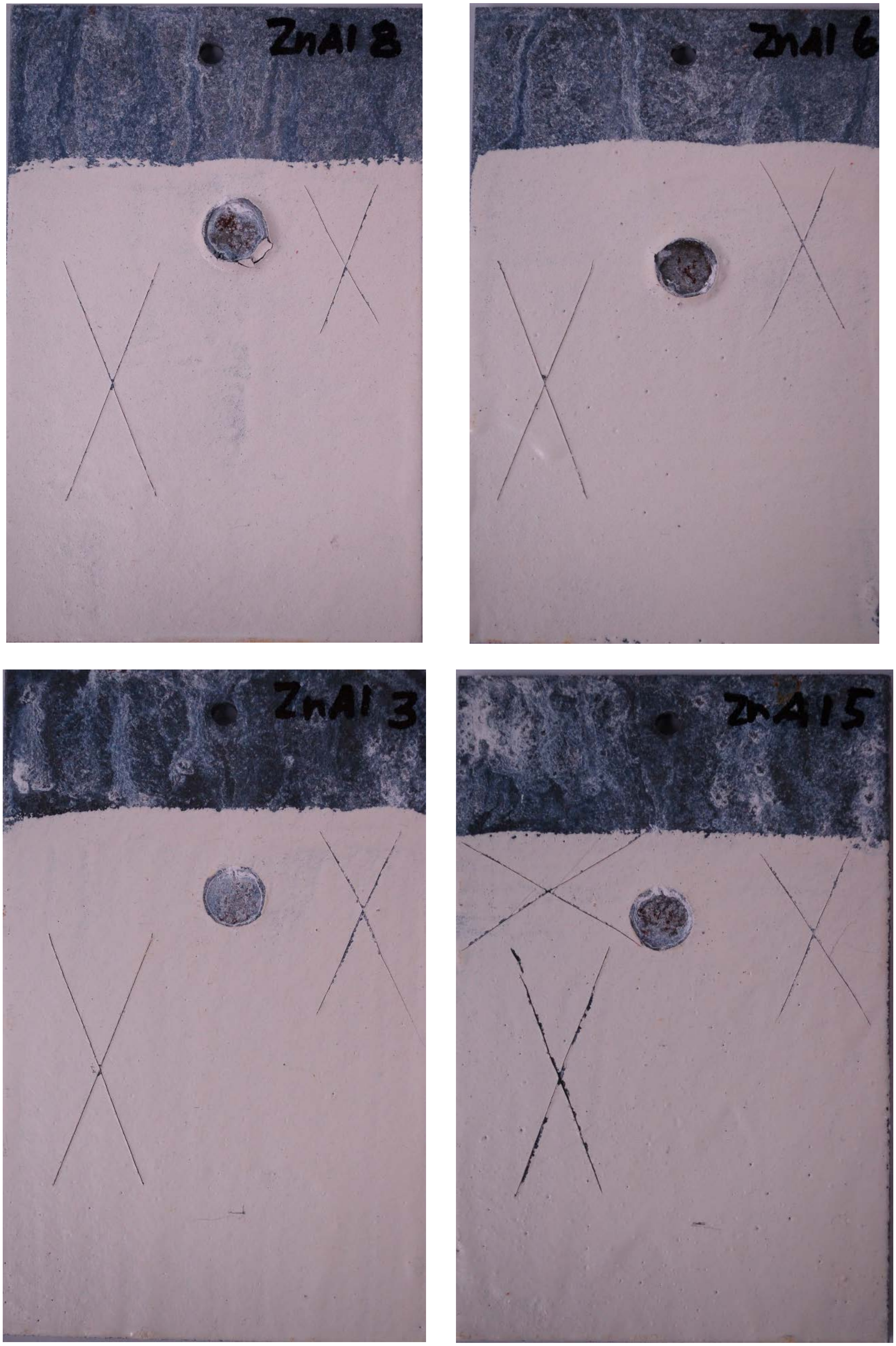


***Figure 5. ZnAl TSC panels following X-cut tape adhesion testing for each of the four oxide conditions: no oxidation (top L), 1 day exposure (top R), 14 days exposure (bottom L), 21 days exposure (bottom R).***

***Figure 6. Al TSC panels following X-cut tape adhesion testing for each of the four oxide conditions: no oxidation (top L), 1 day exposure (top R), 14 days exposure (bottom L), 21 days exposure (bottom R).***

## APPENDIX F: COATING THICKNESS MEASUREMENTS
### HDG Panels, Study 2

| Panel ID | Side | Spot # | HDG Spot Average (mils) | HDG Side Average (mils) | HDG Following SP16 Spot Average (mils) | HDG Following SP16 Side Average (mils) | HDG + Epoxy Spot Average (mils) | HDG + Epoxy Side Average (mils) |
|---|---|---|---|---|---|---|---|---|
| 11 | Front | 1 | 4.5 | 4.7 | 4.0 | 4.2 | 9.6 | 10.7 |
| | | 2 | 5.2 | | 4.1 | | 11.5 | |
| | | 3 | 4.3 | | 4.3 | | 11.0 | |
| | Back | 1 | 4.1 | 4.4 | 4.5 | 4.3 | 10.8 | 11.9 |
| | | 2 | 4.2 | | 4.1 | | 12.2 | |
| | | 3 | 4.8 | | 4.4 | | 12.7 | |
| 12 | Front | 1 | 3.9 | 4.3 | 3.7 | 4.0 | 10.9 | 11.8 |
| | | 2 | 4.4 | | 3.7 | | 12.6 | |
| | | 3 | 4.6 | | 4.4 | | 12.0 | |
| | Back | 1 | 4.9 | 5.2 | 4.8 | 5.1 | 12.0 | 13.4 |
| | | 2 | 5.2 | | 5.1 | | 13.9 | |
| | | 3 | 5.4 | | 5.4 | | 14.3 | |
| 13 | Front | 1 | 3.9 | 4.0 | 3.8 | 3.8 | 10.5 | 11.4 |
| | | 2 | 3.8 | | 3.7 | | 11.3 | |
| | | 3 | 4.2 | | 4.0 | | 12.5 | |
| | Back | 1 | 5.2 | 5.4 | 4.8 | 5.0 | 13.4 | 13.7 |
| | | 2 | 5.5 | | 4.9 | | 13.7 | |
| | | 3 | 5.5 | | 5.2 | | 14.0 | |
| 14 | Front | 1 | 4.3 | 4.3 | 3.8 | 4.2 | 9.4 | 9.5 |
| | | 2 | 3.5 | | 4.0 | | 9.6 | |
| | | 3 | 4.9 | | 4.7 | | 9.6 | |
| | Back | 1 | 4.3 | 4.4 | 4.0 | 4.3 | 10.0 | 10.0 |
| | | 2 | 4.2 | | 4.5 | | 10.8 | |
| | | 3 | 4.8 | | 4.6 | | 9.3 | |
| 15 | Front | 1 | 3.8 | 4.0 | 3.2 | 3.4 | 9.3 | 9.4 |
| | | 2 | 4.1 | | 3.5 | | 9.7 | |
| | | 3 | 4.2 | | 3.5 | | 9.2 | |
| | Back | 1 | 4.6 | 4.7 | 4.2 | 4.4 | 10.6 | 10.8 |
| | | 2 | 4.6 | | 4.4 | | 11.6 | |
| | | 3 | 5.0 | | 4.7 | | 10.2 | |
| 16 | Front | 1 | 3.6 | 4.1 | 3.5 | 3.6 | 8.6 | 9.6 |
| | | 2 | 4.2 | | 3.6 | | 10.9 | |
| | | 3 | 4.5 | | 3.7 | | 9.2 | |
| | Back | 1 | 4.0 | 4.2 | 3.9 | 3.9 | 10.3 | 10.1 |
| | | 2 | 4.2 | | 3.8 | | 10.4 | |
| | | 3 | 4.4 | | 3.9 | | 9.6 | |

**Coating Thickness Measurements - HDG Panels, Study 2**

| Panel ID | Side | Spot # | HDG Spot Average (mils) | HDG Side Average (mils) | HDG Following SP16 Spot Average (mils) | HDG Following SP16 Side Average (mils) | HDG + Epoxy Spot Average (mils) | HDG + Epoxy Side Average (mils) |
|---|---|---|---|---|---|---|---|---|
| 17 | Front | 1 | 4.8 | 4.6 | 4.3 | 4.0 | 10.8 | 11.3 |
| | | 2 | 4.6 | | 3.9 | | 12.1 | |
| | | 3 | 4.4 | | 3.8 | | 11.0 | |
| | Back | 1 | 4.5 | 5.0 | 4.2 | 4.3 | 12.2 | 13.1 |
| | | 2 | 4.8 | | 4.6 | | 14.4 | |
| | | 3 | 5.7 | | 4.2 | | 12.8 | |
| 18 | Front | 1 | 4.2 | 4.5 | 4.0 | 4.3 | 11.8 | 12.1 |
| | | 2 | 5.0 | | 4.6 | | 13.3 | |
| | | 3 | 4.2 | | 4.1 | | 11.3 | |
| | Back | 1 | 5.0 | 6.9 | 4.4 | 6.8 | 13.5 | 13.7 |
| | | 2 | 6.9 | | 4.9 | | 14.2 | |
| | | 3 | 8.8 | | 11.0 | | 13.4 | |
| 19 | Front | 1 | 4.3 | 4.3 | 4.0 | 4.0 | 11.0 | 11.5 |
| | | 2 | 4.3 | | 4.1 | | 12.4 | |
| | | 3 | 4.4 | | 3.9 | | 11.0 | |
| | Back | 1 | 4.6 | 4.6 | 4.2 | 4.3 | 11.6 | 12.2 |
| | | 2 | 4.5 | | 4.2 | | 12.6 | |
| | | 3 | 4.6 | | 4.5 | | 12.3 | |

## Coating Thickness Measurements - Zinc TSC Panels, Study 2

| Panel ID | Side | Spot # | Zn TSC Spot Average (mils) | Zn TSC Side Average (mils) | Zn TSC + Sealer Spot Average (mils) | Zn TSC + Sealer Side Average (mils) | Zn TSC + Sealer + Epoxy Spot Average (mils) | Zn TSC + Sealer + Epoxy Side Average (mils) |
|---|---|---|---|---|---|---|---|---|
| 11 | Front | 1 | 10.5 | 11.0 | 10.5 | 10.4 | 21.8 | 25.2 |
| | | 2 | 10.6 | | 9.9 | | 28.5 | |
| | | 3 | 11.8 | | 10.9 | | 25.3 | |
| | Back | 1 | 8.2 | 9.2 | 11.5 | 10.7 | 16.0 | 16.0 |
| | | 2 | 10.6 | | 10.7 | | 16.8 | |
| | | 3 | 9.0 | | 9.8 | | 15.2 | |
| 12 | Front | 1 | 10.2 | 9.0 | 11.9 | 10.3 | 23.1 | 22.3 |
| | | 2 | 9.5 | | 9.6 | | 22.4 | |
| | | 3 | 7.4 | | 9.5 | | 21.3 | |
| | Back | 1 | 8.4 | 8.2 | 9.9 | 10.0 | 14.7 | 16.2 |
| | | 2 | 8.9 | | 11.4 | | 18.4 | |
| | | 3 | 7.4 | | 8.8 | | 15.5 | |
| 13 | Front | 1 | 9.9 | 10.1 | 10.8 | 11.1 | 21.6 | 21.5 |
| | | 2 | 10.0 | | 11.2 | | 21.7 | |
| | | 3 | 10.2 | | 11.3 | | 21.1 | |
| | Back | 1 | 9.6 | 9.3 | 9.4 | 10.0 | 13.9 | 15.6 |
| | | 2 | 9.1 | | 9.9 | | 16.6 | |
| | | 3 | 9.1 | | 10.9 | | 16.3 | |
| 14 | Front | 1 | 10.2 | 10.4 | 10.4 | 10.8 | 15.6 | 15.9 |
| | | 2 | 10.7 | | 11.6 | | 15.2 | |
| | | 3 | 10.2 | | 10.4 | | 16.9 | |
| | Back | 1 | 10.6 | 12.2 | 11.8 | 12.7 | 15.0 | 15.8 |
| | | 2 | 13.7 | | 13.5 | | 16.2 | |
| | | 3 | 12.4 | | 12.7 | | 16.2 | |
| 15 | Front | 1 | 10.4 | 10.9 | 9.9 | 10.8 | 14.5 | 15.4 |
| | | 2 | 11.3 | | 11.5 | | 15.4 | |
| | | 3 | 10.9 | | 11.0 | | 16.3 | |
| | Back | 1 | 8.2 | 8.7 | 10.2 | 9.5 | 14.4 | 13.9 |
| | | 2 | 8.8 | | 9.3 | | 12.5 | |
| | | 3 | 9.2 | | 9.0 | | 14.8 | |
| 16 | Front | 1 | 10.1 | 9.8 | 10.9 | 10.4 | 15.0 | 14.8 |
| | | 2 | 10.8 | | 10.0 | | 14.5 | |
| | | 3 | 8.4 | | 10.2 | | 14.9 | |
| | Back | 1 | 10.1 | 10.8 | 11.4 | 10.9 | 15.1 | 14.5 |
| | | 2 | 12.0 | | 11.0 | | 15.2 | |
| | | 3 | 10.5 | | 10.3 | | 13.1 | |

**Coating Thickness Measurements - Zinc TSC Panels, Study 2**

| Panel ID | Side | Spot # | Zn TSC Spot Average (mils) | Zn TSC Side Average (mils) | Zn TSC + Sealer Spot Average (mils) | Zn TSC + Sealer Side Average (mils) | Zn TSC + Sealer + Epoxy Spot Average (mils) | Zn TSC + Sealer + Epoxy Side Average (mils) |
|---|---|---|---|---|---|---|---|---|
| 17 | Front | 1 | 10.2 | 9.2 | 9.3 | 9.5 | 14.4 | 14.6 |
| | | 2 | 9.9 | | 9.5 | | 15.0 | |
| | | 3 | 7.4 | | 9.6 | | 14.5 | |
| | Back | 1 | 9.5 | 9.8 | 10.8 | 10.6 | 15.9 | 16.1 |
| | | 2 | 10.2 | | 10.7 | | 17.5 | |
| | | 3 | 9.7 | | 10.3 | | 15.0 | |
| 18 | Front | 1 | 8.7 | 9.2 | 8.9 | 10.3 | 15.7 | 16.9 |
| | | 2 | 9.3 | | 10.2 | | 17.4 | |
| | | 3 | 9.6 | | 11.8 | | 17.6 | |
| | Back | 1 | 9.6 | 9.3 | 10.5 | 10.5 | 16.8 | 17.0 |
| | | 2 | 9.3 | | 11.0 | | 17.6 | |
| | | 3 | 9.1 | | 10.2 | | 16.7 | |
| 19 | Front | 1 | 8.5 | 8.7 | 9.1 | 9.4 | 16.1 | 16.5 |
| | | 2 | 8.5 | | 10.2 | | 16.3 | |
| | | 3 | 9.2 | | 8.9 | | 17.2 | |
| | Back | 1 | 9.3 | 9.3 | 10.7 | 10.4 | 16.0 | 16.3 |
| | | 2 | 9.0 | | 11.2 | | 16.3 | |
| | | 3 | 9.8 | | 9.3 | | 16.6 | |

## Coating Thickness Measurements - Zinc-Aluminum TSC Panels, Study 2

| Panel ID | Side | Spot # | ZnAl TSC Spot Average (mils) | ZnAl TSC Side Average (mils) | ZnAl TSC + Sealer Spot Average (mils) | ZnAl TSC + Sealer Side Average (mils) | ZnAl TSC + Sealer + Epoxy Spot Average | ZnAl TSC + Sealer + Epoxy Side Average (mils) |
|---|---|---|---|---|---|---|---|---|
| 11 | Front | 1 | 9.0 | 10.4 | 10.8 | 12.0 | 15.5 | 17.8 |
| | | 2 | 10.9 | | 11.9 | | 19.4 | |
| | | 3 | 11.3 | | 13.3 | | 18.4 | |
| | Back | 1 | 11.3 | 10.6 | 10.2 | 10.2 | 17.1 | 16.0 |
| | | 2 | 10.2 | | 9.8 | | 15.4 | |
| | | 3 | 10.1 | | 10.7 | | 15.5 | |
| 12 | Front | 1 | 9.5 | 9.5 | 10.4 | 9.9 | 16.3 | 16.6 |
| | | 2 | 9.9 | | 10.0 | | 17.0 | |
| | | 3 | 9.1 | | 9.2 | | 16.4 | |
| | Back | 1 | 9.2 | 9.7 | 11.5 | 11.6 | 16.7 | 17.1 |
| | | 2 | 11.5 | | 13.3 | | 18.7 | |
| | | 3 | 8.3 | | 9.9 | | 15.9 | |
| 13 | Front | 1 | 8.5 | 10.0 | 10.2 | 10.3 | 15.3 | 16.6 |
| | | 2 | 10.7 | | 9.6 | | 16.5 | |
| | | 3 | 10.7 | | 11.0 | | 17.9 | |
| | Back | 1 | 8.6 | 9.8 | 11.6 | 10.6 | 15.5 | 16.2 |
| | | 2 | 11.8 | | 11.1 | | 17.5 | |
| | | 3 | 9.0 | | 9.0 | | 15.6 | |
| 14 | Front | 1 | 9.9 | 9.7 | 11.0 | 9.6 | 15.5 | 14.4 |
| | | 2 | 10.2 | | 9.0 | | 14.2 | |
| | | 3 | 9.1 | | 8.8 | | 13.5 | |
| | Back | 1 | 9.6 | 9.7 | 10.0 | 9.7 | 15.8 | 15.0 |
| | | 2 | 10.0 | | 9.5 | | 14.9 | |
| | | 3 | 9.6 | | 9.5 | | 14.4 | |
| 15 | Front | 1 | 9.1 | 9.0 | 9.7 | 9.2 | 14.2 | 14.4 |
| | | 2 | 9.4 | | 8.6 | | 14.4 | |
| | | 3 | 8.6 | | 9.3 | | 14.5 | |
| | Back | 1 | 9.1 | 8.7 | 9.0 | 9.3 | 15.0 | 14.6 |
| | | 2 | 7.6 | | 9.7 | | 14.0 | |
| | | 3 | 9.4 | | 9.3 | | 14.7 | |
| 16 | Front | 1 | 10.6 | 9.6 | 11.2 | 9.8 | 15.0 | 14.8 |
| | | 2 | 8.8 | | 8.4 | | 14.6 | |
| | | 3 | 9.5 | | 9.8 | | 14.8 | |
| | Back | 1 | 8.9 | 8.1 | 9.9 | 9.5 | 14.6 | 13.8 |
| | | 2 | 8.2 | | 10.1 | | 14.3 | |
| | | 3 | 7.2 | | 8.4 | | 12.6 | |

## Coating Thickness Measurements - Zinc-Aluminum TSC Panels, Study 2

| Panel ID | Side | Spot # | ZnAl TSC Spot Average (mils) | ZnAl TSC Side Average (mils) | ZnAl TSC + Sealer Spot Average (mils) | ZnAl TSC + Sealer Side Average (mils) | ZnAl TSC + Sealer + Epoxy Spot Average | ZnAl TSC + Sealer + Epoxy Side Average (mils) |
|---|---|---|---|---|---|---|---|---|
| 17 | Front | 1 | 8.5 | 8.7 | 8.7 | 9.2 | 14.8 | 16.4 |
| | | 2 | 7.9 | | 8.8 | | 18.3 | |
| | | 3 | 9.8 | | 10.1 | | 15.9 | |
| | Back | 1 | 13.7 | 11.7 | 14.8 | 12.4 | 20.2 | 19.2 |
| | | 2 | 10.2 | | 10.9 | | 18.7 | |
| | | 3 | 11.3 | | 11.6 | | 18.8 | |
| 18 | Front | 1 | 9.8 | 10.0 | 9.2 | 9.5 | 17.0 | 16.5 |
| | | 2 | 9.8 | | 9.9 | | 16.5 | |
| | | 3 | 10.6 | | 9.3 | | 16.0 | |
| | Back | 1 | 11.1 | 9.9 | 10.6 | 10.5 | 16.9 | 17.5 |
| | | 2 | 9.4 | | 11.2 | | 17.7 | |
| | | 3 | 9.4 | | 9.6 | | 17.9 | |
| 19 | Front | 1 | 9.2 | 9.1 | 10.4 | 10.4 | 17.2 | 16.7 |
| | | 2 | 8.4 | | 10.4 | | 17.3 | |
| | | 3 | 9.5 | | 10.6 | | 15.5 | |
| | Back | 1 | 9.7 | 9.6 | 9.8 | 10.0 | 17.3 | 17.3 |
| | | 2 | 10.2 | | 11.1 | | 18.5 | |
| | | 3 | 9.0 | | 9.3 | | 16.0 | |

## Coating Thickness Measurements - Aluminum TSC Panels, Study 2

| Panel ID | Side | Spot # | Al TSC Spot Average (mils) | Al TSC Side Average (mils) | Al TSC + Sealer Spot Average (mils) | Al TSC + Sealer Side Average (mils) | Al TSC + Sealer + Epoxy Spot Average (mils) | Al TSC + Sealer + Epoxy Side Average (mils) |
|---|---|---|---|---|---|---|---|---|
| 11 | Front | 1 | 10.6 | 13.0 | 11.2 | 13.3 | 16.7 | 20.1 |
| | | 2 | 13.3 | | 14.1 | | 19.9 | |
| | | 3 | 15.1 | | 14.7 | | 23.8 | |
| | Back | 1 | 8.0 | 10.7 | 10.0 | 11.4 | 14.9 | 16.4 |
| | | 2 | 10.8 | | 11.2 | | 17.7 | |
| | | 3 | 13.4 | | 12.9 | | 16.6 | |
| 12 | Front | 1 | 10.0 | 11.5 | 11.2 | 11.6 | 18.7 | 18.4 |
| | | 2 | 10.7 | | 11.8 | | 18.2 | |
| | | 3 | 13.8 | | 11.6 | | 18.3 | |
| | Back | 1 | 9.1 | 9.5 | 11.0 | 10.7 | 18.0 | 17.6 |
| | | 2 | 9.3 | | 10.0 | | 18.1 | |
| | | 3 | 10.0 | | 11.1 | | 16.6 | |
| 13 | Front | 1 | 8.5 | 9.1 | 10.0 | 11.0 | 16.2 | 17.4 |
| | | 2 | 9.1 | | 12.2 | | 17.9 | |
| | | 3 | 9.7 | | 10.9 | | 18.1 | |
| | Back | 1 | 10.7 | 9.9 | 11.1 | 11.0 | 18.1 | 18.0 |
| | | 2 | 9.8 | | 10.7 | | 18.6 | |
| | | 3 | 9.3 | | 11.4 | | 17.2 | |
| 14 | Front | 1 | 10.3 | 9.9 | 10.8 | 10.0 | 14.6 | 14.1 |
| | | 2 | 9.4 | | 9.3 | | 14.3 | |
| | | 3 | 9.9 | | 9.9 | | 13.5 | |
| | Back | 1 | 11.8 | 9.8 | 11.0 | 10.1 | 15.0 | 14.4 |
| | | 2 | 9.2 | | 10.1 | | 14.8 | |
| | | 3 | 8.4 | | 9.4 | | 13.3 | |
| 15 | Front | 1 | 10.6 | 10.3 | 11.1 | 11.4 | 16.4 | 15.9 |
| | | 2 | 10.9 | | 12.4 | | 16.7 | |
| | | 3 | 9.6 | | 10.7 | | 14.8 | |
| | Back | 1 | 10.2 | 10.4 | 10.1 | 10.9 | 15.5 | 15.6 |
| | | 2 | 10.4 | | 11.5 | | 15.3 | |
| | | 3 | 10.5 | | 11.1 | | 16.0 | |
| 16 | Front | 1 | 10.2 | 10.1 | 10.5 | 10.0 | 14.7 | 14.6 |
| | | 2 | 10.5 | | 10.0 | | 14.5 | |
| | | 3 | 9.5 | | 9.6 | | 14.4 | |
| | Back | 1 | 8.4 | 9.6 | 9.4 | 10.2 | 14.3 | 14.8 |
| | | 2 | 10.6 | | 11.5 | | 15.7 | |
| | | 3 | 9.9 | | 9.6 | | 14.3 | |

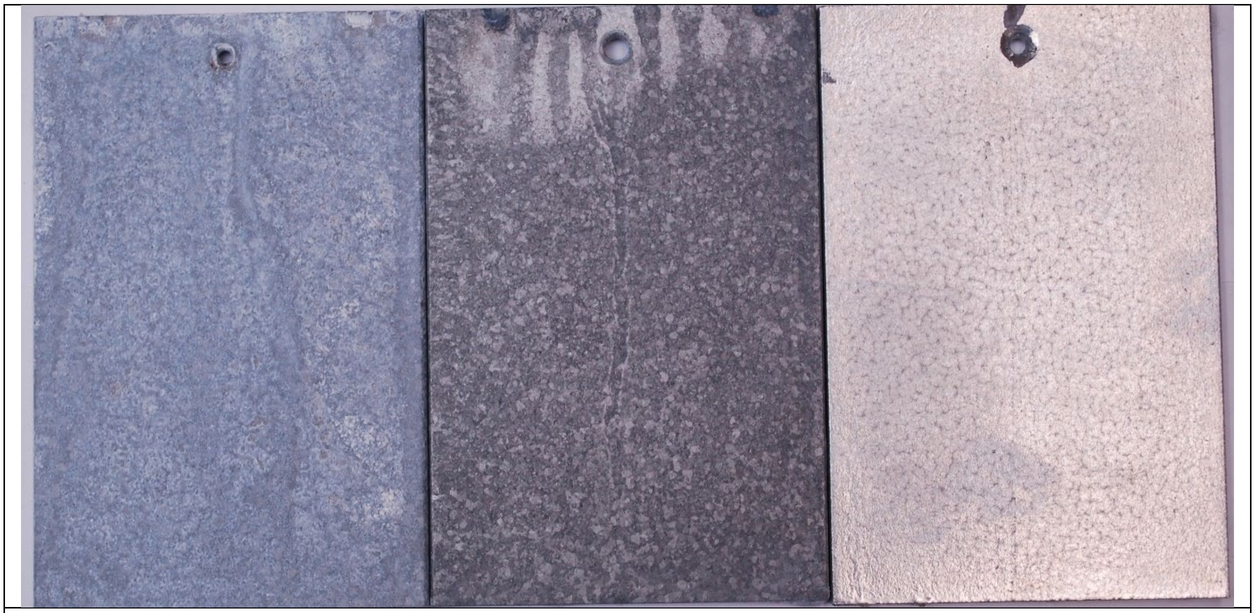
## Coating Thickness Measurements - Aluminum TSC Panels, Study 2

| Panel ID | Side | Spot # | Al TSC Spot Average (mils) | Al TSC Side Average (mils) | Al TSC + Sealer Spot Average (mils) | Al TSC + Sealer Side Average (mils) | Al TSC + Sealer + Epoxy Spot Average (mils) | Al TSC + Sealer + Epoxy Side Average (mils) |
|---|---|---|---|---|---|---|---|---|
| 17 | Front | 1 | 10.0 | 9.7 | 8.9 | 9.7 | 17.0 | 17.9 |
| | | 2 | 8.9 | | 10.2 | | 17.7 | |
| | | 3 | 10.1 | | 10.0 | | 18.9 | |
| | Back | 1 | 11.6 | 10.5 | 11.1 | 10.3 | 16.9 | 17.3 |
| | | 2 | 11.2 | | 9.9 | | 18.2 | |
| | | 3 | 8.7 | | 9.8 | | 16.8 | |
| 18 | Front | 1 | 9.5 | 10.8 | 10.4 | 11.8 | 17.7 | 19.5 |
| | | 2 | 11.4 | | 12.0 | | 20.1 | |
| | | 3 | 11.5 | | 13.1 | | 20.7 | |
| | Back | 1 | 8.7 | 9.0 | 9.7 | 9.5 | 16.7 | 17.9 |
| | | 2 | 8.7 | | 8.4 | | 18.5 | |
| | | 3 | 9.7 | | 10.3 | | 18.3 | |
| 19 | Front | 1 | 9.0 | 10.1 | 9.9 | 11.0 | 16.9 | 18.3 |
| | | 2 | 9.6 | | 11.5 | | 18.8 | |
| | | 3 | 11.6 | | 11.7 | | 19.2 | |
| | Back | 1 | 7.9 | 8.8 | 9.2 | 9.5 | 16.3 | 17.3 |
| | | 2 | 9.3 | | 9.2 | | 18.2 | |
| | | 3 | 9.3 | | 10.1 | | 17.5 | |

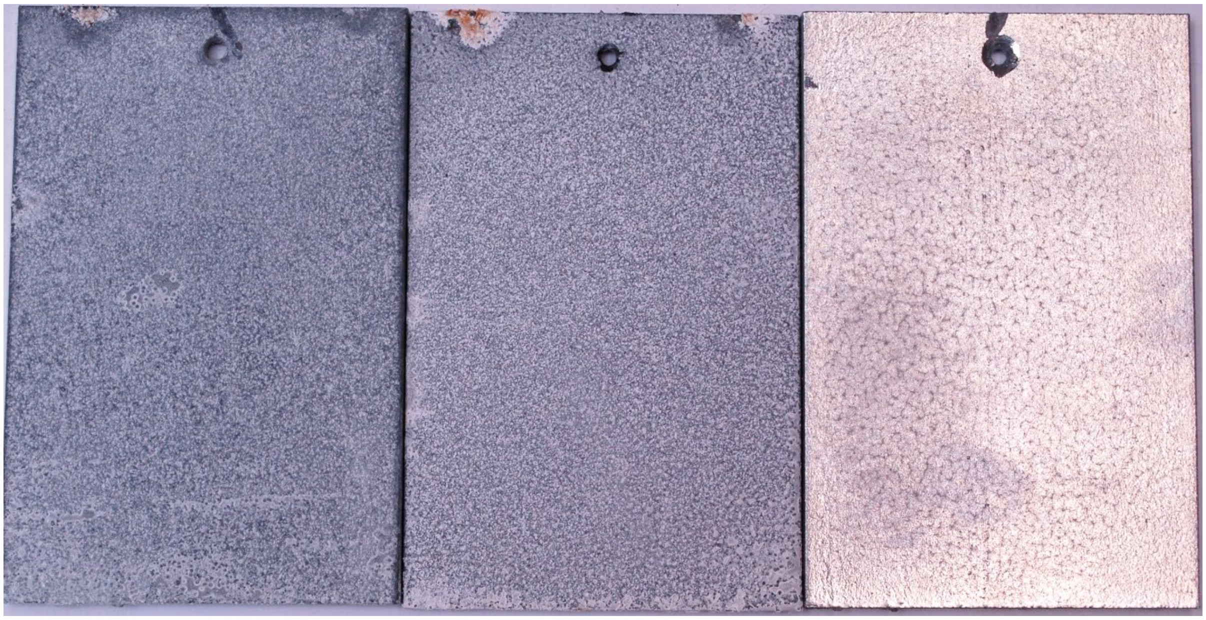
# Appendix G: Study 3 Photographs of Panels Representing Various Oxide Conditions With Surface Preparation Methods

# Attachment: Study 3 – Photographs of Panels Representing Various Oxide Conditions With Surface Preparation Methods

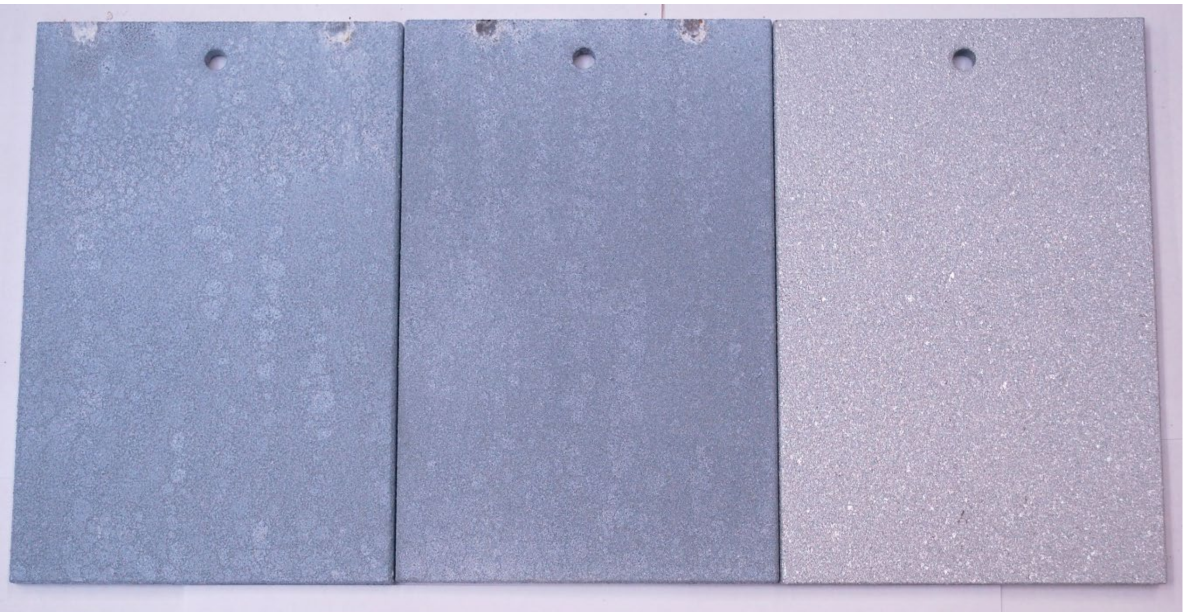
## SSPC-SP 1 PREPARATION



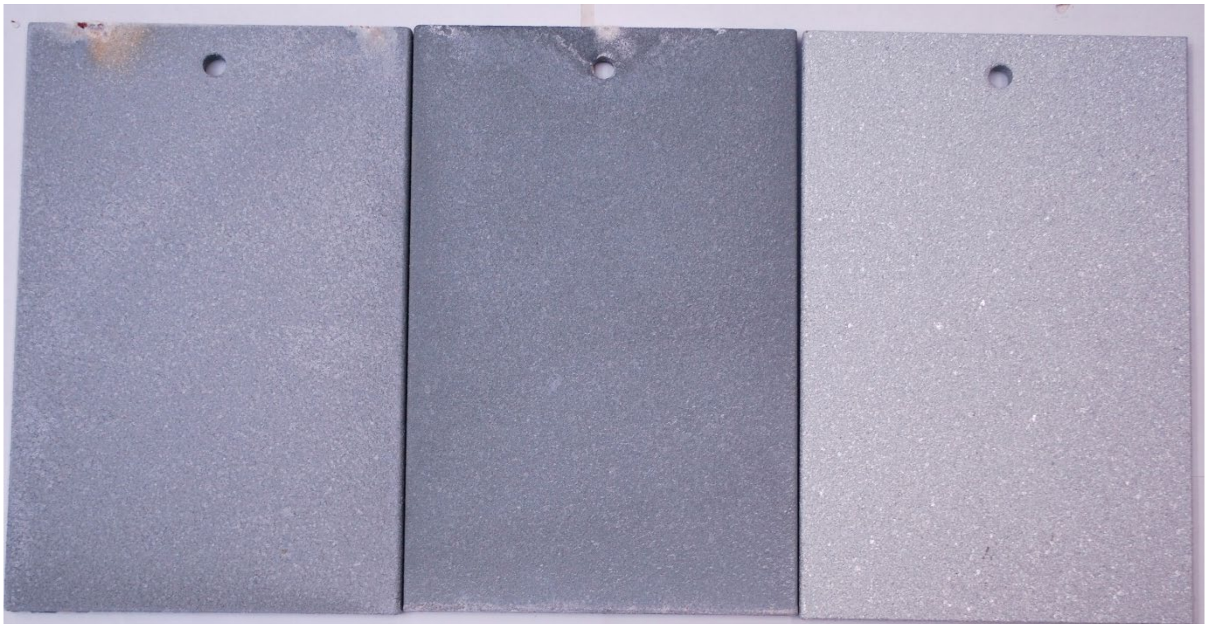
***HDG: Humidity exposed (L), Humidity exposed with SP 1 (C), No exposure***



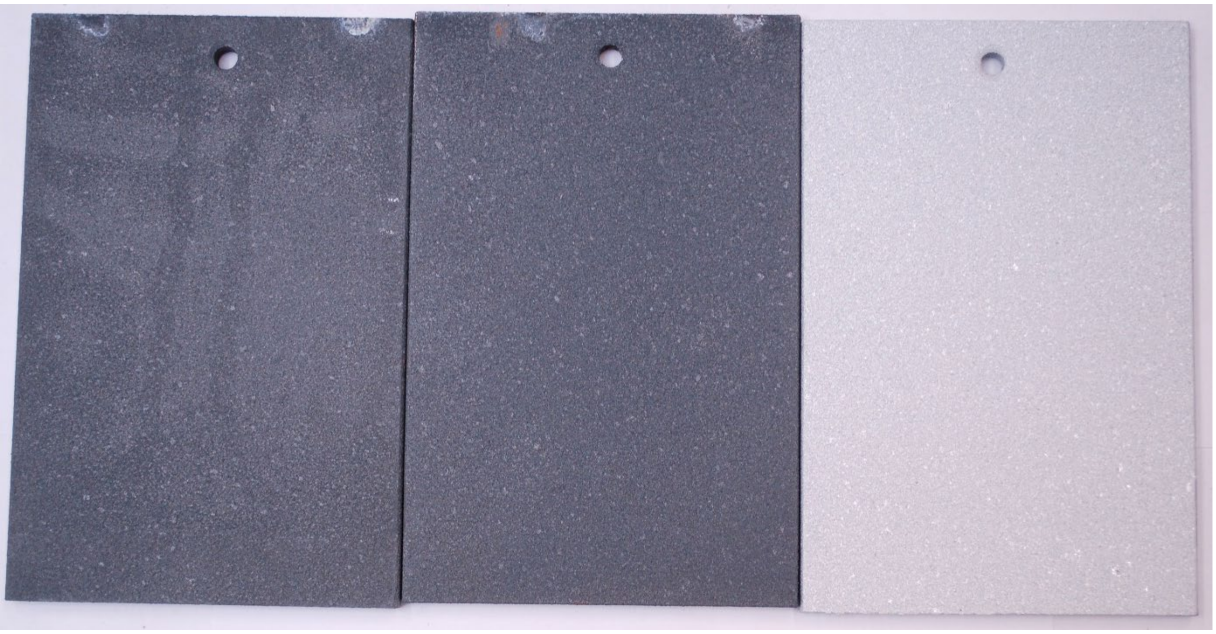
***HDG: Prohesion exposed (L), Prohesion exposed with SP 1 (C), No exposure***



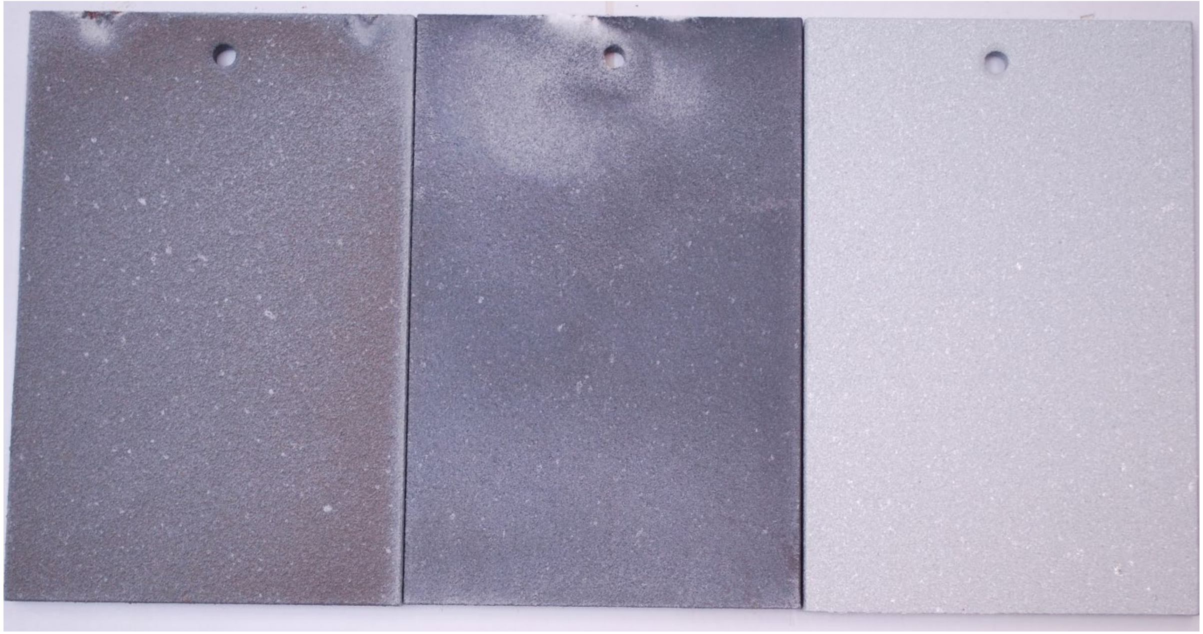
***Zn TSC: Humidity exposed (L), Humidity exposed with SP1 (C), No exposure (R)***



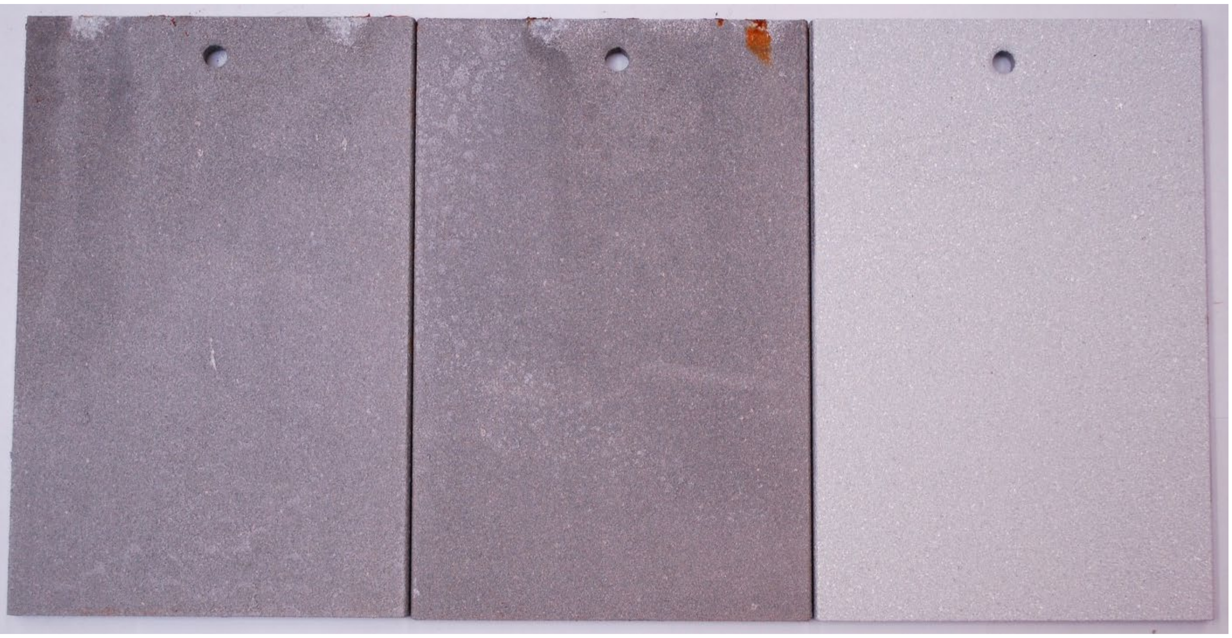
***Zn TSC: Prohesion exposed (L), Prohesion exposed with SP1 (C), No exposure (R)***



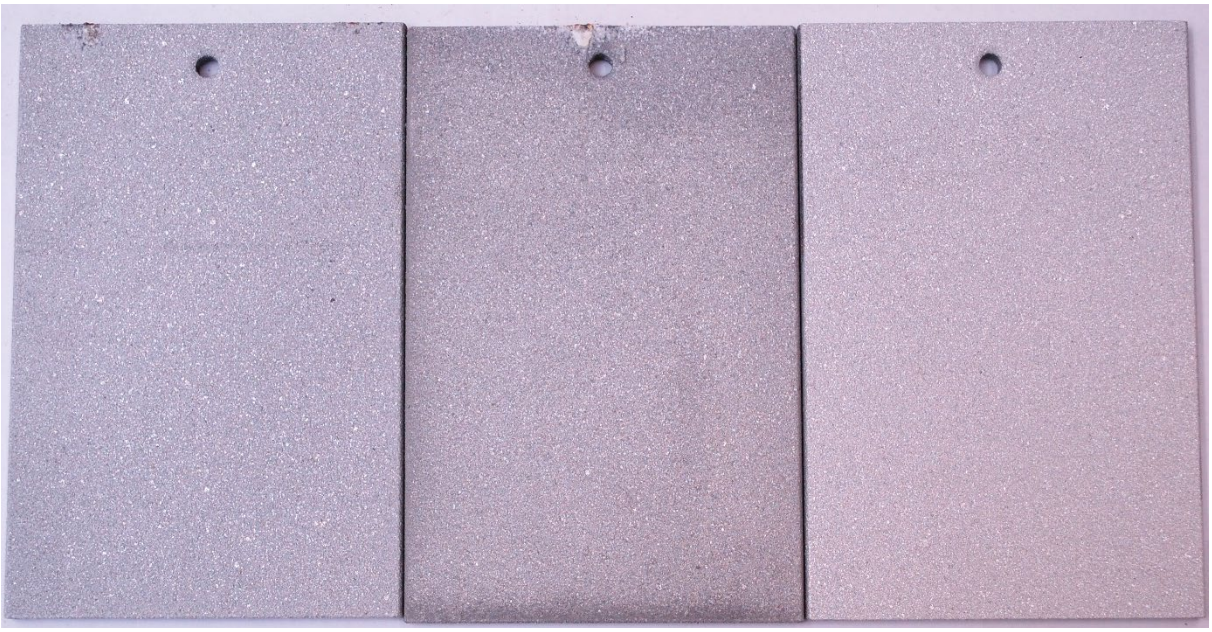
***ZnAl TSC: Humidity exposed (L), Humidity exposed with SP 1 (C), No exposure (R)***



***ZnAl TSC: Prohesion exposed (L), Prohesion exposed with SP 1 (C), No exposure (R)***

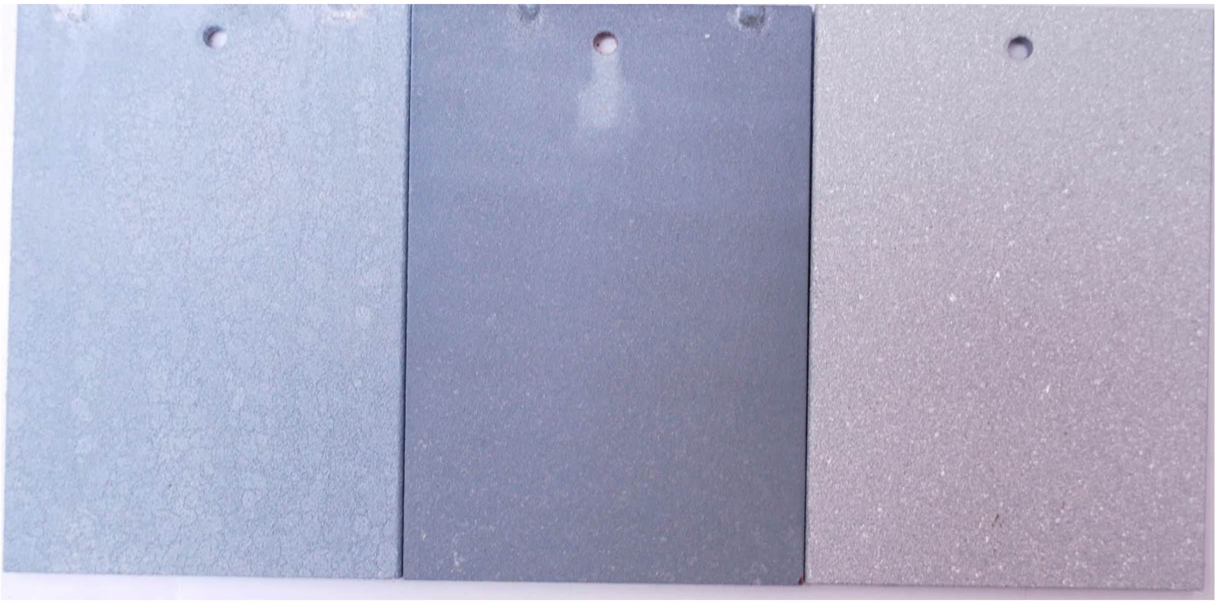


***Al TSC: Humidity exposed (L), Humidity exposed with SP1 (C), No exposure***



***Al TSC: Prohesion exposed (L), Prohesion exposed with SP1 (C), No exposure***

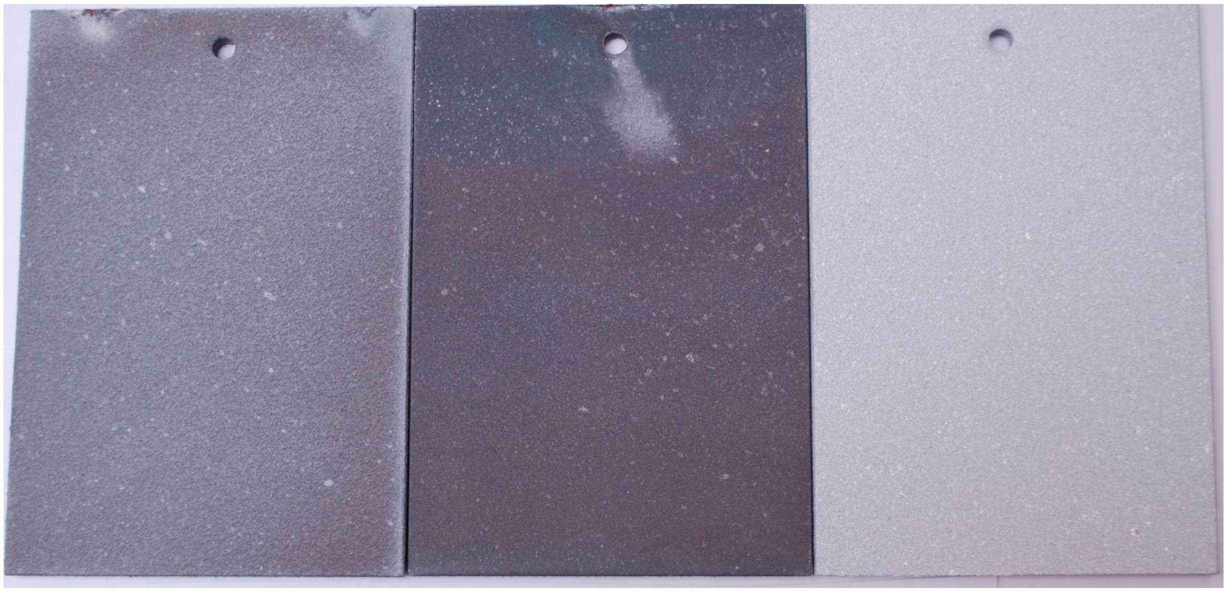
# PRESSURE WASH/BLOW DRY PREPARATION



***Zn TSC: Humidity exposed (L), Humidity exposed with pressure wash/blow dry (C), No exposure (R)***

***Zn TSC: Prohesion exposed (L), Prohesion exposed with pressure wash/blow dry (C), No exposure (R)***

***ZnAl TSC: Humidity exposed (L), Humidity exposed with pressure wash/blow dry (C), No exposure (R)***



***ZnAl TSC: Prohesion exposed (L), Prohesion exposed with pressure wash/blow dry (C), No exposure (R)***

***Al TSC: Humidity exposed (L), Humidity exposed with pressure wash/blow dry (C),***
***No exposure (R)***

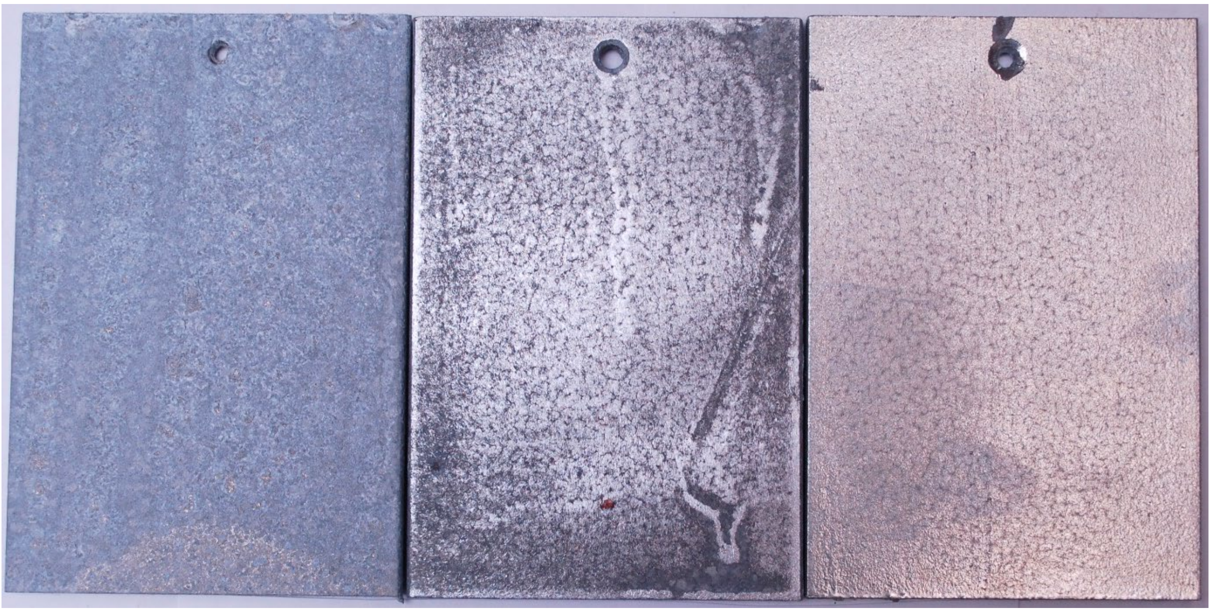
***Al TSC: Prohesion exposed (L), Prohesion exposed with pressure wash/blow dry (C),***
***No exposure (R)***

# WASH PRIMER PREPARATIOIN

***HDG: Humidity exposed (L), Humidity exposed with was primer (C), No exposure (R)***

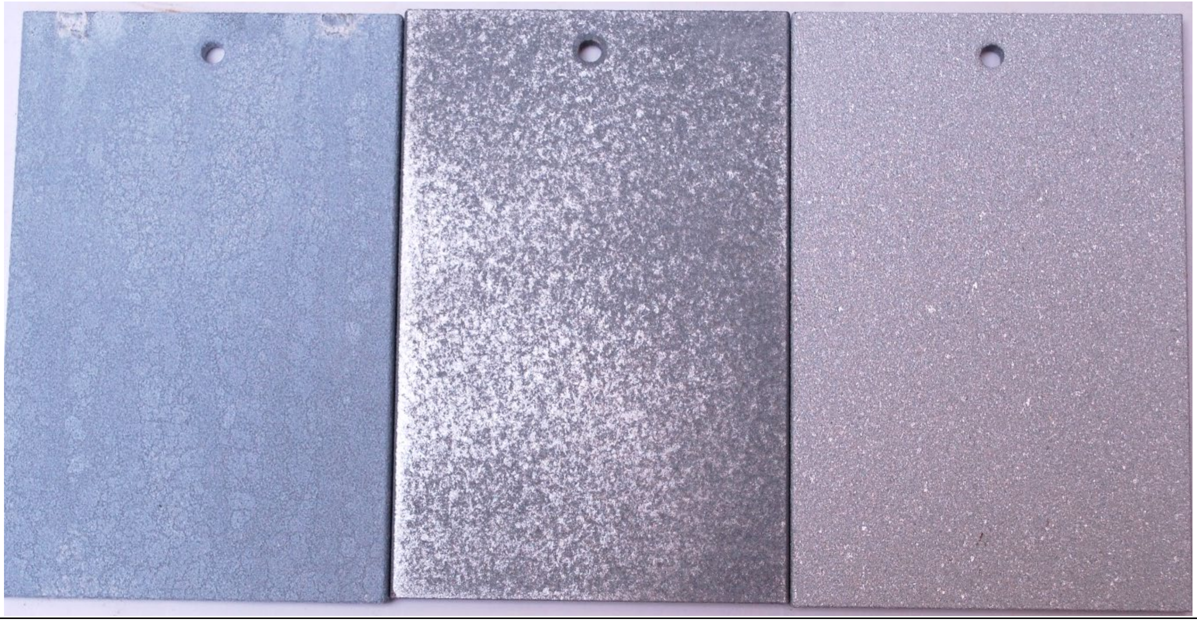
***Prohesion exposed condition photograph was not obtained inadvertently***

# PRESSURE WASH/POWER SAND PREPARATION

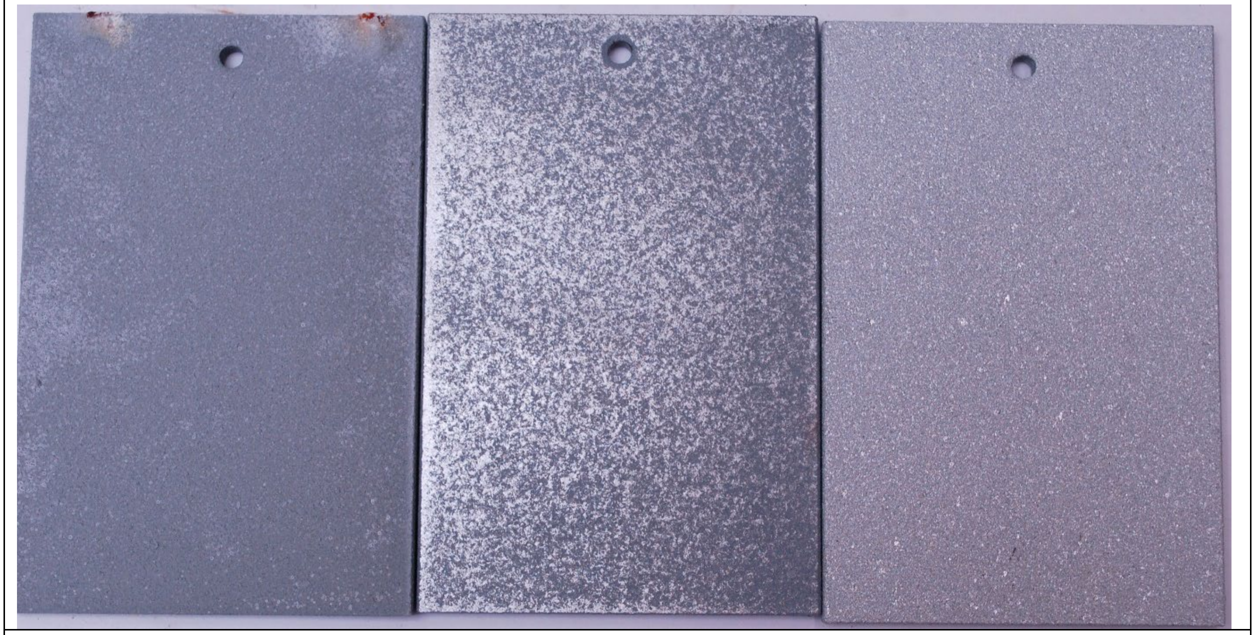


***HDG: Humidity exposed (L), Humidity exposed with power sand (C), No exposure (R)***

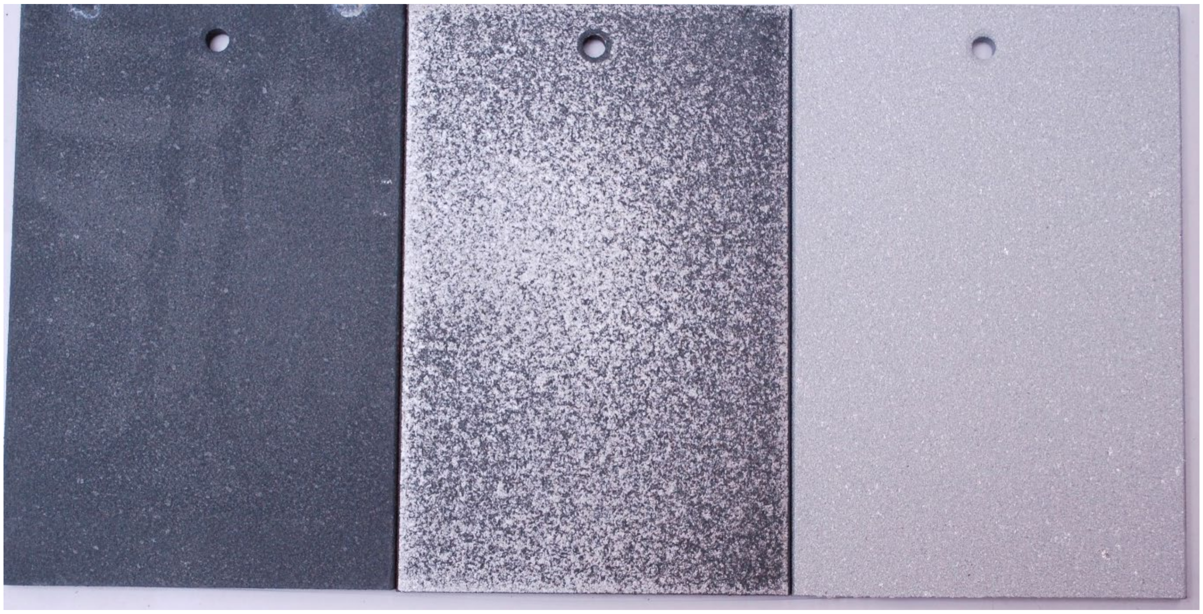
***HDG: Prohesion exposed (L), Prohesion exposed with power sand (C), No exposure (R)***



***Zn TSC: Humidity exposed (L), Humidity exposed with power sand (C), No exposure (R)***



***Zn TSC: Prohesion exposed (L), Prohesion exposed with power sand (C), No exposure (R)***



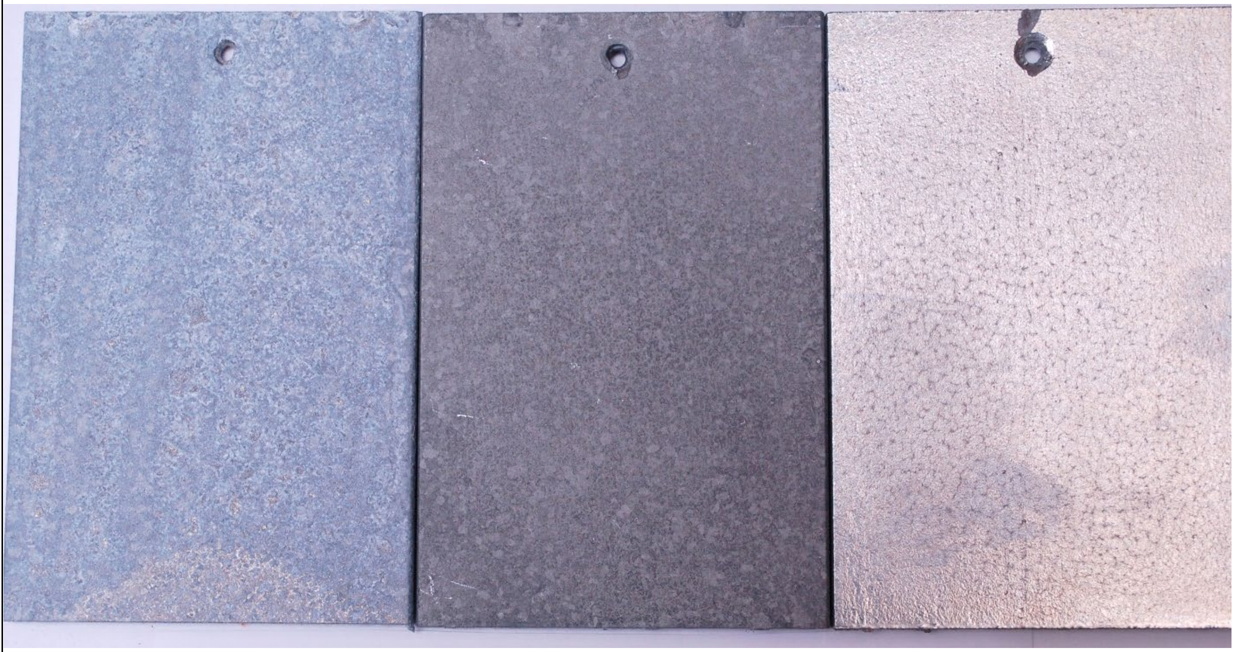
***ZnAl TSC: Humidity exposed (L), Humidity exposed with power sand (C), No exposure (R)***

***ZnAl TSC: Prohesion exposed (L), Prohesion exposed with power sand (C), No exposure (R)***

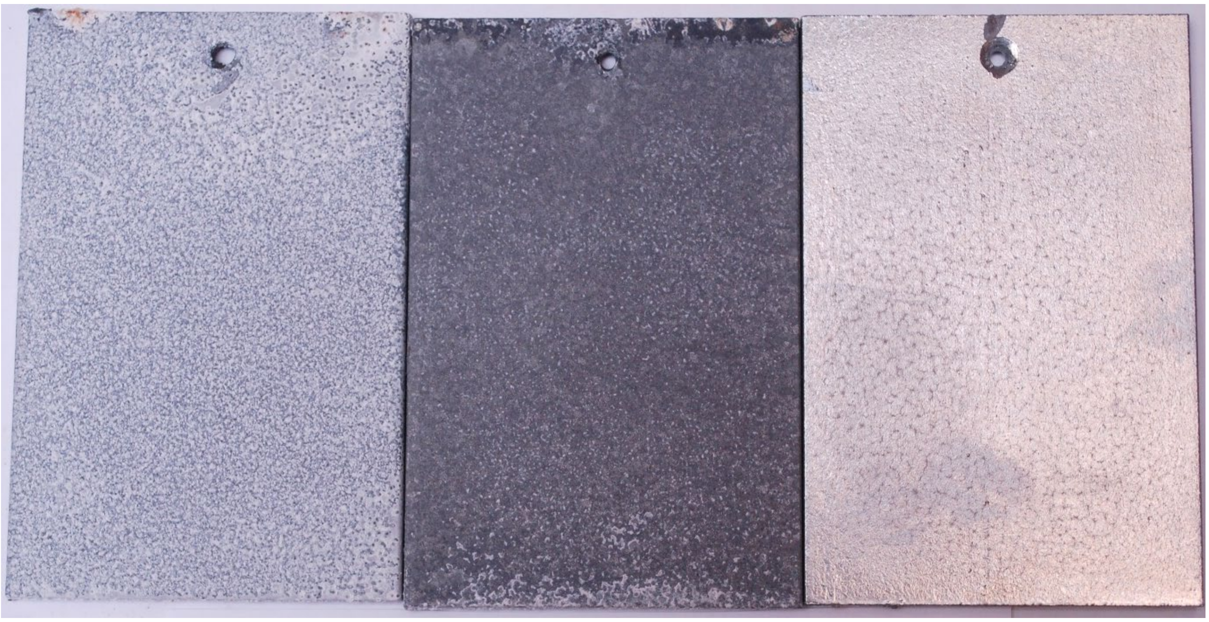
***Al TSC: Humidity exposed (L), Humidity exposed with power sand (C), No exposure (R)***

***Al TSC: Prohesion exposed (L), Prohesion exposed with power sand (C), No exposure (R)***

# SSPC-SP 16 PREPARATION



***HDG: Humidity exposed (L), Humidity exposed with SP16 (C), No exposure (R)***



***HDG: Prohesion exposed (L), Prohesion exposed with SP16 (C), No exposure (R)***

# Appendix H: Dry Film Thickness Measurements
# HDG Panels, Study 5

# Coating Thickness Measurements - HDG Panels, Study 3

| Panel ID | Spot # | HDG Initial Condition Spot Measurements (mils) | HDG Initial Condition Side Average (mils) | HDG Following Exposure and Surface Preparation Spot Measurements (mils) | HDG Following Exposure and Surface Preparation Side Average (mils) | HDG + Epoxy Spot Measurements (mils) | HDG + Epoxy Side Average (mils) | HDG + Epoxy + Urethane Spot Measurements (mils) | HDG + Epoxy + Urethane Side Average (mils) |
|---|---|---|---|---|---|---|---|---|---|
| HDG-20 | 1 | 4.9 | 4.7 | 5.0 | 5.1 | 9.7 | 10.1 | 14.5 | 14.3 |
| | 2 | 4.8 | | 4.8 | | 9.9 | | 14.0 | |
| | 3 | 4.2 | | 5.5 | | 10.6 | | 14.5 | |
| HDG-21 | 1 | 4.7 | 4.5 | 4.6 | 4.2 | 8.8 | 9.2 | 12.3 | 13.6 |
| | 2 | 4.6 | | 4.4 | | 9.4 | | 13.8 | |
| | 3 | 4.3 | | 3.8 | | 9.5 | | 14.8 | |
| HDG-22 | 1 | 5.1 | 4.7 | 4.6 | 4.5 | 9.6 | 9.2 | 13.4 | 13.9 |
| | 2 | 4.5 | | 4.6 | | 9.2 | | 13.7 | |
| | 3 | 4.4 | | 4.3 | | 8.8 | | 14.7 | |
| HDG-23 | 1 | 3.9 | 4.0 | 4.3 | 4.4 | 9.2 | 10.2 | 13.9 | 14.4 |
| | 2 | 3.9 | | 4.3 | | 11.4 | | 15.0 | |
| | 3 | 4.3 | | 4.7 | | 10.1 | | 14.3 | |
| HDG-24 | 1 | 4.6 | 4.6 | 4.8 | 4.9 | 8.9 | 9.6 | 12.7 | 13.8 |
| | 2 | 4.7 | | 4.9 | | 10.8 | | 14.9 | |
| | 3 | 4.4 | | 4.9 | | 9.1 | | 13.9 | |
| HDG-25 | 1 | 4.5 | 4.6 | 5.0 | 5.0 | 9.6 | 9.7 | 13.9 | 14.1 |
| | 2 | 4.6 | | 5.1 | | 9.8 | | 14.4 | |
| | 3 | 4.7 | | 4.8 | | 9.6 | | 13.9 | |
| HDG-26 | 1 | 4.4 | 4.6 | 9.8 | 9.9 | 16.2 | 14.8 | 17.3 | 17.0 |
| | 2 | 4.5 | | 7.9 | | 14.1 | | 16.0 | |
| | 3 | 4.9 | | 12.1 | | 14.0 | | 17.6 | |
| HDG-27 | 1 | 3.9 | 4.1 | 7.7 | 8.6 | 10.7 | 11.2 | 15.1 | 15.2 |
| | 2 | 4.1 | | 6.7 | | 11.5 | | 14.8 | |
| | 3 | 4.2 | | 11.4 | | 11.5 | | 15.6 | |
| HDG-28 | 1 | 5.3 | 5.6 | 14.9 | 14.2 | 19.9 | 21.1 | 20.6 | 19.6 |
| | 2 | 5.6 | | 12.5 | | 19.1 | | 18.5 | |
| | 3 | 6.0 | | 15.1 | | 24.2 | | 19.7 | |
| HDG-29 | 1 | 4.2 | 4.7 | 4.6 | 4.5 | 9.5 | 9.7 | 13.9 | 14.0 |
| | 2 | 5.5 | | 4.3 | | 10.0 | | 14.1 | |
| | 3 | 4.2 | | 4.5 | | 9.6 | | 13.9 | |
| HDG-30 | 1 | 4.3 | 4.3 | 4.1 | 4.3 | 9.1 | 9.4 | 13.4 | 13.9 |
| | 2 | 4.0 | | 4.3 | | 9.3 | | 13.1 | |
| | 3 | 4.6 | | 4.4 | | 9.9 | | 15.1 | |

## Coating Thickness Measurements - HDG Panels, Study 3

| Panel ID | Spot # | HDG Initial Condition Spot Measurements (mils) | HDG Initial Condition Side Average (mils) | HDG Following Exposure and Surface Preparation Spot Measurements (mils) | HDG Following Exposure and Surface Preparation Side Average (mils) | HDG + Epoxy Spot Measurements (mils) | HDG + Epoxy Side Average (mils) | HDG + Epoxy + Urethane Spot Measurements (mils) | HDG + Epoxy + Urethane Side Average (mils) |
|---|---|---|---|---|---|---|---|---|---|
| HDG-31 | 1 | 4.1 | 4.2 | 4.2 | 4.7 | 9.1 | 9.2 | 13.6 | 13.5 |
| | 2 | 4.2 | | 5.7 | | 8.9 | | 13.5 | |
| | 3 | 4.2 | | 4.2 | | 9.5 | | 13.6 | |
| HDG-32 | 1 | 5.2 | 5.1 | 5.0 | 5.5 | 10.2 | 10.2 | 14.0 | 13.8 |
| | 2 | 5.2 | | 5.2 | | 9.9 | | 13.2 | |
| | 3 | 5.0 | | 6.2 | | 10.6 | | 14.1 | |
| HDG-33 | 1 | 5.8 | 5.8 | 5.4 | 5.9 | 10.3 | 10.6 | 14.4 | 15.2 |
| | 2 | 5.7 | | 6.1 | | 11.0 | | 15.2 | |
| | 3 | 5.7 | | 6.0 | | 10.7 | | 16.2 | |
| HDG-34 | 1 | 4.3 | 4.6 | 4.2 | 4.9 | 8.6 | 9.5 | 12.7 | 13.7 |
| | 2 | 4.9 | | 5.2 | | 10.2 | | 15.2 | |
| | 3 | 4.6 | | 5.2 | | 9.6 | | 13.2 | |
| HDG-35 | 1 | 4.1 | 4.3 | 7.1 | 7.8 | 10.2 | 9.6 | 14.9 | 14.6 |
| | 2 | 4.3 | | 8.3 | | 9.2 | | 15.0 | |
| | 3 | 4.4 | | 8.0 | | 9.4 | | 13.9 | |
| HDG-36 | 1 | 5.1 | 5.3 | 10.0 | 10.1 | 11.8 | 11.7 | 14.3 | 15.0 |
| | 2 | 5.4 | | 9.7 | | 10.8 | | 14.4 | |
| | 3 | 5.5 | | 10.7 | | 12.5 | | 16.2 | |
| HDG-37 | 1 | 4.4 | 4.5 | 6.4 | 7.9 | 13.0 | 13.7 | 16.1 | 15.4 |
| | 2 | 4.3 | | 8.4 | | 14.0 | | 15.4 | |
| | 3 | 4.8 | | 8.8 | | 14.2 | | 14.8 | |
| HDG-38 | 1 | 4.1 | 4.1 | 5.3 | 5.3 | 10.0 | 10.1 | 14.2 | 14.3 |
| | 2 | 4.3 | | 5.2 | | 9.7 | | 14.3 | |
| | 3 | 4.1 | | 5.3 | | 10.6 | | 14.4 | |
| HDG-39 | 1 | 4.4 | 4.5 | 6.0 | 5.7 | 9.8 | 9.8 | 14.6 | 14.3 |
| | 2 | 4.4 | | 5.3 | | 9.7 | | 14.5 | |
| | 3 | 4.8 | | 5.7 | | 9.8 | | 13.9 | |
| HDG-40 | 1 | 4.0 | 4.0 | 5.1 | 5.1 | 9.0 | 9.5 | 13.2 | 13.7 |
| | 2 | 4.1 | | 5.1 | | 10.0 | | 15.1 | |
| | 3 | 4.0 | | 5.1 | | 9.7 | | 12.8 | |

## Coating Thickness Measurements - HDG Panels, Study 3

| Panel ID | Spot # | HDG Initial Condition Spot Measurements (mils) | HDG Initial Condition Side Average (mils) | HDG Following Exposure and Surface Preparation Spot Measurements (mils) | HDG Following Exposure and Surface Preparation Side Average (mils) | HDG + Epoxy Spot Measurements (mils) | HDG + Epoxy Side Average (mils) | HDG + Epoxy + Urethane Spot Measurements (mils) | HDG + Epoxy + Urethane Side Average (mils) |
|---|---|---|---|---|---|---|---|---|---|
| HDG-41 | 1 | 4.8 | 4.5 | 5.5 | 6.5 | 9.5 | 9.8 | 14.9 | 15.0 |
| | 2 | 4.3 | | 8.6 | | 9.7 | | 15.3 | |
| | 3 | 4.4 | | 5.5 | | 10.2 | | 14.8 | |
| HDG-42 | 1 | 4.9 | 4.7 | 6.6 | 7.0 | 10.2 | 9.9 | 15.4 | 14.7 |
| | 2 | 4.6 | | 6.9 | | 10.3 | | 14.8 | |
| | 3 | 4.6 | | 7.6 | | 9.2 | | 13.8 | |
| HDG-43 | 1 | 4.4 | 4.5 | 5.8 | 5.8 | 11.5 | 11.5 | 15.3 | 14.7 |
| | 2 | 4.6 | | 5.4 | | 10.7 | | 14.2 | |
| | 3 | 4.6 | | 6.3 | | 12.2 | | 14.5 | |
| HDG-44 | 1 | 5.0 | 5.1 | 6.6 | 6.8 | 12.6 | 12.3 | 17.1 | 16.7 |
| | 2 | 5.1 | | 7.3 | | 12.4 | | 17.1 | |
| | 3 | 5.0 | | 6.4 | | 11.9 | | 16.0 | |
| HDG-45 | 1 | 5.3 | 5.5 | 7.3 | 7.2 | 12.3 | 12.4 | 17.8 | 17.3 |
| | 2 | 5.6 | | 7.3 | | 12.5 | | 18.1 | |
| | 3 | 5.7 | | 7.1 | | 12.5 | | 15.9 | |
| HDG-46 | 1 | 5.5 | 6.1 | 7.3 | 8.0 | 12.6 | 12.7 | 17.3 | 17.6 |
| | 2 | 5.7 | | 8.0 | | 12.2 | | 16.9 | |
| | 3 | 7.3 | | 8.6 | | 13.3 | | 18.5 | |
| HDG-47 | 1 | 4.8 | 4.7 | 4.7 | 4.4 | 10.4 | 10.3 | 15.1 | 14.5 |
| | 2 | 4.4 | | 4.1 | | 10.5 | | 14.4 | |
| | 3 | 4.9 | | 4.5 | | 10.1 | | 14.1 | |
| HDG-48 | 1 | 4.4 | 4.3 | 4.5 | 4.2 | 9.4 | 9.1 | 14.5 | 14.3 |
| | 2 | 4.4 | | 4.2 | | 8.9 | | 14.0 | |
| | 3 | 4.0 | | 4.0 | | 9.0 | | 14.4 | |
| HDG-49 | 1 | 4.7 | 4.7 | 3.9 | 4.4 | 9.4 | 9.8 | 15.6 | 14.9 |
| | 2 | 4.3 | | 4.2 | | 9.5 | | 14.6 | |
| | 3 | 5.1 | | 5.0 | | 10.4 | | 14.6 | |
| HDG-50 | 1 | 4.5 | 4.6 | 4.0 | 4.4 | 9.8 | 9.6 | 13.2 | 13.0 |
| | 2 | 4.2 | | 4.1 | | 8.9 | | 12.8 | |
| | 3 | 5.1 | | 5.2 | | 10.1 | | 13.1 | |

## Coating Thickness Measurements - HDG Panels, Study 3

| Panel ID | Spot # | HDG Initial Condition Spot Measurements (mils) | HDG Initial Condition Side Average (mils) | HDG Following Exposure and Surface Preparation Spot Measurements (mils) | HDG Following Exposure and Surface Preparation Side Average (mils) | HDG + Epoxy Spot Measurements (mils) | HDG + Epoxy Side Average (mils) | HDG + Epoxy + Urethane Spot Measurements (mils) | HDG + Epoxy + Urethane Side Average (mils) |
|---|---|---|---|---|---|---|---|---|---|
| HDG-51 | 1 | 5.3 | 5.2 | 5.0 | 5.1 | 10.0 | 10.1 | 14.2 | 13.7 |
| | 2 | 5.1 | | 5.1 | | 9.7 | | 13.2 | |
| | 3 | 5.3 | | 5.2 | | 10.5 | | 13.8 | |
| HDG-52 | 1 | 4.3 | 4.2 | 4.2 | 4.0 | 9.1 | 9.3 | 13.9 | 13.7 |
| | 2 | 4.3 | | 3.9 | | 9.2 | | 12.9 | |
| | 3 | 4.1 | | 3.9 | | 9.6 | | 14.2 | |
| HDG-53 | 1 | 3.8 | 3.8 | 3.6 | 3.7 | 8.7 | 8.8 | 14.1 | 13.0 |
| | 2 | 3.7 | | 3.3 | | 8.9 | | 12.8 | |
| | 3 | 4.0 | | 4.3 | | 8.9 | | 12.1 | |
| HDG-54 | 1 | 4.0 | 4.1 | 3.9 | 3.9 | 9.3 | 9.0 | 12.4 | 12.7 |
| | 2 | 4.1 | | 3.6 | | 8.6 | | 12.7 | |
| | 3 | 4.3 | | 4.2 | | 9.1 | | 12.9 | |
| HDG-55 | 1 | 4.4 | 4.3 | 3.8 | 4.0 | 8.9 | 9.0 | 14.0 | 13.7 |
| | 2 | 4.0 | | 4.1 | | 9.4 | | 14.5 | |
| | 3 | 4.5 | | 4.0 | | 8.6 | | 12.7 | |
| HDG-56 | 1 | 5.1 | 5.4 | 4.7 | 5.1 | 8.6 | 9.9 | 14.0 | 13.9 |
| | 2 | 5.4 | | 5.4 | | 10.7 | | 14.6 | |
| | 3 | 5.6 | | 5.3 | | 10.2 | | 13.1 | |
| HDG-57 | 1 | 5.1 | 5.3 | 5.5 | 5.3 | 10.0 | 9.9 | 14.9 | 14.4 |
| | 2 | 5.2 | | 4.9 | | 9.3 | | 13.5 | |
| | 3 | 5.5 | | 5.7 | | 10.4 | | 14.8 | |
| HDG-58 | 1 | 4.4 | 4.9 | 4.5 | 4.7 | 9.3 | 9.7 | 13.0 | 14.5 |
| | 2 | 5.4 | | 4.6 | | 9.6 | | 16.1 | |
| | 3 | 4.9 | | 5.0 | | 10.3 | | 14.3 | |
| HDG-59 | 1 | 4.3 | 4.2 | 4.0 | 4.2 | 8.8 | 8.8 | 12.6 | 13.1 |
| | 2 | 4.3 | | 4.3 | | 8.8 | | 13.7 | |
| | 3 | 4.0 | | 4.3 | | 8.9 | | 12.9 | |
| HDG-60 | 1 | 5.5 | 5.5 | 5.3 | 5.3 | 9.9 | 10.0 | 13.4 | 13.8 |
| | 2 | 5.3 | | 5.1 | | 9.8 | | 13.9 | |
| | 3 | 5.9 | | 5.6 | | 10.2 | | 14.0 | |
| HDG-61 | 1 | 3.9 | 4.0 | 3.9 | 3.9 | 7.9 | 8.6 | 12.4 | 12.7 |
| | 2 | 3.9 | | 3.7 | | 8.7 | | 13.1 | |
| | 3 | 4.2 | | 4.0 | | 9.1 | | 12.5 | |

# Coating Thickness Measurements - HDG Panels, Study 3

| Panel ID | Spot # | HDG Initial Condition Spot Measurements (mils) | HDG Initial Condition Side Average (mils) | HDG Following Exposure and Surface Preparation Spot Measurements (mils) | HDG Following Exposure and Surface Preparation Side Average (mils) | HDG + Epoxy Spot Measurements (mils) | HDG + Epoxy Side Average (mils) | HDG + Epoxy + Urethane Spot Measurements (mils) | HDG + Epoxy + Urethane Side Average (mils) |
|---|---|---|---|---|---|---|---|---|---|
| HDG-62 | 1 | 4.5 | 4.7 | 4.5 | 5.0 | 8.2 | 8.6 | 13.5 | 14.5 |
| | 2 | 4.6 | | 5.0 | | 8.7 | | 14.4 | |
| | 3 | 4.8 | | 5.3 | | 8.9 | | 15.5 | |
| HDG-63 | 1 | 4.8 | 4.7 | 4.9 | 4.8 | 9.0 | 9.3 | 13.3 | 14.2 |
| | 2 | 4.4 | | 4.7 | | 9.7 | | 14.4 | |
| | 3 | 4.7 | | 4.7 | | 9.1 | | 15.0 | |
| HDG-64 | 1 | 4.8 | 4.8 | 4.7 | 5.0 | 8.9 | 9.2 | 12.9 | 14.2 |
| | 2 | 4.7 | | 5.4 | | 9.7 | | 15.1 | |
| | 3 | 4.9 | | 5.1 | | 9.1 | | 14.5 | |

## Coating Thickness Measurements - Zinc TSC Panels, Study 3

| Panel ID | Spot # | Zn TSC Initial Condition Spot Measurements (mils) | Zn TSC Initial Condition Side Average (mils) | Zn TSC Following Exposure and Surface Preparation Spot Measurements (mils) | Zn TSC Following Exposure and Surface Preparation Side Average (mils) | Zn TSC + Sealer Spot Measurements (mils) | Zn TSC + Sealer Side Average (mils) | Zn TSC + Sealer + Epoxy Spot Measurements (mils) | Zn TSC + Sealer + Epoxy Side Average (mils) | Zn TSC + Sealer + Epoxy + Urethane Spot Measurements (mils) | Zn TSC + Sealer + Epoxy + Urethane Side Average (mils) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Zn TSC-20 | 1 | 8.2 | 9.4 | 7.9 | 9.8 | 8.2 | 9.3 | 11.7 | 13.0 | 17.0 | 17.2 |
| | 2 | 9.5 | | 11.0 | | 9.2 | | 12.6 | | 16.8 | |
| | 3 | 10.4 | | 10.5 | | 10.7 | | 14.5 | | 17.7 | |
| Zn TSC-21 | 1 | 12.0 | 11.4 | 10.5 | 9.5 | 10.1 | 10.6 | 14.9 | 13.7 | 18.4 | 17.3 |
| | 2 | 9.9 | | 9.2 | | 10.7 | | 13.0 | | 16.6 | |
| | 3 | 12.3 | | 8.8 | | 11.0 | | 13.1 | | 16.9 | |
| Zn TSC-22 | 1 | 10.1 | 10.5 | 10.1 | 10.0 | 10.3 | 10.5 | 13.9 | 14.0 | 18.5 | 18.5 |
| | 2 | 11.5 | | 9.8 | | 10.9 | | 14.0 | | 18.3 | |
| | 3 | 9.9 | | 10.3 | | 10.2 | | 14.0 | | 18.8 | |
| Zn TSC-23 | 1 | 11.3 | 10.6 | 10.0 | 10.3 | 11.7 | 11.0 | 14.6 | 14.8 | 18.9 | 19.0 |
| | 2 | 10.3 | | 10.3 | | 10.8 | | 15.1 | | 19.2 | |
| | 3 | 10.3 | | 10.7 | | 10.4 | | 14.6 | | 18.9 | |
| Zn TSC-24 | 1 | 11.1 | 10.6 | 10.9 | 10.2 | 10.5 | 10.7 | 16.1 | 15.5 | 18.6 | 19.2 |
| | 2 | 10.5 | | 9.7 | | 10.3 | | 16.0 | | 19.8 | |
| | 3 | 10.3 | | 10.0 | | 11.2 | | 14.3 | | 19.2 | |
| Zn TSC-25 | 1 | 9.4 | 9.2 | 9.6 | 9.9 | 9.5 | 10.1 | 14.2 | 14.9 | 18.5 | 19.0 |
| | 2 | 8.7 | | 9.2 | | 10.0 | | 15.6 | | 19.3 | |
| | 3 | 9.6 | | 10.8 | | 10.9 | | 14.8 | | 19.3 | |
| Zn TSC-26 | 1 | 10.7 | 11.1 | 10.0 | 11.2 | 10.6 | 10.8 | 14.3 | 14.9 | 18.6 | 19.3 |
| | 2 | 11.7 | | 13.9 | | 11.8 | | 15.3 | | 20.6 | |
| | 3 | 10.8 | | 9.8 | | 10.1 | | 15.2 | | 18.6 | |
| Zn TSC-27 | 1 | 9.5 | 10.3 | 10.3 | 11.8 | 11.9 | 12.2 | 14.6 | 15.1 | 18.7 | 19.3 |
| | 2 | 10.4 | | 12.5 | | 11.6 | | 14.7 | | 19.2 | |
| | 3 | 11.0 | | 12.7 | | 13.0 | | 16.0 | | 20.0 | |
| Zn TSC-28 | 1 | 8.6 | 8.2 | 10.8 | 9.5 | 10.1 | 10.4 | 13.9 | 13.4 | 17.7 | 18.2 |
| | 2 | 7.4 | | 9.2 | | 11.0 | | 12.9 | | 19.4 | |
| | 3 | 8.6 | | 8.4 | | 10.2 | | 13.5 | | 17.5 | |
| Zn TSC-29 | 1 | 10.0 | 9.3 | 10.9 | 9.6 | 10.2 | 9.3 | 13.3 | 12.6 | 16.9 | 16.6 |
| | 2 | 8.1 | | 8.0 | | 8.2 | | 11.2 | | 16.7 | |
| | 3 | 9.8 | | 9.7 | | 9.5 | | 13.2 | | 16.1 | |
| Zn TSC-30 | 1 | 9.4 | 9.1 | 10.3 | 8.7 | 9.1 | 9.5 | 12.3 | 13.0 | 15.8 | 17.1 |
| | 2 | 9.3 | | 8.8 | | 9.8 | | 13.4 | | 18.1 | |
| | 3 | 8.6 | | 7.1 | | 9.7 | | 13.2 | | 17.2 | |
| Zn TSC-31 | 1 | 9.3 | 10.1 | 8.8 | 9.5 | 11.5 | 10.8 | 13.7 | 14.0 | 17.7 | 17.6 |
| | 2 | 10.5 | | 9.8 | | 11.0 | | 15.0 | | 18.6 | |
| | 3 | 10.7 | | 9.8 | | 9.7 | | 13.2 | | 16.5 | |
| Zn TSC-32 | 1 | 12.4 | 12.3 | 11.1 | 11.6 | 11.7 | 12.4 | 16.8 | 17.2 | 21.1 | 21.9 |
| | 2 | 12.5 | | 11.2 | | 12.4 | | 17.7 | | 22.0 | |
| | 3 | 12.0 | | 12.6 | | 13.2 | | 17.2 | | 22.5 | |
| Zn TSC-33 | 1 | 9.7 | 10.2 | 10.9 | 11.0 | 10.8 | 11.2 | 14.5 | 14.8 | 20.6 | 19.8 |
| | 2 | 10.3 | | 10.0 | | 11.1 | | 14.2 | | 18.4 | |
| | 3 | 10.6 | | 12.0 | | 11.8 | | 15.8 | | 20.4 | |
| Zn TSC-34 | 1 | 10.5 | 10.2 | 11.7 | 11.0 | 10.6 | 10.8 | 15.3 | 15.8 | 19.9 | 20.2 |
| | 2 | 9.5 | | 10.2 | | 10.5 | | 16.0 | | 21.0 | |
| | 3 | 10.7 | | 11.2 | | 11.4 | | 16.0 | | 19.6 | |

# Coating Thickness Measurements - Zinc TSC Panels, Study 3

| Panel ID | Spot # | Zn TSC Initial Condition Spot Measurements (mils) | Zn TSC Initial Condition Side Average (mils) | Zn TSC Following Exposure and Surface Preparation Spot Measurements (mils) | Zn TSC Following Exposure and Surface Preparation Side Average (mils) | Zn TSC + Sealer Spot Measurements (mils) | Zn TSC + Sealer Side Average (mils) | Zn TSC + Sealer + Epoxy Spot Measurements (mils) | Zn TSC + Sealer + Epoxy Side Average (mils) | Zn TSC + Sealer + Epoxy + Urethane Spot Measurements (mils) | Zn TSC + Sealer + Epoxy + Urethane Side Average (mils) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Zn TSC-35 | 1 | 11.4 | 10.3 | 9.3 | 9.6 | 11.2 | 10.7 | 14.7 | 14.3 | 18.8 | 18.3 |
| | 2 | 10.3 | | 10.7 | | 10.9 | | 14.6 | | 18.8 | |
| | 3 | 9.3 | | 8.8 | | 10.0 | | 13.5 | | 17.2 | |
| Zn TSC-36 | 1 | 10.2 | 10.5 | 10.3 | 10.6 | 11.9 | 11.4 | 14.1 | 14.6 | 18.9 | 18.7 |
| | 2 | 11.2 | | 11.6 | | 11.0 | | 14.6 | | 18.9 | |
| | 3 | 10.0 | | 10.0 | | 11.2 | | 15.1 | | 18.2 | |
| Zn TSC-37 | 1 | 9.7 | 9.9 | 10.3 | 10.4 | 10.9 | 11.2 | 14.2 | 15.2 | 18.0 | 17.7 |
| | 2 | 10.0 | | 10.4 | | 11.2 | | 15.8 | | 18.2 | |
| | 3 | 9.9 | | 10.5 | | 11.5 | | 15.5 | | 16.9 | |
| Zn TSC-38 | 1 | 8.6 | 8.7 | 10.7 | 9.4 | 9.2 | 9.5 | 13.6 | 13.3 | 19.0 | 19.3 |
| | 2 | 9.1 | | 8.5 | | 8.6 | | 13.2 | | 20.2 | |
| | 3 | 8.5 | | 9.1 | | 10.8 | | 13.1 | | 18.6 | |
| Zn TSC-39 | 1 | 10.1 | 10.4 | 10.1 | 10.7 | 8.4 | 9.9 | 13.0 | 14.2 | 16.7 | 17.4 |
| | 2 | 10.3 | | 10.0 | | 10.6 | | 15.0 | | 17.6 | |
| | 3 | 10.8 | | 11.9 | | 10.6 | | 14.5 | | 18.0 | |
| Zn TSC-40 | 1 | 7.4 | 8.2 | 7.8 | 8.7 | 7.8 | 8.6 | 12.6 | 12.9 | 17.4 | 18.5 |
| | 2 | 9.4 | | 9.1 | | 9.8 | | 13.1 | | 19.3 | |
| | 3 | 7.7 | | 9.4 | | 8.3 | | 12.9 | | 18.7 | |
| Zn TSC-41 | 1 | 8.9 | 9.8 | 10.3 | 10.5 | 10.4 | 10.2 | 13.3 | 14.3 | 19.2 | 19.4 |
| | 2 | 9.4 | | 9.8 | | 9.4 | | 15.4 | | 20.1 | |
| | 3 | 11.2 | | 11.5 | | 10.9 | | 14.1 | | 18.9 | |
| Zn TSC-42 | 1 | 9.7 | 10.1 | 9.8 | 11.3 | 9.4 | 10.1 | 15.0 | 15.4 | 19.6 | 19.2 |
| | 2 | 10.2 | | 12.4 | | 10.7 | | 16.2 | | 18.8 | |
| | 3 | 10.3 | | 11.7 | | 10.3 | | 15.1 | | 19.2 | |
| Zn TSC-43 | 1 | 10.1 | 10.2 | 11.3 | 10.7 | 11.1 | 10.7 | 16.4 | 15.7 | 18.0 | 18.4 |
| | 2 | 10.8 | | 11.0 | | 10.4 | | 15.6 | | 19.2 | |
| | 3 | 9.8 | | 9.9 | | 10.7 | | 15.0 | | 18.0 | |
| Zn TSC-44 | 1 | 9.5 | 9.9 | 9.7 | 11.6 | 10.5 | 10.6 | 13.0 | 13.8 | 18.9 | 19.1 |
| | 2 | 9.8 | | 12.7 | | 11.0 | | 13.8 | | 19.1 | |
| | 3 | 10.4 | | 12.3 | | 10.4 | | 14.6 | | 19.2 | |
| Zn TSC-45 | 1 | 9.5 | 10.0 | 11.4 | 12.1 | 10.6 | 11.3 | 14.6 | 14.4 | 19.1 | 19.0 |
| | 2 | 9.9 | | 12.2 | | 11.5 | | 13.4 | | 18.4 | |
| | 3 | 10.5 | | 12.7 | | 11.7 | | 15.3 | | 19.5 | |
| Zn TSC-46 | 1 | 9.7 | 9.3 | 9.5 | 9.7 | 10.7 | 10.2 | 12.4 | 12.9 | 19.2 | 18.5 |
| | 2 | 8.8 | | 9.2 | | 9.2 | | 12.7 | | 18.8 | |
| | 3 | 9.5 | | 10.5 | | 10.7 | | 13.7 | | 17.7 | |
| Zn TSC-47 | 1 | 11.2 | 10.5 | 8.9 | 8.7 | 8.9 | 8.9 | 13.3 | 13.2 | 17.0 | 16.7 |
| | 2 | 9.9 | | 8.8 | | 8.6 | | 13.1 | | 16.7 | |
| | 3 | 10.4 | | 8.4 | | 9.3 | | 13.3 | | 16.3 | |
| Zn TSC-48 | 1 | 8.7 | 8.9 | 6.8 | 6.9 | 7.0 | 7.0 | 10.6 | 10.7 | 18.5 | 17.3 |
| | 2 | 9.0 | | 6.4 | | 6.2 | | 9.8 | | 18.0 | |
| | 3 | 8.9 | | 7.6 | | 7.8 | | 11.6 | | 15.4 | |
| Zn TSC-49 | 1 | 9.6 | 9.2 | 7.6 | 7.9 | 7.6 | 7.8 | 12.3 | 11.8 | 18.1 | 17.1 |
| | 2 | 9.9 | | 8.4 | | 8.0 | | 12.1 | | 17.5 | |
| | 3 | 8.2 | | 7.6 | | 7.8 | | 10.9 | | 15.8 | |

# Coating Thickness Measurements - Zinc TSC Panels, Study 3

| Panel ID | Spot # | Zn TSC Initial Condition Spot Measurements (mils) | Zn TSC Initial Condition Side Average (mils) | Zn TSC Following Exposure and Surface Preparation Spot Measurements (mils) | Zn TSC Following Exposure and Surface Preparation Side Average (mils) | Zn TSC + Sealer Spot Measurements (mils) | Zn TSC + Sealer Side Average (mils) | Zn TSC + Sealer + Epoxy Spot Measurements (mils) | Zn TSC + Sealer + Epoxy Side Average (mils) | Zn TSC + Sealer + Epoxy + Urethane Spot Measurements (mils) | Zn TSC + Sealer + Epoxy + Urethane Side Average (mils) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Zn TSC-50 | 1 | 9.5 | 11.0 | 7.5 | 8.7 | 8.3 | 9.0 | 12.6 | 13.3 | 16.6 | 17.8 |
| | 2 | 11.4 | | 8.9 | | 9.0 | | 13.3 | | 18.3 | |
| | 3 | 12.0 | | 9.7 | | 9.7 | | 14.1 | | 18.4 | |
| Zn TSC-51 | 1 | 10.8 | 10.7 | 9.8 | 10.6 | 9.9 | 10.4 | 14.0 | 14.8 | 18.5 | 19.5 |
| | 2 | 10.0 | | 11.2 | | 11.2 | | 15.1 | | 19.5 | |
| | 3 | 11.3 | | 10.7 | | 10.1 | | 15.5 | | 20.4 | |
| Zn TSC-52 | 1 | 11.8 | 10.6 | 8.8 | 9.7 | 9.6 | 10.1 | 13.3 | 13.9 | 17.4 | 18.4 |
| | 2 | 9.2 | | 9.7 | | 10.2 | | 13.8 | | 18.4 | |
| | 3 | 10.8 | | 10.6 | | 10.5 | | 14.5 | | 19.4 | |
| Zn TSC-53 | 1 | 11.3 | 10.4 | 9.1 | 8.5 | 9.6 | 8.9 | 14.2 | 13.0 | 18.9 | 17.7 |
| | 2 | 11.2 | | 9.4 | | 9.7 | | 13.1 | | 17.5 | |
| | 3 | 8.6 | | 7.2 | | 7.3 | | 11.7 | | 16.8 | |
| Zn TSC-54 | 1 | 11.0 | 11.1 | 9.2 | 9.7 | 8.9 | 9.5 | 14.1 | 14.0 | 19.3 | 18.9 |
| | 2 | 12.4 | | 10.2 | | 10.7 | | 14.3 | | 18.6 | |
| | 3 | 9.8 | | 9.6 | | 9.0 | | 13.6 | | 19.0 | |
| Zn TSC-55 | 1 | 9.0 | 9.4 | 6.7 | 7.3 | 7.1 | 7.6 | 11.4 | 12.0 | 15.2 | 16.3 |
| | 2 | 9.9 | | 7.0 | | 7.5 | | 11.6 | | 17.0 | |
| | 3 | 9.1 | | 8.0 | | 8.2 | | 12.8 | | 16.8 | |

# Coating Thickness Measurements - Zinc-Aluminum TSC Panels, Study 3

| Panel ID | Spot # | ZnAl TSC Initial Condition Spot Measurements (mils) | ZnAl TSC Initial Condition Side Average (mils) | ZnAl TSC Following Exposure and Surface Preparation Spot Measurements (mils) | ZnAl TSC Following Exposure and Surface Preparation Side Average (mils) | ZnAl TSC + Sealer Spot Measurements (mils) | Zn Al TSC + Sealer Side Average (mils) | ZnAl TSC + Sealer + Epoxy Spot Measurements (mils) | ZnAl TSC + Sealer + Epoxy Side Average (mils) | ZnAl TSC + Sealer + Epoxy + Urethane Spot Measurements (mils) | ZnAl TSC + Sealer + Epoxy + Urethane Side Average (mils) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TSC-ZnAl-20 | 1 | 10.1 | 9.5 | 10.1 | 9.5 | 9.5 | 10.3 | 13.4 | 13.6 | 18.5 | 17.7 |
| | 2 | 9.2 | | 9.2 | | 10.1 | | 13.6 | | 17.1 | |
| | 3 | 9.2 | | 9.2 | | 11.4 | | 13.9 | | 17.5 | |
| TSC-ZnAl-21 | 1 | 10.5 | 9.2 | 10.5 | 9.2 | 10.3 | 10.1 | 14.7 | 13.3 | 18.2 | 17.8 |
| | 2 | 9.9 | | 9.9 | | 10.8 | | 14.3 | | 19.4 | |
| | 3 | 7.0 | | 7.0 | | 9.2 | | 11.0 | | 15.6 | |
| TSC-ZnAl-22 | 1 | 8.5 | 9.2 | 8.5 | 9.2 | 9.9 | 9.6 | 13.4 | 12.8 | 17.9 | 17.5 |
| | 2 | 8.9 | | 8.9 | | 10.2 | | 12.4 | | 17.0 | |
| | 3 | 10.2 | | 10.2 | | 8.8 | | 12.6 | | 17.5 | |
| TSC-ZnAl-23 | 1 | 10.8 | 10.6 | 9.5 | 10.7 | 12.3 | 11.6 | 14.1 | 15.0 | 18.8 | 19.8 |
| | 2 | 10.5 | | 11.5 | | 11.2 | | 15.5 | | 21.3 | |
| | 3 | 10.6 | | 11.2 | | 11.5 | | 15.4 | | 19.4 | |
| TSC-ZnAl-24 | 1 | 8.6 | 9.0 | 9.4 | 9.4 | 11.3 | 10.7 | 13.6 | 13.8 | 17.3 | 17.5 |
| | 2 | 8.6 | | 9.0 | | 10.1 | | 14.6 | | 17.7 | |
| | 3 | 9.6 | | 9.8 | | 10.7 | | 13.2 | | 17.4 | |
| TSC-ZnAl-25 | 1 | 11.1 | 10.8 | 13.6 | 12.8 | 14.3 | 13.2 | 17.0 | 16.7 | 22.4 | 21.7 |
| | 2 | 10.9 | | 12.8 | | 12.9 | | 16.4 | | 21.5 | |
| | 3 | 10.3 | | 12.0 | | 12.3 | | 16.6 | | 21.3 | |
| TSC-ZnAl-26 | 1 | 9.5 | 9.9 | 9.7 | 9.6 | 11.3 | 11.0 | 14.4 | 14.2 | 19.1 | 19.3 |
| | 2 | 9.9 | | 9.3 | | 10.5 | | 14.0 | | 19.8 | |
| | 3 | 10.3 | | 9.7 | | 11.4 | | 14.2 | | 18.9 | |
| TSC-ZnAl-27 | 1 | 14.3 | 12.4 | 13.3 | 12.8 | 13.8 | 14.3 | 18.0 | 17.4 | 22.9 | 21.2 |
| | 2 | 11.5 | | 12.6 | | 13.6 | | 17.2 | | 20.5 | |
| | 3 | 11.3 | | 12.6 | | 15.5 | | 16.9 | | 20.3 | |
| TSC-ZnAl-28 | 1 | 9.3 | 9.5 | 9.3 | 9.6 | 11.2 | 10.9 | 15.0 | 14.7 | 19.5 | 19.4 |
| | 2 | 9.3 | | 8.8 | | 9.9 | | 14.3 | | 18.6 | |
| | 3 | 9.8 | | 10.6 | | 11.4 | | 14.9 | | 20.0 | |
| TSC-ZnAl-29 | 1 | 8.5 | 8.3 | 9.7 | 9.0 | 9.8 | 9.8 | 12.1 | 12.4 | 17.3 | 16.7 |
| | 2 | 8.2 | | 9.4 | | 10.0 | | 12.1 | | 16.0 | |
| | 3 | 8.3 | | 7.9 | | 9.7 | | 13.0 | | 16.9 | |
| TSC-ZnAl-30 | 1 | 10.0 | 9.8 | 9.4 | 9.1 | 8.7 | 9.6 | 11.9 | 12.6 | 16.5 | 17.5 |
| | 2 | 10.0 | | 9.0 | | 10.4 | | 13.6 | | 18.1 | |
| | 3 | 9.5 | | 8.8 | | 9.6 | | 12.4 | | 17.8 | |
| TSC-ZnAl-31 | 1 | 10.2 | 10.1 | 10.4 | 10.1 | 9.9 | 10.1 | 13.9 | 13.1 | 18.3 | 17.7 |
| | 2 | 9.4 | | 8.5 | | 9.7 | | 12.0 | | 17.2 | |
| | 3 | 10.6 | | 11.3 | | 10.7 | | 13.3 | | 17.7 | |
| TSC-ZnAl-32 | 1 | 12.1 | 11.0 | 14.6 | 14.0 | 14.3 | 13.9 | 17.4 | 16.7 | 22.1 | 21.4 |
| | 2 | 11.2 | | 14.1 | | 14.2 | | 15.8 | | 21.4 | |
| | 3 | 9.8 | | 13.4 | | 13.1 | | 16.8 | | 20.9 | |
| TSC-ZnAl-33 | 1 | 9.6 | 9.6 | 12.2 | 12.0 | 13.6 | 12.5 | 15.6 | 15.7 | 20.5 | 19.9 |
| | 2 | 9.1 | | 11.8 | | 11.6 | | 15.3 | | 19.7 | |
| | 3 | 10.1 | | 11.9 | | 12.4 | | 16.1 | | 19.4 | |

## Coating Thickness Measurements - Zinc-Aluminum TSC Panels, Study 3

| Panel ID | Spot # | ZnAl TSC Initial Condition Spot Measurements (mils) | ZnAl TSC Initial Condition Side Average (mils) | ZnAl TSC Following Exposure and Surface Preparation Spot Measurements (mils) | ZnAl TSC Following Exposure and Surface Preparation Side Average (mils) | ZnAl TSC + Sealer Spot Measurements (mils) | Zn Al TSC + Sealer Side Average (mils) | ZnAl TSC + Sealer + Epoxy Spot Measurements (mils) | ZnAl TSC + Sealer + Epoxy Side Average (mils) | ZnAl TSC + Sealer + Epoxy + Urethane Spot Measurements (mils) | ZnAl TSC + Sealer + Epoxy + Urethane Side Average (mils) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TSC-ZnAl-34 | 1 | 9.0 | 9.3 | 12.3 | 10.8 | 12.2 | 11.5 | 15.1 | 15.0 | 20.6 | 20.1 |
| | 2 | 8.6 | | 9.3 | | 11.0 | | 13.8 | | 19.2 | |
| | 3 | 10.3 | | 10.9 | | 11.4 | | 16.0 | | 20.4 | |
| TSC-ZnAl-35 | 1 | 10.0 | 9.0 | 10.4 | 9.4 | 11.8 | 9.9 | 13.3 | 12.3 | 17.3 | 17.4 |
| | 2 | 8.4 | | 9.3 | | 9.2 | | 11.5 | | 16.4 | |
| | 3 | 8.6 | | 8.5 | | 8.7 | | 12.0 | | 18.4 | |
| TSC-ZnAl-36 | 1 | 10.2 | 10.3 | 9.7 | 10.9 | 9.3 | 11.1 | 13.8 | 14.3 | 18.0 | 18.5 |
| | 2 | 10.1 | | 11.0 | | 11.7 | | 14.3 | | 18.8 | |
| | 3 | 10.4 | | 12.1 | | 12.2 | | 14.9 | | 18.7 | |
| TSC-ZnAl-37 | 1 | 10.3 | 10.1 | 9.8 | 9.6 | 10.0 | 10.7 | 13.3 | 13.9 | 19.1 | 18.3 |
| | 2 | 10.0 | | 9.2 | | 10.8 | | 13.9 | | 17.4 | |
| | 3 | 10.1 | | 9.8 | | 11.2 | | 14.6 | | 18.4 | |
| TSC-ZnAl-38 | 1 | 9.7 | 9.3 | 9.5 | 10.3 | 9.9 | 10.3 | 13.2 | 13.4 | 17.5 | 17.0 |
| | 2 | 9.7 | | 9.6 | | 10.1 | | 12.8 | | 16.9 | |
| | 3 | 8.7 | | 11.8 | | 10.9 | | 14.3 | | 16.5 | |
| TSC-ZnAl-39 | 1 | 9.9 | 9.2 | 10.6 | 9.7 | 10.3 | 9.6 | 13.4 | 12.4 | 18.3 | 16.7 |
| | 2 | 9.8 | | 9.0 | | 9.9 | | 12.2 | | 16.5 | |
| | 3 | 7.8 | | 9.6 | | 8.7 | | 11.6 | | 15.3 | |
| TSC-ZnAl-40 | 1 | 9.8 | 8.7 | 9.8 | 9.7 | 9.4 | 9.2 | 13.2 | 12.5 | 17.8 | 17.3 |
| | 2 | 8.9 | | 10.2 | | 9.3 | | 12.5 | | 17.4 | |
| | 3 | 7.6 | | 9.0 | | 9.0 | | 11.9 | | 16.6 | |
| TSC-ZnAl-41 | 1 | 8.9 | 8.8 | 11.8 | 11.4 | 12.2 | 11.2 | 14.7 | 14.4 | 19.6 | 19.6 |
| | 2 | 8.3 | | 10.7 | | 10.5 | | 14.7 | | 19.2 | |
| | 3 | 9.2 | | 11.7 | | 10.9 | | 13.9 | | 20.1 | |
| TSC-ZnAl-42 | 1 | 7.9 | 8.7 | 10.5 | 11.6 | 9.8 | 11.4 | 13.0 | 14.4 | 18.3 | 19.2 |
| | 2 | 9.4 | | 12.4 | | 13.0 | | 14.9 | | 19.6 | |
| | 3 | 8.7 | | 12.0 | | 11.4 | | 15.3 | | 19.7 | |
| TSC-ZnAl-43 | 1 | 10.0 | 10.5 | 12.7 | 13.0 | 13.3 | 13.3 | 14.9 | 15.6 | 19.4 | 19.6 |
| | 2 | 9.7 | | 13.0 | | 12.0 | | 14.1 | | 19.0 | |
| | 3 | 11.6 | | 13.2 | | 14.7 | | 17.7 | | 20.5 | |
| TSC-ZnAl-44 | 1 | 9.0 | 8.9 | 9.8 | 9.6 | 9.6 | 9.1 | 13.4 | 13.0 | 19.3 | 18.3 |
| | 2 | 8.7 | | 8.6 | | 8.5 | | 12.3 | | 17.0 | |
| | 3 | 9.0 | | 10.3 | | 9.3 | | 13.1 | | 18.6 | |
| TSC-ZnAl-45 | 1 | 11.4 | 10.9 | 11.0 | 10.8 | 11.2 | 11.0 | 14.9 | 14.7 | 19.8 | 19.5 |
| | 2 | 9.9 | | 10.0 | | 10.0 | | 13.7 | | 18.9 | |
| | 3 | 11.3 | | 11.2 | | 11.9 | | 15.4 | | 19.8 | |
| TSC-ZnAl-46 | 1 | 12.1 | 10.4 | 10.1 | 10.7 | 10.3 | 10.2 | 13.6 | 13.3 | 18.4 | 18.3 |
| | 2 | 9.6 | | 10.2 | | 10.4 | | 13.2 | | 19.4 | |
| | 3 | 9.5 | | 11.7 | | 9.7 | | 13.1 | | 17.0 | |
| TSC-ZnAl-47 | 1 | 10.8 | 11.5 | 9.8 | 9.7 | 9.7 | 9.6 | 13.7 | 14.2 | 17.9 | 18.6 |
| | 2 | 10.7 | | 9.0 | | 8.9 | | 13.4 | | 18.4 | |
| | 3 | 13.1 | | 10.2 | | 10.3 | | 15.5 | | 19.4 | |

### Coating Thickness Measurements - Zinc-Aluminum TSC Panels, Study 3

| Panel ID | Spot # | ZnAl TSC Initial Condition Spot Measurements (mils) | ZnAl TSC Initial Condition Side Average (mils) | ZnAl TSC Following Exposure and Surface Preparation Spot Measurements (mils) | ZnAl TSC Following Exposure and Surface Preparation Side Average (mils) | ZnAl TSC + Sealer Spot Measurements (mils) | Zn Al TSC + Sealer Side Average (mils) | ZnAl TSC + Sealer + Epoxy Spot Measurements (mils) | ZnAl TSC + Sealer + Epoxy Side Average (mils) | ZnAl TSC + Sealer + Epoxy + Urethane Spot Measurements (mils) | ZnAl TSC + Sealer + Epoxy + Urethane Side Average (mils) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TSC-ZnAl-48 | 1 | 10.2 | 10.1 | 8.2 | 8.4 | 8.9 | 8.5 | 14.1 | 13.1 | 18.2 | 17.3 |
| | 2 | 9.7 | | 7.2 | | 7.2 | | 11.5 | | 16.5 | |
| | 3 | 10.3 | | 9.9 | | 9.5 | | 13.7 | | 17.1 | |
| TSC-ZnAl-49 | 1 | 9.4 | 9.2 | 8.0 | 7.6 | 8.1 | 7.8 | 10.6 | 11.3 | 15.7 | 16.4 |
| | 2 | 9.8 | | 7.2 | | 7.3 | | 11.5 | | 16.8 | |
| | 3 | 8.3 | | 7.7 | | 8.1 | | 12.0 | | 16.6 | |
| TSC-ZnAl-50 | 1 | 10.6 | 11.1 | 12.0 | 11.8 | 11.6 | 11.6 | 15.6 | 15.5 | 20.2 | 20.1 |
| | 2 | 13.2 | | 12.5 | | 12.3 | | 17.2 | | 21.4 | |
| | 3 | 9.6 | | 10.8 | | 10.9 | | 13.7 | | 18.6 | |
| TSC-ZnAl-51 | 1 | 7.7 | 8.9 | 8.6 | 9.8 | 8.6 | 9.9 | 12.9 | 14.1 | 16.9 | 18.6 |
| | 2 | 9.9 | | 9.6 | | 9.9 | | 14.8 | | 19.2 | |
| | 3 | 9.1 | | 11.1 | | 11.1 | | 14.8 | | 19.6 | |
| TSC-ZnAl-52 | 1 | 11.7 | 10.7 | 10.9 | 11.1 | 12.2 | 11.6 | 15.3 | 15.0 | 19.7 | 20.1 |
| | 2 | 9.9 | | 10.9 | | 11.0 | | 14.7 | | 19.5 | |
| | 3 | 10.4 | | 11.5 | | 11.7 | | 15.1 | | 21.3 | |
| TSC-ZnAl-53 | 1 | 10.4 | 10.2 | 9.4 | 8.4 | 9.2 | 8.5 | 12.5 | 12.5 | 17.4 | 17.3 |
| | 2 | 9.5 | | 7.8 | | 7.5 | | 12.0 | | 16.6 | |
| | 3 | 10.7 | | 8.1 | | 8.8 | | 13.0 | | 17.9 | |
| TSC-ZnAl-54 | 1 | 9.8 | 9.6 | 7.2 | 7.8 | 7.8 | 8.2 | 11.2 | 11.9 | 16.7 | 17.8 |
| | 2 | 10.1 | | 8.0 | | 8.7 | | 12.3 | | 19.0 | |
| | 3 | 9.0 | | 8.2 | | 8.2 | | 12.1 | | 17.5 | |
| TSC-ZnAl-55 | 1 | 9.1 | 8.6 | 8.0 | 6.6 | 8.4 | 7.2 | 12.2 | 11.3 | 15.6 | 15.1 |
| | 2 | 8.4 | | 5.8 | | 5.9 | | 10.3 | | 14.2 | |
| | 3 | 8.1 | | 6.1 | | 7.2 | | 11.5 | | 15.7 | |

| Panel ID | Spot # | Al TSC Initial Condition Spot Measurements (mils) | Al TSC Initial Condition Side Average (mils) | Al TSC Following Exposure and Surface Preparation Spot Measurements (mils) | AL TSC Following Exposure and Surface Preparation Side Average (mils) | TSC + Sealer Spot Measurements (mils) | TSC + Sealer Side Average (mils) | TSC + Sealer + Epoxy Spot Measurements (mils) | TSC + Sealer + Epoxy Side Average (mils) | TSC + Sealer + Epoxy + Urethane Spot Measurements (mils) | TSC + Sealer + Epoxy + Urethane Side Average (mils) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TSC-Al-20 | 1 | 11.4 | 12.0 | 13.1 | 12.7 | 12.8 | 12.9 | 16.0 | 16.0 | 20.4 | 20.0 |
| | 2 | 12.3 | | 12.6 | | 13.2 | | 15.9 | | 19.6 | |
| | 3 | 12.4 | | 12.4 | | 12.8 | | 15.9 | | 20.1 | |
| TSC-Al-21 | 1 | 13.2 | 10.9 | 10.6 | 10.3 | 11.1 | 10.5 | 13.2 | 13.2 | 17.0 | 17.1 |
| | 2 | 9.7 | | 9.9 | | 10.3 | | 13.0 | | 17.4 | |
| | 3 | 9.8 | | 10.3 | | 10.3 | | 13.5 | | 16.9 | |
| TSC-Al-22 | 1 | 11.3 | 10.2 | 9.8 | 9.7 | 11.5 | 10.8 | 14.9 | 14.0 | 18.1 | 18.3 |
| | 2 | 10.0 | | 10.1 | | 11.3 | | 14.7 | | 18.9 | |
| | 3 | 9.4 | | 9.1 | | 9.7 | | 12.4 | | 17.8 | |
| TSC-Al-23 | 1 | 16.7 | 15.5 | 15.8 | 14.7 | 16.3 | 16.9 | 20.9 | 19.0 | 24.6 | 23.5 |
| | 2 | 15.6 | | 14.7 | | 16.2 | | 18.3 | | 23.0 | |
| | 3 | 14.1 | | 13.5 | | 18.3 | | 17.7 | | 22.8 | |
| TSC-Al-24 | 1 | 8.8 | 9.8 | 8.9 | 10.3 | 10.3 | 10.5 | 12.9 | 13.7 | 16.4 | 17.9 |
| | 2 | 10.2 | | 10.0 | | 10.8 | | 14.6 | | 19.8 | |
| | 3 | 10.3 | | 12.1 | | 10.4 | | 13.8 | | 17.4 | |
| TSC-Al-25 | 1 | 11.1 | 12.0 | 12.8 | 12.6 | 11.7 | 13.1 | 15.9 | 16.4 | 20.0 | 20.2 |
| | 2 | 12.9 | | 12.4 | | 13.9 | | 16.6 | | 19.6 | |
| | 3 | 12.0 | | 12.7 | | 13.8 | | 16.7 | | 21.1 | |
| TSC-Al-26 | 1 | 9.2 | 9.3 | 10.1 | 10.7 | 10.0 | 10.6 | 15.0 | 14.4 | 20.0 | 18.4 |
| | 2 | 9.4 | | 10.9 | | 11.4 | | 15.3 | | 17.8 | |
| | 3 | 9.3 | | 11.2 | | 10.4 | | 13.0 | | 17.3 | |
| TSC-Al-27 | 1 | 11.6 | 11.4 | 12.6 | 12.0 | 12.4 | 12.5 | 16.6 | 16.8 | 21.4 | 20.2 |
| | 2 | 11.4 | | 10.8 | | 12.7 | | 16.7 | | 19.0 | |
| | 3 | 11.2 | | 12.5 | | 12.4 | | 17.0 | | 20.0 | |
| TSC-Al-28 | 1 | 9.9 | 10.5 | 11.8 | 11.5 | 13.6 | 12.7 | 15.1 | 15.4 | 19.5 | 19.6 |
| | 2 | 9.8 | | 10.7 | | 12.2 | | 15.2 | | 19.1 | |
| | 3 | 11.7 | | 11.9 | | 12.3 | | 16.0 | | 20.1 | |
| TSC-Al-29 | 1 | 11.9 | 10.9 | 11.6 | 10.1 | 11.1 | 10.7 | 15.1 | 14.3 | 19.2 | 17.8 |
| | 2 | 11.1 | | 9.5 | | 10.4 | | 14.2 | | 18.2 | |
| | 3 | 9.8 | | 9.3 | | 10.5 | | 13.6 | | 16.0 | |
| TSC-Al-30 | 1 | 10.1 | 10.9 | 10.6 | 11.1 | 11.0 | 11.0 | 14.9 | 14.9 | 19.8 | 19.7 |
| | 2 | 11.2 | | 9.9 | | 11.2 | | 14.5 | | 19.7 | |
| | 3 | 11.5 | | 12.6 | | 10.7 | | 15.3 | | 19.7 | |
| TSC-Al-31 | 1 | 12.3 | 12.8 | 12.1 | 12.9 | 12.5 | 13.9 | 16.5 | 16.6 | 21.8 | 21.3 |
| | 2 | 12.3 | | 12.8 | | 13.9 | | 16.6 | | 21.6 | |
| | 3 | 13.7 | | 13.7 | | 15.2 | | 16.7 | | 20.5 | |
| TSC-Al-32 | 1 | 10.1 | 10.9 | 10.1 | 11.9 | 10.7 | 11.7 | 14.1 | 14.6 | 18.9 | 18.9 |
| | 2 | 11.5 | | 12.0 | | 12.2 | | 15.7 | | 19.4 | |
| | 3 | 11.0 | | 13.5 | | 12.0 | | 14.0 | | 18.3 | |
| TSC-Al-33 | 1 | 11.2 | 12.4 | 11.1 | 11.7 | 12.1 | 12.6 | 14.0 | 15.6 | 18.2 | 19.8 |
| | 2 | 11.9 | | 12.2 | | 13.0 | | 16.2 | | 20.3 | |
| | 3 | 14.0 | | 11.8 | | 12.9 | | 16.6 | | 21.0 | |
| TSC-Al-34 | 1 | 9.9 | 9.5 | 10.8 | 10.4 | 11.2 | 10.7 | 14.3 | 14.4 | 19.4 | 19.3 |
| | 2 | 9.6 | | 11.0 | | 10.7 | | 14.2 | | 20.1 | |
| | 3 | 9.1 | | 9.4 | | 10.3 | | 14.8 | | 18.3 | |

**Coating Thickness Measurements - Aluminum TSC Panels, Study 3**

| Panel ID | Spot # | Al TSC Initial Condition Spot Measurements (mils) | Al TSC Initial Condition Side Average (mils) | Al TSC Following Exposure and Surface Preparation Spot Measurements (mils) | AL TSC Following Exposure and Surface Preparation Side Average (mils) | TSC + Sealer Spot Measurements (mils) | TSC + Sealer Side Average (mils) | TSC + Sealer + Epoxy Spot Measurements (mils) | TSC + Sealer + Epoxy Side Average (mils) | TSC + Sealer + Epoxy + Urethane Spot Measurements (mils) | TSC + Sealer + Epoxy + Urethane Side Average (mils) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TSC-Al-35 | 1 | 9.1 | 9.1 | 9.4 | 9.4 | 10.1 | 9.8 | 12.9 | 13.1 | 18.3 | 17.9 |
| | 2 | 9.6 | | 9.4 | | 9.2 | | 13.1 | | 18.2 | |
| | 3 | 8.6 | | 9.3 | | 10.2 | | 13.2 | | 17.3 | |
| TSC-Al-36 | 1 | 11.3 | 11.4 | 11.2 | 12.0 | 12.2 | 13.1 | 16.1 | 16.0 | 22.0 | 20.5 |
| | 2 | 11.8 | | 12.8 | | 13.7 | | 16.2 | | 20.1 | |
| | 3 | 11.1 | | 11.9 | | 13.3 | | 15.6 | | 19.3 | |
| TSC-Al-37 | 1 | 9.8 | 10.0 | 9.4 | 9.9 | 10.5 | 10.6 | 14.3 | 14.3 | 17.5 | 18.3 |
| | 2 | 9.6 | | 10.4 | | 10.8 | | 13.7 | | 18.3 | |
| | 3 | 10.7 | | 9.9 | | 10.6 | | 14.9 | | 19.0 | |
| TSC-Al-38 | 1 | 11.2 | 11.4 | 11.8 | 12.4 | 11.9 | 11.7 | 14.5 | 14.3 | 17.4 | 18.4 |
| | 2 | 11.4 | | 12.4 | | 11.3 | | 13.9 | | 17.9 | |
| | 3 | 11.5 | | 13.0 | | 12.0 | | 14.5 | | 19.9 | |
| TSC-Al-39 | 1 | 12.7 | 12.9 | 13.3 | 13.5 | 13.0 | 13.4 | 14.9 | 16.3 | 20.4 | 20.3 |
| | 2 | 13.4 | | 14.5 | | 13.3 | | 17.8 | | 19.5 | |
| | 3 | 12.6 | | 12.9 | | 13.9 | | 16.2 | | 20.9 | |
| TSC-Al-40 | 1 | 11.9 | 12.2 | 13.0 | 13.3 | 10.6 | 11.8 | 15.0 | 15.6 | 19.5 | 19.8 |
| | 2 | 11.9 | | 12.8 | | 11.9 | | 15.4 | | 19.7 | |
| | 3 | 12.9 | | 14.1 | | 12.7 | | 16.4 | | 20.3 | |
| TSC-Al-41 | 1 | 9.1 | 9.5 | 11.3 | 11.0 | 10.4 | 10.5 | 13.9 | 14.1 | 17.4 | 18.3 |
| | 2 | 10.0 | | 10.8 | | 10.5 | | 13.6 | | 18.2 | |
| | 3 | 9.5 | | 10.9 | | 10.4 | | 14.7 | | 19.2 | |
| TSC-Al-42 | 1 | 12.9 | 11.9 | 12.4 | 13.0 | 12.8 | 12.5 | 17.8 | 16.7 | 22.6 | 21.5 |
| | 2 | 11.4 | | 13.1 | | 13.0 | | 16.2 | | 20.8 | |
| | 3 | 11.2 | | 13.6 | | 11.8 | | 16.0 | | 20.9 | |
| TSC-Al-43 | 1 | 10.5 | 11.6 | 10.8 | 12.4 | 11.7 | 12.4 | 14.7 | 15.9 | 19.7 | 21.1 |
| | 2 | 12.2 | | 13.6 | | 13.2 | | 16.6 | | 20.7 | |
| | 3 | 12.1 | | 13.0 | | 12.5 | | 16.5 | | 22.8 | |
| TSC-Al-44 | 1 | 10.3 | 11.1 | 12.1 | 12.0 | 11.1 | 11.9 | 14.4 | 14.6 | 19.4 | 19.2 |
| | 2 | 11.1 | | 11.4 | | 11.6 | | 14.4 | | 19.0 | |
| | 3 | 12.0 | | 12.6 | | 13.0 | | 15.1 | | 19.2 | |
| TSC-Al-45 | 1 | 13.2 | 11.4 | 13.1 | 12.7 | 11.8 | 11.5 | 17.3 | 15.5 | 22.5 | 20.6 |
| | 2 | 11.0 | | 12.8 | | 11.2 | | 14.9 | | 19.6 | |
| | 3 | 10.1 | | 12.1 | | 11.5 | | 14.4 | | 19.7 | |
| TSC-Al-46 | 1 | 8.6 | 9.2 | 12.4 | 11.8 | 10.4 | 10.5 | 13.3 | 13.8 | 17.2 | 17.8 |
| | 2 | 9.4 | | 11.4 | | 10.6 | | 14.3 | | 18.2 | |
| | 3 | 9.7 | | 11.5 | | 10.4 | | 13.8 | | 17.9 | |
| TSC-Al-47 | 1 | 9.9 | 9.9 | 7.9 | 8.2 | 8.1 | 8.3 | 12.3 | 12.7 | 17.0 | 17.3 |
| | 2 | 10.2 | | 7.9 | | 7.8 | | 12.6 | | 17.3 | |
| | 3 | 9.6 | | 8.9 | | 9.0 | | 13.1 | | 17.5 | |
| TSC-Al-48 | 1 | 9.7 | 10.8 | 7.8 | 7.9 | 8.0 | 8.0 | 12.6 | 12.3 | 16.4 | 16.5 |
| | 2 | 13.0 | | 8.1 | | 8.3 | | 11.9 | | 17.0 | |
| | 3 | 9.7 | | 7.9 | | 7.6 | | 12.5 | | 16.3 | |
| TSC-Al-49 | 1 | 9.7 | 10.2 | 7.7 | 8.0 | 8.1 | 7.9 | 11.9 | 12.2 | 15.9 | 16.5 |
| | 2 | 10.5 | | 7.9 | | 7.9 | | 11.9 | | 16.2 | |
| | 3 | 10.6 | | 8.3 | | 7.9 | | 12.7 | | 17.3 | |

## Coating Thickness Measurements - Aluminum TSC Panels, Study 3

| Panel ID | Spot # | Al TSC Initial Condition Spot Measurements (mils) | Al TSC Initial Condition Side Average (mils) | Al TSC Following Exposure and Surface Preparation Spot Measurements (mils) | AL TSC Following Exposure and Surface Preparation Side Average (mils) | TSC + Sealer Spot Measurements (mils) | TSC + Sealer Side Average (mils) | TSC + Sealer + Epoxy Spot Measurements (mils) | TSC + Sealer + Epoxy Side Average (mils) | TSC + Sealer + Epoxy + Urethane Spot Measurements (mils) | TSC + Sealer + Epoxy + Urethane Side Average (mils) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TSC-Al-50 | 1 | 11.6 | 10.9 | 9.6 | 9.0 | 9.5 | 9.0 | 14.2 | 14.0 | 18.8 | 18.2 |
|  | 2 | 10.5 |  | 9.0 |  | 8.9 |  | 14.0 |  | 17.9 |  |
|  | 3 | 10.5 |  | 8.5 |  | 8.7 |  | 13.7 |  | 17.8 |  |
| TSC-Al-51 | 1 | 15.3 | 14.9 | 10.8 | 12.1 | 11.5 | 12.5 | 16.9 | 17.5 | 21.5 | 22.1 |
|  | 2 | 14.4 |  | 12.3 |  | 12.7 |  | 17.1 |  | 20.7 |  |
|  | 3 | 15.1 |  | 13.3 |  | 13.3 |  | 18.3 |  | 24.1 |  |
| TSC-Al-52 | 1 | 8.9 | 9.7 | 8.0 | 8.3 | 7.9 | 8.2 | 12.2 | 12.8 | 18.3 | 18.4 |
|  | 2 | 10.9 |  | 8.1 |  | 8.4 |  | 12.9 |  | 18.8 |  |
|  | 3 | 9.4 |  | 8.7 |  | 8.4 |  | 13.4 |  | 18.1 |  |
| TSC-Al-53 | 1 | 8.3 | 9.3 | 6.4 | 6.9 | 6.2 | 7.0 | 10.7 | 11.4 | 17.3 | 16.9 |
|  | 2 | 11.1 |  | 6.7 |  | 6.9 |  | 11.5 |  | 17.0 |  |
|  | 3 | 8.5 |  | 7.7 |  | 8.0 |  | 12.1 |  | 16.5 |  |
| TSC-Al-54 | 1 | 8.9 | 9.7 | 6.8 | 7.3 | 6.7 | 7.7 | 11.1 | 11.7 | 16.6 | 16.3 |
|  | 2 | 9.8 |  | 6.8 |  | 7.5 |  | 11.4 |  | 15.2 |  |
|  | 3 | 10.4 |  | 8.4 |  | 9.1 |  | 12.6 |  | 17.0 |  |
| TSC-Al-55 | 1 | 9.2 | 11.1 | 6.6 | 7.8 | 7.2 | 8.7 | 11.0 | 13.2 | 16.7 | 18.5 |
|  | 2 | 11.4 |  | 7.4 |  | 8.5 |  | 12.7 |  | 19.3 |  |
|  | 3 | 12.7 |  | 9.4 |  | 10.3 |  | 15.8 |  | 19.5 |  |

# Appendix I: Adhesion Results

## Adhesion Results

### HDG

| Panel ID | Surface Preparation | Exposure | Tape Adhesion Result | Coating Disbondment from Scribe | Pull-Off Strength (psi) | Primary Location of Break (Pull-Off Test) |
|---|---|---|---|---|---|---|
| HDG-20 | None | None | 0A, 0A | Up to 4 mm | 809<br>410 | Epoxy to HDG<br>Epoxy to HDG |
| HDG-21 | | | 0A, 1A | Up to 4 mm | 706<br>1265 | Epoxy to HDG<br>Epoxy to HDG |
| HDG-23 | | Humidity | 3A, 2A | Up to 2 mm | 1256<br>1404 | Epoxy to HDG, Cohesive within epoxy<br>Epoxy to HDG |
| HDG-24 | | | 1A, 1A | Up to 1 ½ mm | 1451<br>1068 | Epoxy to HDG<br>Epoxy to HDG |
| HDG-26 | | Prohesion | 2A, 2A | Up to 1 mm | 1604<br>1305 | Cohesive within Epoxy<br>Epoxy to HDG |
| HDG-27 | | | 2A, 3A | Up to 1 ½ mm | 1948<br>1458 | Epoxy to HDG<br>Epoxy to HDG |
| HDG-29 | SP1 | None | 2A, 2A | None | >3500<br>1639 | None<br>Cohesive within epoxy |
| HDG-30 | | | 4A, 3A | Up to ½ mm | 2833<br>2705 | Epoxy to HDG<br>Glue, Epoxy to HDG |
| HDG-32 | | Humidity | 3A, 3A | None | 2939<br>2649 | Epoxy to HDG, Cohesive within TC<br>Glue |
| HDG-33 | | | 3A, 4A | Up to ½ mm | >3000<br>>3000 | None<br>None |
| HDG-35 | | Prohesion | 2A, 2A | Up to 1 mm | 1782<br>1140 | Cohesive within epoxy<br>Epoxy to HDG, Cohesive within epoxy |
| HDG-36 | | | 2A, 1A | Up to 2 ½ mm | 1468<br>1364 | Epoxy to HDG<br>Epoxy to HDG |
| HDG-38 | Wash Primer | None | 4A, 4A | Up to 1 mm | 1606<br>1562 | 100% within wash primer<br>100% within wash primer |
| HDG-39 | | | 3A, 3A | None | 1833<br>1816 | 100% within wash primer<br>100% within wash primer |
| HDG-41 | | Humidity | 4A, 4A | None | 1717<br>1582 | 100% within wash primer<br>100% within wash primer |
| HDG-42 | | | 5A, 4A | Up to ½ mm | 1700<br>1776 | 100% within wash primer<br>100% within wash primer |
| HDG-44 | | Prohesion | 5A, 3A | None | 1363<br>976 | 100% wash primer to HDG<br>100% wash primer to HDG |
| HDG-45 | | | 4A, 3A | Up to 1 mm | 1244<br>1175 | 100% within wash primer<br>100% within wash primer |

### HDG

| Panel ID | Surface Preparation | Exposure | Tape Adhesion Result | Coating Disbondment from Scribe | Pull-Off Strength (psi) | Primary Location of Break (Pull-Off Test) |
|---|---|---|---|---|---|---|
| HDG-47 | PW/Power sand | None | 2A, 2A | Up to 4 mm | 2516<br>3212 | Cohesive within epoxy<br>Cohesive within epoxy |
| HDG-48 | | | 3A, 5A | Up to 2 mm | 2777<br>>3000 | Glue<br>None |
| HDG-50 | | Humidity | 3A, 3A | Up to 1 mm | >3500<br>3149 | None<br>Cohesive within TC |
| HDG-51 | | | 3A, 4A | Up to 1 mm | >3000<br>>3000 | None<br>None |
| HDG-53 | | Prohesion | 2A, 3A | Up to 3 mm | 2545<br>1986 | Cohesive within epoxy<br>Cohesive within epoxy |
| HDG-54 | | | 2A, 3A | Up to ½ mm | 2984<br>2751 | Epoxy to HDG<br>Glue, Epoxy to HDG |
| HDG-56 | PW/SP 16 | None | 3A, 4A | Up to 2 mm | 2157<br>2724 | Cohesive within epoxy<br>Cohesive within epoxy |
| HDG-57 | | | 2A, 2A | Up to 1 ½ mm | >3000<br>>3000 | None<br>None |
| HDG-59 | | Humidity | 4A, 3A | None | 2970<br>2613 | Cohesive within TC<br>Glue |
| HDG-60 | | | 3A, 3A | Up to ½ mm | >3000<br>>3000 | None<br>None |
| HDG-62 | | Prohesion | 2A, 2A | Up to 2 mm | 2230<br>1809 | Cohesive within epoxy<br>Epoxy to HDG |
| HDG-63 | | | 2A, 5A | Up to 1 mm | 2817<br>2333 | Epoxy to HDG<br>Epoxy to HDG |

### Zn-TSC

| Panel ID | Surface Preparation | Exposure | Tape Adhesion Result | Coating Disbondment from Scribe | Pull-Off Strength (psi) | Primary Location of Break (Pull-Off Test) |
|---|---|---|---|---|---|---|
| Zn-20 | None | None | 4A, 4A | None | 2898<br>2419 | Glue, cohesive within TSC<br>Cohesive within TSC |
| Zn-21 | | | 3A, 4A | None | 2662<br>2572 | Epoxy to TSC<br>Cohesive within TSC |
| Zn-23 | | Humidity | 4A, 4A | None | 1840<br>1762 | Cohesive within TSC<br>TSC to substrate |
| Zn-24 | | | 3A, 3A | None | 1734<br>1756 | TSC to substrate<br>TSC to substrate |
| Zn-26 | | Prohesion | 3A, 3A | None | 1368<br>1221 | Cohesive within TSC<br>Cohesive within TSC |
| Zn-27 | | | 3A, 2A | None | 1269<br>1341 | Cohesive within TSC<br>Cohesive within TSC |

**Zn-TSC**

| Panel ID | Surface Preparation | Exposure | Tape Adhesion Result | Coating Disbondment from Scribe | Pull-Off Strength (psi) | Primary Location of Break (Pull-Off Test) |
|---|---|---|---|---|---|---|
| Zn-29 | SP1 | None | 3A, 4A | None | 2290<br>2096 | Epoxy to TSC<br>Epoxy to TSC |
| Zn-30 | | | 3A, 5A | None | 2261<br>2460 | Epoxy to TSC<br>Cohesive within TSC |
| Zn-32 | | Humidity | 4A, 4A | None | 1488<br>1480 | TSC to substrate<br>Epoxy to TSC |
| Zn-33 | | | 3A, 3A | None | 1776<br>1572 | TSC to substrate<br>TSC to substrate |
| Zn-35 | | Prohesion | 4A, 3A | None | 1613<br>1381 | TSC to substrate<br>Cohesive within TSC |
| Zn-36 | | | 2A, 3A | None | 1080<br>1275 | Cohesive within TSC<br>Cohesive within TSC |
| Zn-38 | PW/Blow dry | None | 3A, 4A | None | 2462<br>2117 | Cohesive within TSC<br>Cohesive within TSC |
| Zn-39 | | | 4A, 4A | None | 2525<br>1766 | Cohesive within TSC<br>Epoxy to TSC |
| Zn-41 | | Humidity | 4A, 4A | None | 1736<br>1607 | Cohesive within TSC<br>Cohesive within TSC |
| Zn-42 | | | 3A, 3A | None | 1222<br>1553 | Cohesive within TSC<br>Epoxy to TSC |
| Zn-44 | | Prohesion | 5A, 4A | None | 1651<br>1917 | Cohesive within TSC<br>Epoxy to TSC |
| Zn-45 | | | 3A, 3A | None | 1585<br>2087 | Cohesive within TSC<br>Epoxy to TSC |
| Zn-47 | PW/Power sand | None | 5A, 4A | None | 2392<br>1937 | Cohesive within TSC<br>Cohesive within TSC |
| Zn-48 | | | 3A, 3A | None | 2744<br>2390 | Glue, Cohesive within TSC<br>Glue, Cohesive within TSC |
| Zn-50 | | Humidity | 3A, 3A | Up to 2 mm | 1963<br>1288 | TSC to substrate<br>Epoxy to TSC |
| Zn-51 | | | 3A, 3A | None | 1656<br>1511 | TSC to substrate<br>TSC to substrate |
| Zn-53 | | Prohesion | 3A, 3A | None | 1651<br>1733 | Cohesive within TSC<br>Cohesive within TSC |
| Zn-54 | | | 3A, 3A | None | 1652<br>1533 | TSC to substrate<br>Cohesive within TSC |

**Zinc-Aluminum TSC**

| Panel ID | Surface Preparation | Exposure | Tape Adhesion Result | Coating Disbondment from Scribe | Pull-Off Strength (psi) | Primary Location of Break (Pull-Off Test) |
|---|---|---|---|---|---|---|
| ZnAl-20 | None | None | 4A, 5A | None | 3275<br>2726 | Cohesive within TSC<br>Cohesive within TSC |
| ZnAl-21 | | | 4A, 3A | None | 2440<br>2824 | Cohesive within TSC<br>Glue, Cohesive within TSC |
| ZnAl-23 | | Humidity | 5A, 5A | None | 2032<br>1776 | TSC to substrate<br>TSC to substrate |
| ZnAl-24 | | | 4A, 4A | Up to 2 ½ mm | 1993<br>1691 | TSC to substrate<br>Epoxy to TSC |
| ZnAl-26 | | Prohesion | 3A, 4A | Up to 1 mm | 1288<br>1141 | TSC to substrate<br>TSC to substrate |
| ZnAl-27 | | | 3A, 3A | Up to 1 mm | 1111<br>1259 | TSC to substrate<br>TSC to substrate |
| ZnAl-29 | SP1 | None | 3A, 5A | None | 2070<br>2122 | Cohesive within TSC<br>Cohesive within TSC |
| ZnAl-30 | | | 3A, 3A | None | 1925<br>1745 | Cohesive within TSC<br>Cohesive within TSC |
| ZnAl-32 | | Humidity | 4A, 4A | None | 1582<br>963 | TSC to substrate<br>Epoxy to TSC |
| ZnAl-33 | | | 3A, 3A | None | 1632<br>1279 | TSC to substrate<br>TSC to substrate |
| ZnAl-35 | | Prohesion | 3A, 3A | None | 1381<br>1581 | TSC to substrate<br>TSC to substrate |
| ZnAl-36 | | | 3A, 4A | None | 1505<br>1154 | Cohesive within TSC<br>TSC to substrate |
| ZnAl-38 | PW/Blow dry | None | 5A, 4A | None | 2938<br>2578 | Cohesive within TSC<br>Cohesive within TSC |
| ZnAl-39 | | | 3A, 3A | None | 2429<br>2847 | Cohesive within TSC<br>Cohesive within TSC |
| ZnAl-41 | | Humidity | 4A, 4A | None | 1726<br>1765 | TSC to substrate<br>TSC to substrate |
| ZnAl-42 | | | 3A, 4A | Up to ½ mm | 1998<br>1986 | TSC to substrate<br>TSC to substrate |
| ZnAl-44 | | Prohesion | 3A, 4A | Up to 1 mm | 1609<br>1174 | Cohesive within TSC<br>TSC to substrate |
| ZnAl-45 | | | 4A, 4A | None | 1431<br>1525 | TSC to substrate<br>Epoxy to TSC |

## Zinc-Aluminum TSC

| Panel ID | Surface Preparation | Exposure | Tape Adhesion Result | Coating Disbondment from Scribe | Pull-Off Strength (psi) | Primary Location of Break (Pull-Off Test) |
|---|---|---|---|---|---|---|
| ZnAl-47 | PW/Power sand | None | 4A, 4A | None | 2929<br>2827 | Epoxy to TSC<br>Cohesive within TSC |
| ZnAl-48 | | | 4A, 2A | None | 2712<br>2226 | Cohesive within TSC<br>Cohesive within TSC |
| ZnAl-50 | | Humidity | 4A, 4A | None | 1754<br>1276 | TSC to substrate<br>Epoxy to TSC |
| ZnAl-51 | | | 3A, 3A | Up to 1mm | 2150<br>1801 | TSC to substrate<br>TSC to substrate |
| ZnAl-53 | | Prohesion | 4A, 4A | Up to 1 mm | 1720<br>1062 | TSC to substrate<br>Epoxy to TSC |
| ZnAl-54 | | | 3A, 3A | Up to 1mm | 1496<br>1298 | TSC to substrate<br>TSC to substrate |

## Aluminum TSC

| Panel ID | Surface Preparation | Exposure | Tape Adhesion Result | Coating Disbondment from Scribe | Pull-Off Strength (psi) | Primary Location of Break (Pull-Off Test) |
|---|---|---|---|---|---|---|
| Al-20 | None | None | 5A, 5A | None | 3500<br>3047 | Cohesive within TSC<br>Cohesive within TSC |
| Al-21 | | | 5A, 5A | None | 2747<br>2664 | TSC to substrate<br>Cohesive within TSC |
| Al-23 | | Humidity | 3A, 4A | None | 2122<br>1781 | Epoxy to TSC<br>Epoxy to TSC |
| Al-24 | | | 2A, 2A | None | 2242<br>1619 | Epoxy to TSC<br>Cohesive within Epoxy |
| Al-26 | | Prohesion | 3A, 3A | None | 2566<br>2306 | TSC to substrate<br>TSC to substrate |
| Al-27 | | | 3A, 3A | None | 2820<br>2762 | Cohesive within TSC<br>Cohesive within TSC |
| Al-29 | SP1 | None | 4A, 4A | None | 2202<br>2395 | TSC to substrate<br>TSC to substrate |
| Al-30 | | | 3A, 4A | None | 1751<br>2444 | Glue<br>TSC to substrate |
| Al-32 | | Humidity | 4A, 3A | None | 2187<br>1894 | Epoxy to TSC<br>Epoxy to TSC |
| Al-33 | | | 3A, 3A | None | 2124<br>1324 | Epoxy to TSC<br>Epoxy to TSC |
| Al-35 | | Prohesion | 4A, 4A | None | 2255<br>2806 | Cohesive within TSC<br>Cohesive within TSC |
| Al-36 | | | 3A, 4A | None | 2538<br>2106 | Cohesive within TSC<br>Epoxy to TSC |

**Aluminum TSC**

| Panel ID | Surface Preparation | Exposure | Tape Adhesion Result | Coating Disbondment from Scribe | Pull-Off Strength (psi) | Primary Location of Break (Pull-Off Test) |
|---|---|---|---|---|---|---|
| Al-38 | PW/Blow dry | None | 4A, 4A | None | 2647<br>3370 | Glue<br>Glue |
| Al-39 | | | 5A, 3A | None | 2873<br>2961 | TSC to substrate<br>TSC to substrate |
| Al-41 | | Humidity | 3A, 3A | None | 2008<br>1110 | Epoxy to TSC<br>Epoxy to TSC |
| Al-42 | | | 2A, 3A | None | 1766<br>1591 | Epoxy to TSC<br>Epoxy to TSC |
| Al-44 | | Prohesion | 4A, 4A | None | 2423<br>1761 | Cohesive within TSC<br>Epoxy to TSC |
| Al-45 | | | 3A, 5A | None | 2721<br>2698 | Cohesive within TSC<br>Cohesive within TSC |
| Al-47 | PW/Power sand | None | 4A, 4A | None | 2372<br>3142 | Glue<br>Glue |
| Al-48 | | | 4A, 3A | None | 3367<br>2199 | Glue<br>Glue |
| Al-50 | | Humidity | 3A, 2A | Up to 3 mm | 2402<br>1453 | Topcoat to Epoxy<br>Epoxy to TSC |
| Al-51 | | | 3A, 3A | None | 2119<br>2152 | TSC to substrate<br>TSC to substrate |
| Al-53 | | Prohesion | 4A, 4A | None | 2761<br>2371 | TSC to substrate<br>TSC to substrate |
| Al-54 | | | 4A, 3A | Up to 3 mm | 2827<br>2729 | Cohesive within TSC<br>Cohesive within TSC |

# Appendix J: Photographs of Representative Test Panels

# STUDY 3 PANELS FOLLOWING ADHEISON AND UNDERCUTTING EVALUATIONS

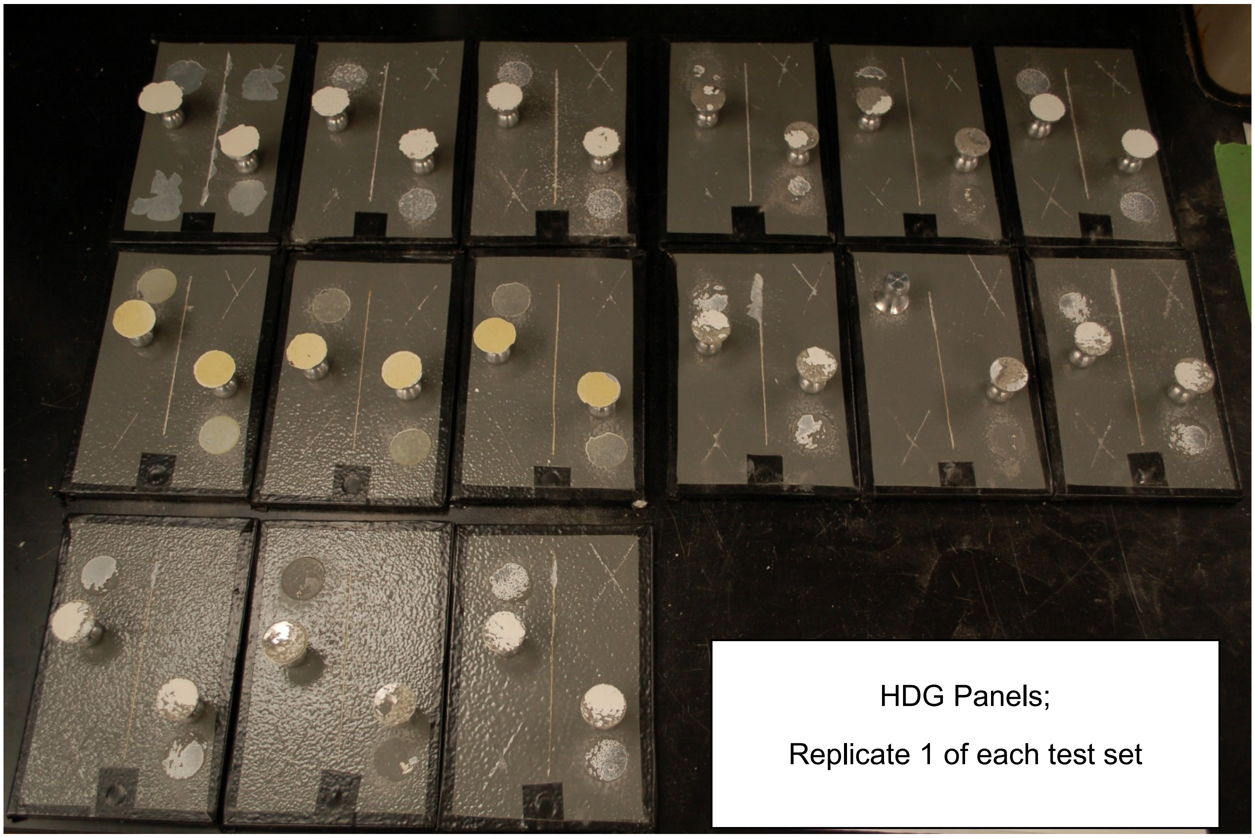


***Figure 1. HDG panels. Top row: Panel ID 20, 23, 26, 29, 32, 35.***

***Middle row: Panel ID 38, 41, 44, 47, 50, 53. Bottom row: 56, 59, 62.***

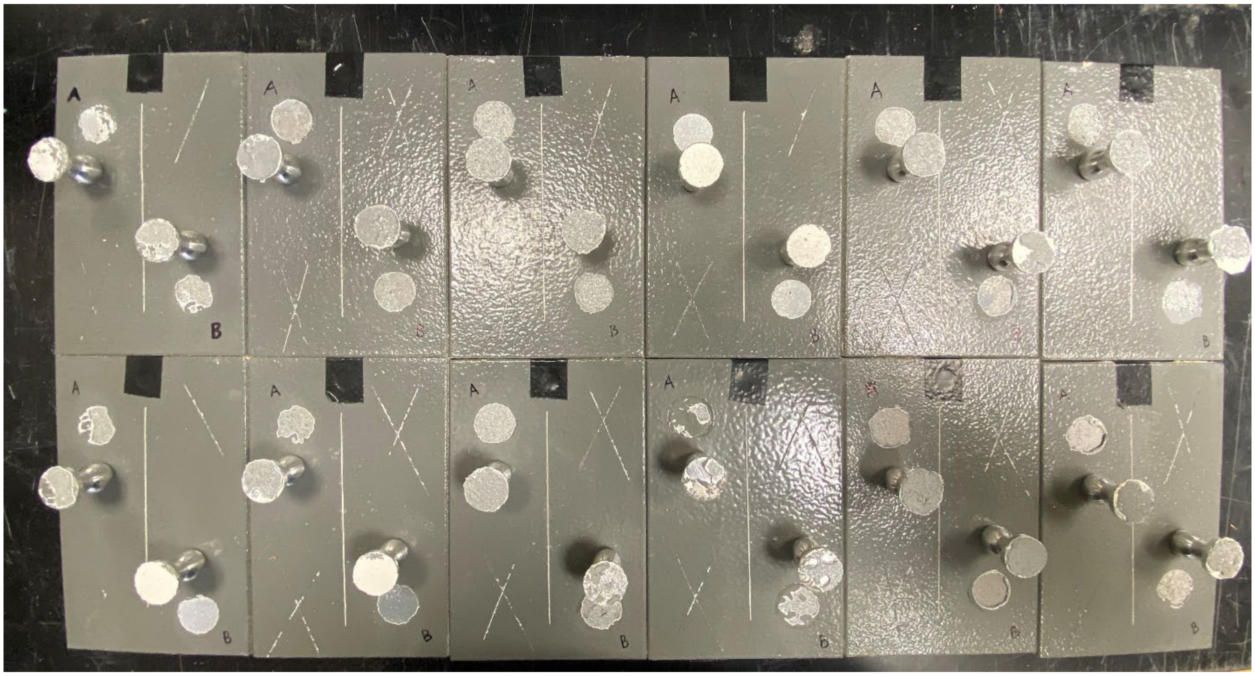


***Figure 2. Zn TSC panels. Top row: Panel ID 21, 24, 27, 30, 33, 36.***

***Bottom row: Panel ID 39, 42, 45, 48, 51, 54.***

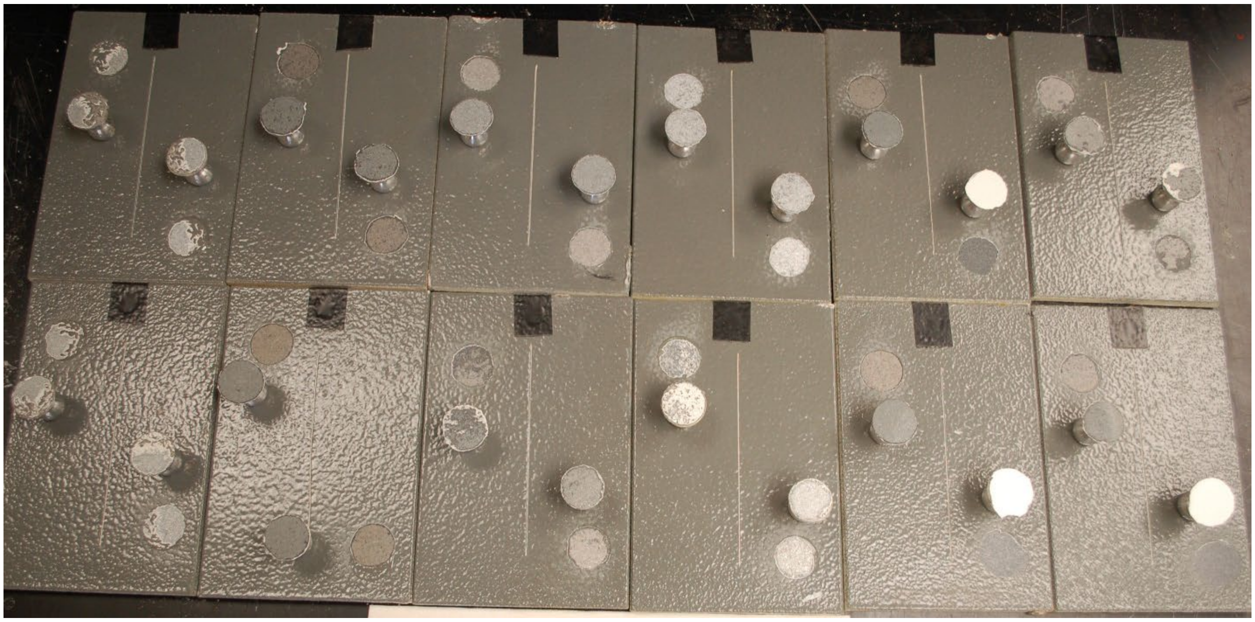


***Figure 3. ZnAl TSC panels. Top row: Panel ID 20, 23, 26, 29, 32, 35.***

***Bottom row: Panel ID 38, 41, 44, 47, 50, 53.***

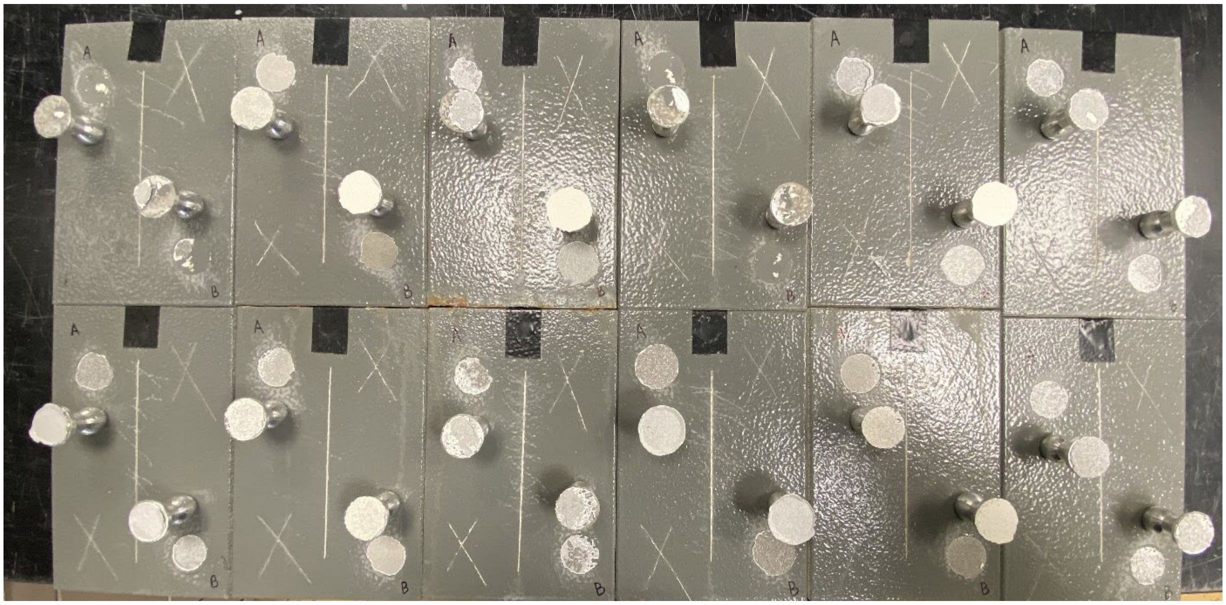


*Figure 4. Al TSC panels. Top row: Panel ID 20, 23, 26, 29, 32, 35.*

*Bottom row: Panel ID 38, 41, 44, 47, 50, 53.*

# Appendix K: Study 4, Dry Film Thickness

## Dry Film Thickness Measurements - Test 1

| Panel ID | Side | Spot # | Coating Spot Average (mils) | Coating Side Average (mils) |
|---|---|---|---|---|
| 1 | F | 1 | 10.3 | 9.6 |
| | | 2 | 9.1 | |
| | | 3 | 9.3 | |
| | B | 1 | 11.7 | 9.6 |
| | | 2 | 8.6 | |
| | | 3 | 8.4 | |
| 2 | F | 1 | 7.8 | 9.1 |
| | | 2 | 10.9 | |
| | | 3 | 8.5 | |
| | B | 1 | 8.1 | 9.1 |
| | | 2 | 9.2 | |
| | | 3 | 9.9 | |
| 3 | F | 1 | 9.3 | 10.1 |
| | | 2 | 11.8 | |
| | | 3 | 9.2 | |
| | B | 1 | 9.5 | 9.7 |
| | | 2 | 11.1 | |
| | | 3 | 8.6 | |
| 4 | F | 1 | 10.0 | 9.2 |
| | | 2 | 9.5 | |
| | | 3 | 8.2 | |
| | B | 1 | 9.9 | 9.2 |
| | | 2 | 9.3 | |
| | | 3 | 8.3 | |
| 5 | F | 1 | 9.2 | 8.8 |
| | | 2 | 9.2 | |
| | | 3 | 8.1 | |
| | B | 1 | 9.9 | 9.4 |
| | | 2 | 9.7 | |
| | | 3 | 8.5 | |
| 6 | F | 1 | 9.5 | 9.3 |
| | | 2 | 9.9 | |
| | | 3 | 8.4 | |
| | B | 1 | 7.6 | 8.8 |
| | | 2 | 9.7 | |
| | | 3 | 9.2 | |

# Dry Film Thickness Measurements - Test 1

| Panel ID | Side | Spot # | Coating Spot Average (mils) | Coating Side Average (mils) |
|---|---|---|---|---|
| 7 | F | 1 | 9.2 | 9.5 |
| | | 2 | 10.4 | |
| | | 3 | 9.0 | |
| | B | 1 | 10.1 | 10.0 |
| | | 2 | 10.8 | |
| | | 3 | 9.1 | |
| 8 | F | 1 | 10.7 | 10.6 |
| | | 2 | 10.7 | |
| | | 3 | 10.3 | |
| | B | 1 | 10.8 | 10.3 |
| | | 2 | 11.1 | |
| | | 3 | 9.0 | |
| 9 | F | 1 | 11.6 | 10.2 |
| | | 2 | 10.4 | |
| | | 3 | 8.6 | |
| | B | 1 | 9.0 | 8.9 |
| | | 2 | 9.1 | |
| | | 3 | 8.6 | |
| 10 | F | 1 | 8.5 | 9.5 |
| | | 2 | 11.5 | |
| | | 3 | 8.4 | |
| | B | 1 | 9.4 | 9.4 |
| | | 2 | 9.9 | |
| | | 3 | 8.8 | |
| 11 | F | 1 | 10.4 | 10.3 |
| | | 2 | 11.8 | |
| | | 3 | 8.8 | |
| | B | 1 | 9.9 | 10.3 |
| | | 2 | 10.8 | |
| | | 3 | 10.1 | |
| 12 | F | 1 | 10.1 | 10.8 |
| | | 2 | 10.9 | |
| | | 3 | 11.3 | |
| | B | 1 | 8.2 | 8.0 |
| | | 2 | 8.2 | |
| | | 3 | 7.5 | |

# Dry Film Thickness Measurements - Test 1

| Panel ID | Side | Spot # | Coating Spot Average (mils) | Coating Side Average (mils) |
|---|---|---|---|---|
| 13 | F | 1 | 8.6 | 9.3 |
| | | 2 | 9.8 | |
| | | 3 | 9.5 | |
| | B | 1 | 11.0 | 11.3 |
| | | 2 | 11.7 | |
| | | 3 | 11.3 | |
| 14 | F | 1 | 9.1 | 9.8 |
| | | 2 | 10.4 | |
| | | 3 | 10.1 | |
| | B | 1 | 8.8 | 8.7 |
| | | 2 | 9.1 | |
| | | 3 | 8.3 | |
| 15 | F | 1 | 9.7 | 8.5 |
| | | 2 | 7.9 | |
| | | 3 | 7.8 | |
| | B | 1 | 10.5 | 8.9 |
| | | 2 | 8.2 | |
| | | 3 | 7.9 | |
| 16 | F | 1 | 13.6 | 13.2 |
| | | 2 | 13.9 | |
| | | 3 | 12.2 | |
| | B | 1 | 11.7 | 11.1 |
| | | 2 | 10.9 | |
| | | 3 | 10.8 | |
| 17 | F | 1 | 10.3 | 10.9 |
| | | 2 | 11.6 | |
| | | 3 | 10.9 | |
| | B | 1 | 11.1 | 11.5 |
| | | 2 | 12.4 | |
| | | 3 | 11.1 | |
| 18 | F | 1 | 11.6 | 11.6 |
| | | 2 | 12.2 | |
| | | 3 | 10.9 | |
| | B | 1 | 11.6 | 12.1 |
| | | 2 | 13.3 | |
| | | 3 | 11.3 | |

## Dry Film Thickness Measurements - Test 1

| Panel ID | Side | Spot # | Coating Spot Average (mils) | Coating Side Average (mils) |
|---|---|---|---|---|
| 19 | F | 1 | 14.4 | 14.4 |
| | | 2 | 14.7 | |
| | | 3 | 13.9 | |
| | B | 1 | 9.9 | 10.3 |
| | | 2 | 10.8 | |
| | | 3 | 10.2 | |
| 20 | F | 1 | 11.5 | 10.9 |
| | | 2 | 11.9 | |
| | | 3 | 9.2 | |
| | B | 1 | 10.3 | 11.4 |
| | | 2 | 10.9 | |
| | | 3 | 12.8 | |
| 21 | F | 1 | 11.7 | 11.6 |
| | | 2 | 11.2 | |
| | | 3 | 11.9 | |
| | B | 1 | 11.5 | 12.5 |
| | | 2 | 13.5 | |
| | | 3 | 12.3 | |
| 22 | F | 1 | 11.9 | 11.6 |
| | | 2 | 12.4 | |
| | | 3 | 10.4 | |
| | B | 1 | 11.1 | 10.4 |
| | | 2 | 11.1 | |
| | | 3 | 8.8 | |
| 23 | F | 1 | 10.3 | 11.0 |
| | | 2 | 11.1 | |
| | | 3 | 11.5 | |
| | B | 1 | 11.8 | 13.0 |
| | | 2 | 14.8 | |
| | | 3 | 12.5 | |
| 24 | F | 1 | 9.9 | 10.8 |
| | | 2 | 12.4 | |
| | | 3 | 10.2 | |
| | B | 1 | 12.7 | 12.7 |
| | | 2 | 12.4 | |
| | | 3 | 13.0 | |

## Dry Film Thickness Measurements - Test 2

| Panel ID | Side | Spot # | Coating Spot Average (mils) | Coating Side Average (mils) |
|---|---|---|---|---|
| 25 | F | 1 | 8.8 | 9.6 |
| | | 2 | 9.9 | |
| | | 3 | 10.1 | |
| | B | 1 | 9.8 | 10.7 |
| | | 2 | 11.6 | |
| | | 3 | 10.8 | |
| 26 | F | 1 | 8.1 | 8.5 |
| | | 2 | 9.4 | |
| | | 3 | 7.9 | |
| | B | 1 | 8.5 | 8.4 |
| | | 2 | 10.0 | |
| | | 3 | 6.7 | |
| 27 | F | 1 | 8.8 | 9.1 |
| | | 2 | 9.4 | |
| | | 3 | 9.0 | |
| | B | 1 | 8.5 | 9.2 |
| | | 2 | 9.9 | |
| | | 3 | 9.3 | |
| 28 | F | 1 | 8.6 | 8.6 |
| | | 2 | 8.6 | |
| | | 3 | 8.7 | |
| | B | 1 | 8.9 | 8.7 |
| | | 2 | 9.0 | |
| | | 3 | 8.1 | |
| 29 | F | 1 | 8.1 | 8.8 |
| | | 2 | 10.5 | |
| | | 3 | 7.8 | |
| | B | 1 | 7.2 | 8.4 |
| | | 2 | 10.0 | |
| | | 3 | 7.9 | |
| 81 | F | 1 | 10.7 | 11.2 |
| | | 2 | 13.5 | |
| | | 3 | 9.5 | |
| | B | 1 | 10.9 | 11.5 |
| | | 2 | 12.2 | |
| | | 3 | 11.2 | |

## Dry Film Thickness Measurements - Test 2

| Panel ID | Side | Spot # | Coating Spot Average (mils) | Coating Side Average (mils) |
|---|---|---|---|---|
| 82 | F | 1 | 8.9 | 9.6 |
| | | 2 | 10.5 | |
| | | 3 | 9.3 | |
| | B | 1 | 9.1 | 9.6 |
| | | 2 | 9.5 | |
| | | 3 | 10.1 | |
| 83 | F | 1 | 9.1 | 9.5 |
| | | 2 | 11.1 | |
| | | 3 | 8.3 | |
| | B | 1 | 10.0 | 10.4 |
| | | 2 | 12.2 | |
| | | 3 | 9.0 | |
| 84 | F | 1 | 9.3 | 9.3 |
| | | 2 | 8.9 | |
| | | 3 | 9.7 | |
| | B | 1 | 9.4 | 9.2 |
| | | 2 | 9.2 | |
| | | 3 | 9.1 | |
| 85 | F | 1 | 9.6 | 11.2 |
| | | 2 | 13.3 | |
| | | 3 | 10.7 | |
| | B | 1 | 8.5 | 9.3 |
| | | 2 | 10.5 | |
| | | 3 | 8.9 | |
| 86 | F | 1 | 9.2 | 9.9 |
| | | 2 | 10.6 | |
| | | 3 | 10.0 | |
| | B | 1 | 7.9 | 9.2 |
| | | 2 | 10.9 | |
| | | 3 | 8.8 | |
| 87 | F | 1 | 13.3 | 12.3 |
| | | 2 | 11.9 | |
| | | 3 | 11.7 | |
| | B | 1 | 13.1 | 11.8 |
| | | 2 | 11.0 | |
| | | 3 | 11.2 | |

## Dry Film Thickness Measurements - Test 2

| Panel ID | Side | Spot # | Coating Spot Average (mils) | Coating Side Average (mils) |
|---|---|---|---|---|
| 88 | F | 1 | 8.9 | 9.7 |
| | | 2 | 10.3 | |
| | | 3 | 9.8 | |
| | B | 1 | 10.1 | 11.2 |
| | | 2 | 10.6 | |
| | | 3 | 12.8 | |
| 89 | F | 1 | 9.4 | 9.1 |
| | | 2 | 9.3 | |
| | | 3 | 8.7 | |
| | B | 1 | 8.7 | 9.5 |
| | | 2 | 10.4 | |
| | | 3 | 9.5 | |
| 90 | F | 1 | 9.8 | 10.3 |
| | | 2 | 11.6 | |
| | | 3 | 9.4 | |
| | B | 1 | 9.7 | 9.4 |
| | | 2 | 8.5 | |
| | | 3 | 10.1 | |
| 30 | F | 1 | 9.9 | 9.9 |
| | | 2 | 9.2 | |
| | | 3 | 10.5 | |
| | B | 1 | 9.4 | 9.5 |
| | | 2 | 9.9 | |
| | | 3 | 9.2 | |
| 31 | F | 1 | 10.2 | 9.8 |
| | | 2 | 10.0 | |
| | | 3 | 9.1 | |
| | B | 1 | 8.8 | 8.6 |
| | | 2 | 9.2 | |
| | | 3 | 7.8 | |
| 32 | F | 1 | 10.7 | 10.0 |
| | | 2 | 8.9 | |
| | | 3 | 10.2 | |
| | B | 1 | 10.5 | 10.1 |
| | | 2 | 10.7 | |
| | | 3 | 9.2 | |

## Dry Film Thickness Measurements - Test 2

| Panel ID | Side | Spot # | Coating Spot Average (mils) | Coating Side Average (mils) |
|---|---|---|---|---|
| 91 | F | 1 | 11.3 | 10.8 |
| | | 2 | 9.9 | |
| | | 3 | 11.2 | |
| | B | 1 | 9.6 | 9.0 |
| | | 2 | 8.1 | |
| | | 3 | 9.4 | |
| 92 | F | 1 | 13.1 | 12.3 |
| | | 2 | 10.9 | |
| | | 3 | 12.9 | |
| | B | 1 | 9.0 | 7.9 |
| | | 2 | 7.2 | |
| | | 3 | 7.5 | |
| 93 | F | 1 | 8.6 | 8.9 |
| | | 2 | 8.4 | |
| | | 3 | 9.6 | |
| | B | 1 | 10.2 | 10.4 |
| | | 2 | 10.2 | |
| | | 3 | 10.7 | |
| 94 | F | 1 | 8.1 | 8.7 |
| | | 2 | 9.6 | |
| | | 3 | 8.2 | |
| | B | 1 | 9.8 | 9.6 |
| | | 2 | 8.2 | |
| | | 3 | 10.7 | |
| 95 | F | 1 | 9.3 | 9.2 |
| | | 2 | 10.0 | |
| | | 3 | 8.3 | |
| | B | 1 | 9.0 | 8.8 |
| | | 2 | 8.2 | |
| | | 3 | 9.1 | |
| 96 | F | 1 | 9.2 | 10.0 |
| | | 2 | 9.9 | |
| | | 3 | 10.9 | |
| | B | 1 | 9.5 | 10.3 |
| | | 2 | 9.5 | |
| | | 3 | 11.8 | |

## Dry Film Thickness Measurements - Test 3

| Panel ID | Side | Spot # | Coating Spot Average (mils) | Coating Side Average (mils) |
|---|---|---|---|---|
| 33 | F | 1 | 11.5 | 11.4 |
| | | 2 | 11.7 | |
| | | 3 | 10.9 | |
| | B | 1 | 10.0 | 10.5 |
| | | 2 | 11.8 | |
| | | 3 | 9.7 | |
| 34 | F | 1 | 11.2 | 10.7 |
| | | 2 | 10.9 | |
| | | 3 | 10.0 | |
| | B | 1 | 11.6 | 10.7 |
| | | 2 | 10.2 | |
| | | 3 | 10.2 | |
| 35 | F | 1 | 11.8 | 10.7 |
| | | 2 | 9.2 | |
| | | 3 | 11.2 | |
| | B | 1 | 12.8 | 11.2 |
| | | 2 | 10.7 | |
| | | 3 | 10.1 | |
| 36 | F | 1 | 9.3 | 9.1 |
| | | 2 | 9.1 | |
| | | 3 | 9.0 | |
| | B | 1 | 10.0 | 9.6 |
| | | 2 | 9.6 | |
| | | 3 | 9.2 | |
| 37 | F | 1 | 10.0 | 10.1 |
| | | 2 | 9.8 | |
| | | 3 | 10.6 | |
| | B | 1 | 7.4 | 8.0 |
| | | 2 | 8.5 | |
| | | 3 | 8.1 | |
| 49 | F | 1 | 5.1 | 5.4 |
| | | 2 | 5.5 | |
| | | 3 | 5.5 | |
| | B | 1 | 5.1 | 5.3 |
| | | 2 | 5.8 | |
| | | 3 | 4.9 | |

## Dry Film Thickness Measurements - Test 3

| Panel ID | Side | Spot # | Coating Spot Average (mils) | Coating Side Average (mils) |
|---|---|---|---|---|
| 50 | F | 1 | 5.4 | 5.8 |
| | | 2 | 5.7 | |
| | | 3 | 6.3 | |
| | B | 1 | 5.1 | 5.0 |
| | | 2 | 5.1 | |
| | | 3 | 4.8 | |
| 51 | F | 1 | 4.6 | 5.3 |
| | | 2 | 6.2 | |
| | | 3 | 5.1 | |
| | B | 1 | 5.7 | 5.5 |
| | | 2 | 5.3 | |
| | | 3 | 5.5 | |
| 52 | F | 1 | 5.1 | 5.2 |
| | | 2 | 5.3 | |
| | | 3 | 5.2 | |
| | B | 1 | 6.2 | 5.6 |
| | | 2 | 5.6 | |
| | | 3 | 5.1 | |
| 53 | F | 1 | 5.2 | 5.2 |
| | | 2 | 5.3 | |
| | | 3 | 5.0 | |
| | B | 1 | 8.6 | 6.4 |
| | | 2 | 5.4 | |
| | | 3 | 5.3 | |
| 54 | F | 1 | 5.5 | 5.3 |
| | | 2 | 5.1 | |
| | | 3 | 5.2 | |
| | B | 1 | 4.9 | 5.1 |
| | | 2 | 5.4 | |
| | | 3 | 5.1 | |
| 55 | F | 1 | 5.6 | 5.4 |
| | | 2 | 5.5 | |
| | | 3 | 5.2 | |
| | B | 1 | 5.4 | 4.9 |
| | | 2 | 4.7 | |
| | | 3 | 4.8 | |

## Dry Film Thickness Measurements - Test 3

| Panel ID | Side | Spot # | Coating Spot Average (mils) | Coating Side Average (mils) |
|---|---|---|---|---|
| 56 | F | 1 | 5.4 | 5.3 |
| | | 2 | 5.3 | |
| | | 3 | 5.4 | |
| | B | 1 | 5.0 | 5.3 |
| | | 2 | 5.3 | |
| | | 3 | 5.6 | |
| 57 | F | 1 | 5.0 | 4.9 |
| | | 2 | 4.9 | |
| | | 3 | 4.7 | |
| | B | 1 | 5.6 | 5.6 |
| | | 2 | 5.5 | |
| | | 3 | 5.7 | |
| 58 | F | 1 | 5.7 | 5.5 |
| | | 2 | 5.7 | |
| | | 3 | 5.0 | |
| | B | 1 | 4.6 | 4.9 |
| | | 2 | 5.0 | |
| | | 3 | 5.0 | |
| 38 | F | 1 | 8.6 | 9.7 |
| | | 2 | 10.5 | |
| | | 3 | 10.0 | |
| | B | 1 | 9.2 | 9.5 |
| | | 2 | 9.7 | |
| | | 3 | 9.6 | |
| 39 | F | 1 | 7.8 | 8.9 |
| | | 2 | 9.9 | |
| | | 3 | 9.1 | |
| | B | 1 | 9.7 | 10.0 |
| | | 2 | 10.2 | |
| | | 3 | 10.2 | |
| 40 | F | 1 | 10.6 | 9.5 |
| | | 2 | 8.6 | |
| | | 3 | 9.4 | |
| | B | 1 | 10.5 | 9.3 |
| | | 2 | 8.3 | |
| | | 3 | 9.2 | |

## Dry Film Thickness Measurements - Test 3

| Panel ID | Side | Spot # | Coating Spot Average (mils) | Coating Side Average (mils) |
|---|---|---|---|---|
| 59 | F | 1 | 5.7 | 5.9 |
| | | 2 | 5.6 | |
| | | 3 | 6.5 | |
| | B | 1 | 5.9 | 5.9 |
| | | 2 | 5.8 | |
| | | 3 | 5.9 | |
| 60 | F | 1 | 6.3 | 6.4 |
| | | 2 | 6.3 | |
| | | 3 | 6.5 | |
| | B | 1 | 8.0 | 7.3 |
| | | 2 | 6.6 | |
| | | 3 | 7.4 | |
| 61 | F | 1 | 6.8 | 6.5 |
| | | 2 | 6.3 | |
| | | 3 | 6.4 | |
| | B | 1 | 5.7 | 5.8 |
| | | 2 | 6.0 | |
| | | 3 | 5.8 | |
| 62 | F | 1 | 5.8 | 6.1 |
| | | 2 | 6.3 | |
| | | 3 | 6.1 | |
| | B | 1 | 5.7 | 5.9 |
| | | 2 | 6.0 | |
| | | 3 | 6.1 | |
| 63 | F | 1 | 6.0 | 6.1 |
| | | 2 | 6.0 | |
| | | 3 | 6.2 | |
| | B | 1 | 5.7 | 5.8 |
| | | 2 | 6.0 | |
| | | 3 | 5.8 | |
| 64 | F | 1 | 6.6 | 6.3 |
| | | 2 | 6.4 | |
| | | 3 | 5.9 | |
| | B | 1 | 6.6 | 6.3 |
| | | 2 | 6.2 | |
| | | 3 | 6.1 | |

# Dry Film Thickness Measurements - Test 4

| Panel ID | Side | Spot # | Coating Spot Average (mils) | Coating Side Average (mils) |
|---|---|---|---|---|
| 41 | F | 1 | 9.1 | 9.6 |
| | | 2 | 10.1 | |
| | | 3 | 9.5 | |
| | B | 1 | 11.3 | 10.1 |
| | | 2 | 9.0 | |
| | | 3 | 10.1 | |
| 42 | F | 1 | 8.9 | 10.4 |
| | | 2 | 9.0 | |
| | | 3 | 13.3 | |
| | B | 1 | 8.8 | 9.1 |
| | | 2 | 8.1 | |
| | | 3 | 10.2 | |
| 43 | F | 1 | 8.9 | 10.1 |
| | | 2 | 10.3 | |
| | | 3 | 11.1 | |
| | B | 1 | 9.6 | 10.8 |
| | | 2 | 9.7 | |
| | | 3 | 13.1 | |
| 44 | F | 1 | 9.3 | 8.5 |
| | | 2 | 7.6 | |
| | | 3 | 8.7 | |
| | B | 1 | 10.2 | 10.0 |
| | | 2 | 10.4 | |
| | | 3 | 9.3 | |
| 45 | F | 1 | 10.4 | 9.8 |
| | | 2 | 9.1 | |
| | | 3 | 9.8 | |
| | B | 1 | 8.7 | 7.9 |
| | | 2 | 7.3 | |
| | | 3 | 7.8 | |
| 46 | F | 1 | 12.2 | 11.9 |
| | | 2 | 11.1 | |
| | | 3 | 12.3 | |
| | B | 1 | 8.3 | 9.1 |
| | | 2 | 9.3 | |
| | | 3 | 9.8 | |

# Dry Film Thickness Measurements - Test 4

| Panel ID | Side | Spot # | Coating Spot Average (mils) | Coating Side Average (mils) |
|---|---|---|---|---|
| 47 | F | 1 | 9.0 | 9.4 |
| | | 2 | 9.7 | |
| | | 3 | 9.5 | |
| | B | 1 | 8.2 | 9.7 |
| | | 2 | 10.7 | |
| | | 3 | 10.2 | |
| 48 | F | 1 | 9.6 | 9.3 |
| | | 2 | 9.1 | |
| | | 3 | 9.3 | |
| | B | 1 | 8.1 | 8.5 |
| | | 2 | 8.5 | |
| | | 3 | 8.8 | |
| 113 | F | 1 | 7.7 | 7.3 |
| | | 2 | 7.1 | |
| | | 3 | 7.1 | |
| | B | 1 | 8.0 | 7.8 |
| | | 2 | 7.4 | |
| | | 3 | 8.0 | |
| 114 | F | 1 | 7.9 | 7.9 |
| | | 2 | 7.8 | |
| | | 3 | 8.0 | |
| | B | 1 | 7.3 | 7.9 |
| | | 2 | 8.6 | |
| | | 3 | 8.0 | |
| 115 | F | 1 | 7.2 | 7.4 |
| | | 2 | 7.6 | |
| | | 3 | 7.5 | |
| | B | 1 | 7.6 | 7.8 |
| | | 2 | 7.0 | |
| | | 3 | 8.7 | |
| 116 | F | 1 | 6.9 | 6.9 |
| | | 2 | 7.3 | |
| | | 3 | 6.5 | |
| | B | 1 | 7.2 | 7.2 |
| | | 2 | 7.1 | |
| | | 3 | 7.2 | |

## Dry Film Thickness Measurements - Test 4

| Panel ID | Side | Spot # | Coating Spot Average (mils) | Coating Side Average (mils) |
|---|---|---|---|---|
| 117 | F | 1 | 7.6 | 7.5 |
| | | 2 | 7.6 | |
| | | 3 | 7.1 | |
| | B | 1 | 6.9 | 7.0 |
| | | 2 | 7.0 | |
| | | 3 | 7.0 | |
| 118 | F | 1 | 7.5 | 7.4 |
| | | 2 | 7.4 | |
| | | 3 | 7.3 | |
| | B | 1 | 7.5 | 7.5 |
| | | 2 | 7.7 | |
| | | 3 | 7.4 | |
| 119 | F | 1 | 7.5 | 6.9 |
| | | 2 | 6.8 | |
| | | 3 | 6.4 | |
| | B | 1 | 7.1 | 7.3 |
| | | 2 | 7.0 | |
| | | 3 | 7.8 | |
| 120 | F | 1 | 6.1 | 6.3 |
| | | 2 | 6.6 | |
| | | 3 | 6.3 | |
| | B | 1 | 7.3 | 7.4 |
| | | 2 | 7.8 | |
| | | 3 | 7.2 | |
| 121 | F | 1 | 7.3 | 7.0 |
| | | 2 | 6.8 | |
| | | 3 | 6.9 | |
| | B | 1 | 7.1 | 7.1 |
| | | 2 | 7.2 | |
| | | 3 | 7.1 | |
| 122 | F | 1 | 7.6 | 7.3 |
| | | 2 | 7.5 | |
| | | 3 | 6.7 | |
| | B | 1 | 7.1 | 7.1 |
| | | 2 | 6.9 | |
| | | 3 | 7.2 | |

## Dry Film Thickness Measurements - Test 4

| Panel ID | Side | Spot # | Coating Spot Average (mils) | Coating Side Average (mils) |
|---|---|---|---|---|
| 123 | F | 1 | 7.5 | 7.1 |
| | | 2 | 6.9 | |
| | | 3 | 7.0 | |
| | B | 1 | 7.7 | 7.4 |
| | | 2 | 7.4 | |
| | | 3 | 7.1 | |
| 124 | F | 1 | 6.8 | 7.3 |
| | | 2 | 7.5 | |
| | | 3 | 7.6 | |
| | B | 1 | 7.6 | 7.8 |
| | | 2 | 7.7 | |
| | | 3 | 8.2 | |
| 125 | F | 1 | 7.2 | 7.4 |
| | | 2 | 7.4 | |
| | | 3 | 7.5 | |
| | B | 1 | 8.7 | 8.7 |
| | | 2 | 8.6 | |
| | | 3 | 8.9 | |
| 126 | F | 1 | 8.6 | 8.7 |
| | | 2 | 8.4 | |
| | | 3 | 9.1 | |
| | B | 1 | 7.3 | 7.5 |
| | | 2 | 7.7 | |
| | | 3 | 7.6 | |
| 127 | F | 1 | 6.1 | 6.1 |
| | | 2 | 6.2 | |
| | | 3 | 5.9 | |
| | B | 1 | 7.1 | 6.7 |
| | | 2 | 6.5 | |
| | | 3 | 6.5 | |
| 128 | F | 1 | 7.6 | 7.0 |
| | | 2 | 6.2 | |
| | | 3 | 7.3 | |
| | B | 1 | 5.4 | 5.7 |
| | | 2 | 5.7 | |
| | | 3 | 5.9 | |

## Dry Film Thickness Measurements - Test 5

| Panel ID | Side | Spot # | Coating Spot Average (mils) | Coating Side Average (mils) |
|---|---|---|---|---|
| 65 | F | 1 | 5.4 | 4.9 |
| | | 2 | 4.5 | |
| | | 3 | 4.8 | |
| | B | 1 | 4.8 | 4.8 |
| | | 2 | 4.9 | |
| | | 3 | 4.7 | |
| 66 | F | 1 | 4.8 | 4.9 |
| | | 2 | 4.8 | |
| | | 3 | 4.9 | |
| | B | 1 | 5.3 | 4.7 |
| | | 2 | 4.4 | |
| | | 3 | 4.5 | |
| 67 | F | 1 | 5.0 | 4.8 |
| | | 2 | 4.8 | |
| | | 3 | 4.6 | |
| | B | 1 | 4.9 | 4.7 |
| | | 2 | 4.4 | |
| | | 3 | 4.9 | |
| 68 | F | 1 | 5.1 | 4.7 |
| | | 2 | 4.8 | |
| | | 3 | 4.3 | |
| | B | 1 | 5.1 | 5.2 |
| | | 2 | 4.9 | |
| | | 3 | 5.6 | |
| 69 | F | 1 | 5.0 | 5.0 |
| | | 2 | 4.9 | |
| | | 3 | 5.1 | |
| | B | 1 | 4.8 | 4.7 |
| | | 2 | 4.5 | |
| | | 3 | 4.8 | |
| 97 | F | 1 | 9.5 | 10.2 |
| | | 2 | 11.4 | |
| | | 3 | 9.7 | |
| | B | 1 | 8.8 | 9.7 |
| | | 2 | 10.4 | |
| | | 3 | 9.8 | |

## Dry Film Thickness Measurements - Test 5

| Panel ID | Side | Spot # | Coating Spot Average (mils) | Coating Side Average (mils) |
|---|---|---|---|---|
| 98 | F | 1 | 9.1 | 9.2 |
| | | 2 | 10.7 | |
| | | 3 | 7.9 | |
| | B | 1 | 9.0 | 10.3 |
| | | 2 | 12.4 | |
| | | 3 | 9.3 | |
| 99 | F | 1 | 12.1 | 10.9 |
| | | 2 | 11.0 | |
| | | 3 | 9.7 | |
| | B | 1 | 11.8 | 10.7 |
| | | 2 | 10.2 | |
| | | 3 | 10.1 | |
| 100 | F | 1 | 7.0 | 7.9 |
| | | 2 | 9.1 | |
| | | 3 | 7.7 | |
| | B | 1 | 10.0 | 9.9 |
| | | 2 | 10.4 | |
| | | 3 | 9.3 | |
| 101 | F | 1 | 9.9 | 9.4 |
| | | 2 | 8.5 | |
| | | 3 | 9.8 | |
| | B | 1 | 10.7 | 10.3 |
| | | 2 | 10.0 | |
| | | 3 | 10.1 | |
| 102 | F | 1 | 10.0 | 9.8 |
| | | 2 | 9.8 | |
| | | 3 | 9.6 | |
| | B | 1 | 9.3 | 9.0 |
| | | 2 | 8.0 | |
| | | 3 | 9.8 | |
| 103 | F | 1 | 8.7 | 8.2 |
| | | 2 | 8.5 | |
| | | 3 | 7.5 | |
| | B | 1 | 9.3 | 9.9 |
| | | 2 | 11.3 | |
| | | 3 | 9.3 | |

## Dry Film Thickness Measurements - Test 5

| Panel ID | Side | Spot # | Coating Spot Average (mils) | Coating Side Average (mils) |
|---|---|---|---|---|
| 104 | F | 1 | 8.7 | 8.7 |
| | | 2 | 8.5 | |
| | | 3 | 8.9 | |
| | B | 1 | 9.9 | 9.5 |
| | | 2 | 8.7 | |
| | | 3 | 9.9 | |
| 105 | F | 1 | 9.9 | 9.4 |
| | | 2 | 9.5 | |
| | | 3 | 8.8 | |
| | B | 1 | 12.0 | 10.6 |
| | | 2 | 10.0 | |
| | | 3 | 9.8 | |
| 106 | F | 1 | 10.5 | 10.0 |
| | | 2 | 9.1 | |
| | | 3 | 10.4 | |
| | B | 1 | 8.1 | 9.0 |
| | | 2 | 9.1 | |
| | | 3 | 9.8 | |
| 70 | F | 1 | 5.4 | 5.4 |
| | | 2 | 5.4 | |
| | | 3 | 5.4 | |
| | B | 1 | 5.1 | 5.2 |
| | | 2 | 5.3 | |
| | | 3 | 5.1 | |
| 71 | F | 1 | 5.3 | 5.5 |
| | | 2 | 5.5 | |
| | | 3 | 5.7 | |
| | B | 1 | 5.4 | 5.5 |
| | | 2 | 5.3 | |
| | | 3 | 5.8 | |
| 72 | F | 1 | 5.5 | 5.4 |
| | | 2 | 5.1 | |
| | | 3 | 5.5 | |
| | B | 1 | 5.2 | 5.3 |
| | | 2 | 4.9 | |
| | | 3 | 5.7 | |

# Dry Film Thickness Measurements - Test 5

| Panel ID | Side | Spot # | Coating Spot Average (mils) | Coating Side Average (mils) |
|---|---|---|---|---|
| 107 | F | 1 | 9.2 | 9.1 |
| | | 2 | 8.8 | |
| | | 3 | 9.2 | |
| | B | 1 | 9.3 | 9.4 |
| | | 2 | 9.8 | |
| | | 3 | 9.2 | |
| 108 | F | 1 | 11.6 | 11.3 |
| | | 2 | 10.2 | |
| | | 3 | 12.0 | |
| | B | 1 | 9.1 | 9.0 |
| | | 2 | 8.6 | |
| | | 3 | 9.3 | |
| 109 | F | 1 | 7.5 | 8.3 |
| | | 2 | 8.9 | |
| | | 3 | 8.5 | |
| | B | 1 | 9.4 | 9.3 |
| | | 2 | 9.8 | |
| | | 3 | 8.7 | |
| 110 | F | 1 | 9.1 | 10.0 |
| | | 2 | 10.5 | |
| | | 3 | 10.3 | |
| | B | 1 | 9.6 | 9.4 |
| | | 2 | 9.8 | |
| | | 3 | 8.7 | |
| 111 | F | 1 | 9.4 | 9.6 |
| | | 2 | 10.1 | |
| | | 3 | 9.1 | |
| | B | 1 | 8.5 | 8.6 |
| | | 2 | 9.3 | |
| | | 3 | 8.1 | |
| 112 | F | 1 | 10.6 | 10.1 |
| | | 2 | 10.1 | |
| | | 3 | 9.5 | |
| | B | 1 | 10.9 | 10.1 |
| | | 2 | 9.4 | |
| | | 3 | 10.1 | |

## Dry Film Thickness Measurements - Test 6

| Panel ID | Side | Spot # | Coating Spot Average (mils) | Coating Side Average (mils) |
|---|---|---|---|---|
| 73 | F | 1 | 3.1 | 3.3 |
| | | 2 | 3.4 | |
| | | 3 | 3.6 | |
| | B | 1 | 3.4 | 3.5 |
| | | 2 | 3.7 | |
| | | 3 | 3.4 | |
| 74 | F | 1 | 3.0 | 3.0 |
| | | 2 | 3.2 | |
| | | 3 | 2.9 | |
| | B | 1 | 3.2 | 3.2 |
| | | 2 | 2.8 | |
| | | 3 | 3.8 | |
| 75 | F | 1 | 3.5 | 3.3 |
| | | 2 | 3.0 | |
| | | 3 | 3.4 | |
| | B | 1 | 2.8 | 3.0 |
| | | 2 | 3.0 | |
| | | 3 | 3.1 | |
| 76 | F | 1 | 2.9 | 3.1 |
| | | 2 | 2.9 | |
| | | 3 | 3.5 | |
| | B | 1 | 3.2 | 3.1 |
| | | 2 | 3.3 | |
| | | 3 | 2.8 | |
| 77 | F | 1 | 2.9 | 3.0 |
| | | 2 | 3.0 | |
| | | 3 | 3.2 | |
| | B | 1 | 2.7 | 2.7 |
| | | 2 | 2.6 | |
| | | 3 | 2.8 | |
| 78 | F | 1 | 3.2 | 3.6 |
| | | 2 | 3.8 | |
| | | 3 | 3.7 | |
| | B | 1 | 3.8 | 4.0 |
| | | 2 | 3.8 | |
| | | 3 | 4.4 | |

## Dry Film Thickness Measurements - Test 6

| Panel ID | Side | Spot # | Coating Spot Average (mils) | Coating Side Average (mils) |
|---|---|---|---|---|
| 79 | F | 1 | 3.9 | 4.0 |
| | | 2 | 4.0 | |
| | | 3 | 4.0 | |
| | B | 1 | 3.7 | 3.8 |
| | | 2 | 3.8 | |
| | | 3 | 4.0 | |
| 80 | F | 1 | 4.2 | 4.1 |
| | | 2 | 3.9 | |
| | | 3 | 4.3 | |
| | B | 1 | 3.8 | 3.5 |
| | | 2 | 3.4 | |
| | | 3 | 3.4 | |
| 129 | F | 1 | 7.4 | 7.4 |
| | | 2 | 7.7 | |
| | | 3 | 7.0 | |
| | B | 1 | 7.4 | 7.5 |
| | | 2 | 7.7 | |
| | | 3 | 7.5 | |
| 130 | F | 1 | 7.0 | 7.4 |
| | | 2 | 7.5 | |
| | | 3 | 7.7 | |
| | B | 1 | 7.3 | 7.4 |
| | | 2 | 7.9 | |
| | | 3 | 7.1 | |
| 131 | F | 1 | 7.4 | 7.3 |
| | | 2 | 7.0 | |
| | | 3 | 7.6 | |
| | B | 1 | 6.8 | 7.1 |
| | | 2 | 6.9 | |
| | | 3 | 7.7 | |
| 132 | F | 1 | 7.2 | 7.0 |
| | | 2 | 7.0 | |
| | | 3 | 6.7 | |
| | B | 1 | 7.5 | 7.1 |
| | | 2 | 7.1 | |
| | | 3 | 6.7 | |

## Dry Film Thickness Measurements - Test 6

| Panel ID | Side | Spot # | Coating Spot Average (mils) | Coating Side Average (mils) |
|---|---|---|---|---|
| 133 | F | 1 | 7.2 | 7.5 |
| | | 2 | 7.7 | |
| | | 3 | 7.8 | |
| | B | 1 | 8.0 | 8.1 |
| | | 2 | 8.4 | |
| | | 3 | 8.0 | |
| 134 | F | 1 | 7.3 | 7.4 |
| | | 2 | 8.1 | |
| | | 3 | 6.9 | |
| | B | 1 | 8.1 | 7.6 |
| | | 2 | 7.6 | |
| | | 3 | 7.2 | |
| 135 | F | 1 | 5.7 | 5.8 |
| | | 2 | 5.5 | |
| | | 3 | 6.2 | |
| | B | 1 | 7.4 | 6.5 |
| | | 2 | 6.4 | |
| | | 3 | 5.6 | |
| 136 | F | 1 | 5.9 | 6.0 |
| | | 2 | 6.3 | |
| | | 3 | 5.8 | |
| | B | 1 | 5.8 | 5.8 |
| | | 2 | 6.2 | |
| | | 3 | 5.6 | |
| 137 | F | 1 | 5.9 | 5.6 |
| | | 2 | 5.3 | |
| | | 3 | 5.6 | |
| | B | 1 | 6.1 | 5.9 |
| | | 2 | 6.4 | |
| | | 3 | 5.2 | |
| 138 | F | 1 | 5.7 | 5.8 |
| | | 2 | 5.7 | |
| | | 3 | 6.1 | |
| | B | 1 | 5.6 | 5.9 |
| | | 2 | 6.3 | |
| | | 3 | 5.9 | |

## Dry Film Thickness Measurements - Test 6

| Panel ID | Side | Spot # | Coating Spot Average (mils) | Coating Side Average (mils) |
|---|---|---|---|---|
| 139 | F | 1 | 5.3 | 5.4 |
| | | 2 | 5.6 | |
| | | 3 | 5.4 | |
| | B | 1 | 5.9 | 6.0 |
| | | 2 | 6.1 | |
| | | 3 | 6.0 | |
| 140 | F | 1 | 7.3 | 7.5 |
| | | 2 | 7.7 | |
| | | 3 | 7.5 | |
| | B | 1 | 5.7 | 5.8 |
| | | 2 | 5.7 | |
| | | 3 | 5.9 | |
| 141 | F | 1 | 5.8 | 5.8 |
| | | 2 | 5.8 | |
| | | 3 | 5.7 | |
| | B | 1 | 5.6 | 5.5 |
| | | 2 | 5.3 | |
| | | 3 | 5.6 | |
| 142 | F | 1 | 7.5 | 7.2 |
| | | 2 | 7.2 | |
| | | 3 | 7.0 | |
| | B | 1 | 6.3 | 6.0 |
| | | 2 | 5.7 | |
| | | 3 | 5.9 | |
| 143 | F | 1 | 6.0 | 5.8 |
| | | 2 | 5.5 | |
| | | 3 | 5.8 | |
| | B | 1 | 6.3 | 6.0 |
| | | 2 | 5.5 | |
| | | 3 | 6.2 | |
| 144 | F | 1 | 6.1 | 6.1 |
| | | 2 | 6.3 | |
| | | 3 | 6.0 | |
| | B | 1 | 5.7 | 5.5 |
| | | 2 | 5.2 | |
| | | 3 | 5.5 | |

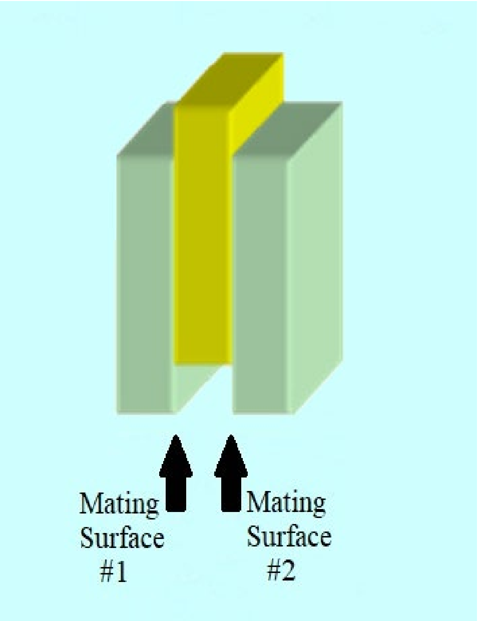
# Appendix L: Replicate Data, Study 4

## KTA Form T7095A

## Compression Slip Test Data

| | |
|---|---|
| Project No. | 393000 |
| Client | Elzly Technology |
| Coating Manufacturer | N/A |
| Coating Name | Test 1: Zinc TSC / Zinc TSC |
| Technician A | SM |
| Technician B | RTW |
| Panel Numbers | Test 1: #1-16 |

| | |
|---|---|
| Slip Testing Date | 1/8/2019 |
| Calibration (Cal Fig) Factor | 60.9 |
| Coating Application Date | N/A |
| Cure Time | N/A |
| Cure Location and Conditions | N/A |



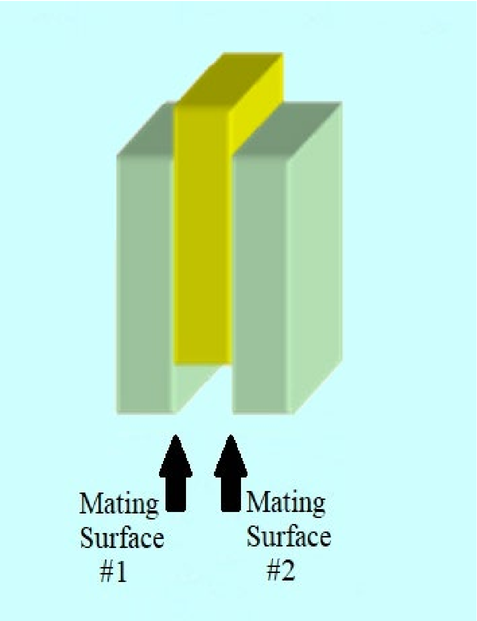
| Panel ID and Face Used | Replicate 1 | | Replicate 2 | | Replicate 3 | | Replicate 4 | | Replicate 5 | | Additional Replicate | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mating Surface #1 | 1F | 6F | 2F | 7F | 3F | 8F | 4F | 9F | 5F | 10F | | |
| DFT Mating Surface #1 (mils) | 9.6 | 9.3 | 9.1 | 9.5 | 10.1 | 10.6 | 9.2 | 10.2 | 8.8 | 9.5 | #N/A | #N/A |
| Mating Surface #2 | 6B | 11F | 7B | 12F | 8B | 13F | 9B | 14F | 10B | 15F | | |
| DFT Mating Surface #2 (mils) | 8.8 | 10.3 | 10.0 | 10.8 | 10.3 | 9.3 | 8.9 | 9.8 | 9.4 | 8.5 | #N/A | #N/A |
| | | | | | | | | | | | | |
| Start Time | 1051 | | 1113 | | 1128 | | 1142 | | 1155 | | | |
| Stop Time | 1102 | | 1122 | | 1137 | | 1150 | | 1204 | | | |
| | | | | | | | | | | | | |
| Target Clamping Force (kips) | 49.3 | | 49.3 | | 49.3 | | 49.3 | | 49.3 | | | |
| Clamping Force Deviation from Target (±, kips) | 0.2 | | 0.2 | | 0.2 | | 0.2 | | 0.2 | | | |
| | | | | | | | | | | | | |
| Y-axis value at 0.020" deformation, from the initial 1 kip applied (cm) | 17.4 | | 17.3 | | 17.3 | | 17.4 | | 17.4 | | | |
| | | | | | | | | | | | | |
| Slip load at 0.020" deformation, from the initial 1 kip applied (lb$_f$) | 69600 | | 69200 | | 69200 | | 69600 | | 69600 | | #NUM! | |
| | | | | | | | | | | | | |
| Slip Coefficient (ks) | 0.706 | | 0.702 | | 0.702 | | 0.706 | | 0.706 | | #DIV/0! | |
| | | | | | | | | | | | | |
| Post-Test Comments (fusion of surfaces, burnishing only, solvent smell, etc.): | fusion | | fusion | | fusion | | fusion | | fusion | | | |
| | | | | | | | | | | | | |
| Average Slip Coefficient: μ | 0.704 | | | | | | | | | | | |

## KTA Form T7095A

## Compression Slip Test Data

| | |
|---|---|
| Project No. | 393000 |
| Client | Elzly Technology |
| Coating Manufacturer | N/A |
| Coating Name | Test 2: Zn-Al TSC / Zn TSC |
| Technician A | SM |
| Technician B | RTW |
| Panel Numbers | Test 2: 25-29 & 81-96 |

| | |
|---|---|
| Slip Testing Date | 1/9/2020 |
| Calibration (Cal Fig) Factor | 60.90 |
| Coating Application Date | N/A |
| Cure Time | N/A |
| Cure Location and Conditions | N/A |



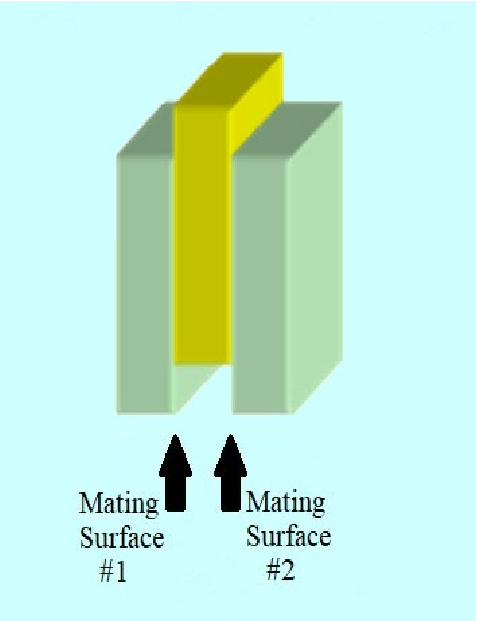
| Panel ID and Face Used | Replicate 1 | | Replicate 2 | | Replicate 3 | | Replicate 4 | | Replicate 5 | | Additional Replicate | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mating Surface #1 | 81F | 25F | 82F | 26F | 83F | 27F | 84F | 28F | 85F | 29F | | |
| DFT Mating Surface #1 (mils) | 11.2 | 9.6 | 9.6 | 8.5 | 9.5 | 9.1 | 9.3 | 8.6 | 11.2 | 8.8 | #N/A | #N/A |
| Mating Surface #2 | 25B | 86F | 26B | 87F | 27B | 88F | 28B | 89F | 29B | 90F | | |
| DFT Mating Surface #2 (mils) | 10.7 | 9.9 | 8.4 | 12.3 | 9.2 | 9.7 | 8.7 | 9.1 | 8.4 | 10.3 | #N/A | #N/A |
| Start Time | 8:45 | | 9:09 | | 9:23 | | 9:39 | | 9:51 | | | |
| Stop Time | 8:55 | | 9:19 | | 9:32 | | 9:48 | | 9:59 | | | |
| Target Clamping Force (kips) | 49.3 | | 49.3 | | 49.3 | | 49.3 | | 49.3 | | | |
| Clamping Force Deviation from Target (±, kips) | 0.2 | | 0.2 | | 0.2 | | 0.2 | | 0.2 | | | |
| Y-axis value at 0.020" deformation, from the initial 1 kip applied (cm) | 17.4 | | 17.4 | | 17.4 | | 17.4 | | 17.5 | | | |
| Slip load at 0.020" deformation, from the initial 1 kip applied (lb$_f$) | 69600 | | 69600 | | 69600 | | 69600 | | 70000 | | #NUM! | |
| Slip Coefficient (ks) | 0.706 | | 0.706 | | 0.706 | | 0.706 | | 0.710 | | #DIV/0! | |
| Post-Test Comments (fusion of surfaces, burnishing only, solvent smell, etc.): | Fused | | Fused | | Fused | | Fused | | Fused | | | |
| Average Slip Coefficient: μ | 0.707 | | | | | | | | | | | |

## KTA Form T7095A

## Compression Slip Test Data

| | |
|---|---|
| Project No. | 393000 |
| Client | Elzly Technology |
| Coating Manufacturer | N/A |
| Coating Name | Test 3: HDG / Zn TSC |
| Technician A | RTW |
| Technician B | N/A |
| Panel Numbers or Set Number | Test 3; 33-40, 49-64 |

| | |
|---|---|
| Slip Testing Date | 2/20/2020 |
| Calibration (Cal Fig) Factor | 60.90 |
| Coating Application Date | N/A |
| Cure Time | N/A |
| Cure Location and Conditions | N/A |



| Panel ID and Face Used | Replicate 1 | | Replicate 2 | | Replicate 3 | | Replicate 4 | | Replicate 5 | | Additional Replicate | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mating Surface #1 | 49F | 33F | 50F | 34F | 51F | 35F | 52F | 36F | 53F | 37F | | |
| DFT Mating Surface #1 (mils) | 5.4 | 11.4 | 5.8 | 10.7 | 5.3 | 10.7 | 5.2 | 9.1 | 5.2 | 10.1 | #N/A | #N/A |
| Mating Surface #2 | 33B | 54F | 34B | 55F | 35B | 56F | 36B | 57F | 37B | 58F | | |
| DFT Mating Surface #2 (mils) | 10.5 | 5.3 | 10.7 | 5.4 | 11.2 | 5.3 | 9.6 | 4.9 | 8.0 | 5.5 | #N/A | #N/A |

| | Replicate 1 | Replicate 2 | Replicate 3 | Replicate 4 | Replicate 5 | Additional Replicate |
|---|---|---|---|---|---|---|
| Start Time | 0905 | 0922 | 0936 | 0949 | 1024 | |
| Stop Time | 0918 | 0933 | 0945 | 0958 | 1036 | |
| Target Clamping Force (kips) | 49.3 | 49.3 | 49.3 | 49.3 | 49.3 | |
| Clamping Force Deviation from Target (±, kips) | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | |
| Y-axis value at 0.020" deformation, from the initial 1 kip applied (cm) | 17.4 | 17.3 | 16.8 | 16.9 | 15.8 | |
| Slip load at 0.020" deformation, from the initial 1 kip applied ($lb_f$) | 69600 | 69200 | 67200 | 67600 | 63200 | #NUM! |
| Slip Coefficient (ks) | 0.706 | 0.702 | 0.682 | 0.686 | 0.641 | #DIV/0! |
| Post-Test Comments (fusion of surfaces, burnishing only, solvent smell, etc.): | | | | | | |

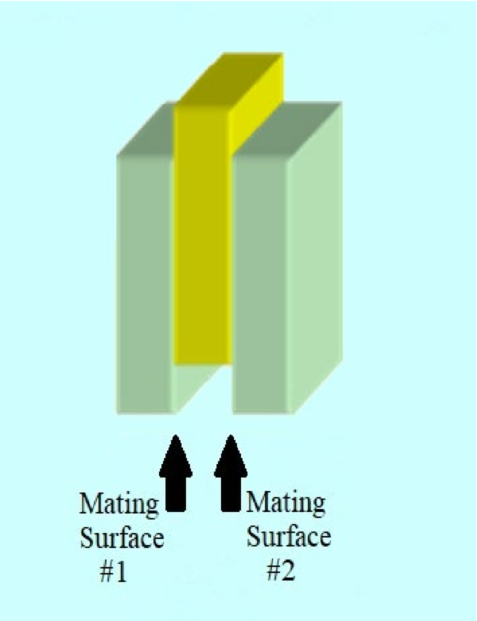
| | |
|---|---|
| Average Slip Coefficient: μ | 0.683 |

**KTA Form T7095A**

**Compression Slip Test Data**

| | |
|---|---|
| Project No. | 393000 |
| Client | Elzly Technology |
| Coating Manufacturer | Sherwin Williams |
| Coating Name | Test 4: Zinc Clad 4100 / Zinc TSC |
| Technician A | DGC |
| Technician B | CMM |
| Panel Numbers or Set Number | Test 4: 41-48, 113-128 |

| | |
|---|---|
| Slip Testing Date | 3/16/2020 |
| Calibration (Cal Fig) Factor | 60.9 |
| Coating Application Date | 3/13/2020 |
| Cure Time | 72 Hours |
| Cure Location and Conditions | Norlake 25°C and 65% RH |



| Panel ID and Face Used | Replicate 1 | | Replicate 2 | | Replicate 3 | | Replicate 4 | | Replicate 5 | | Additional Replicate | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mating Surface #1 | 113F | 41F | 115F | 42F | 117B | 43F | 119F | 44F | 121F | 45F | | |
| DFT Mating Surface #1 (mils) | 7.3 | 9.6 | 7.4 | 10.4 | 7.0 | 10.1 | 6.9 | 8.5 | 7.0 | 9.8 | #N/A | #N/A |
| Mating Surface #2 | 41B | 114F | 42B | 116B | 43B | 118F | 44B | 120B | 45B | 122B | | |
| DFT Mating Surface #2 (mils) | 10.1 | 7.9 | 9.1 | 7.2 | 10.8 | 7.4 | 10.0 | 7.4 | 7.9 | 7.1 | #N/A | #N/A |
| Start Time | 1040 | | 1059 | | 1113 | | 1128 | | 1148 | | | |
| Stop Time | 1053 | | 1107 | | 1123 | | 1141 | | 1159 | | | |
| Target Clamping Force (kips) | 49.3 | | 49.3 | | 49.3 | | 49.3 | | 49.3 | | | |
| Clamping Force Deviation from Target (±, kips) | 0.2 | | 0.2 | | 0.2 | | 0.2 | | 0.2 | | | |
| Y-axis value at 0.020" deformation, from the initial 1 kip applied (cm) | 15.0 | | 14.9 | | 15.1 | | 15.1 | | 15.1 | | | |
| Slip load at 0.020" deformation, from the initial 1 kip applied (lb$_f$) | 60000 | | 59600 | | 60400 | | 60400 | | 60400 | | #NUM! | |
| Slip Coefficient (ks) | 0.609 | | 0.604 | | 0.613 | | 0.613 | | 0.613 | | #DIV/0! | |
| Post-Test Comments (fusion of surfaces, burnishing only, solvent smell, etc.): | fusion | | fusion | | fusion | | fusion | | fusion | | | |

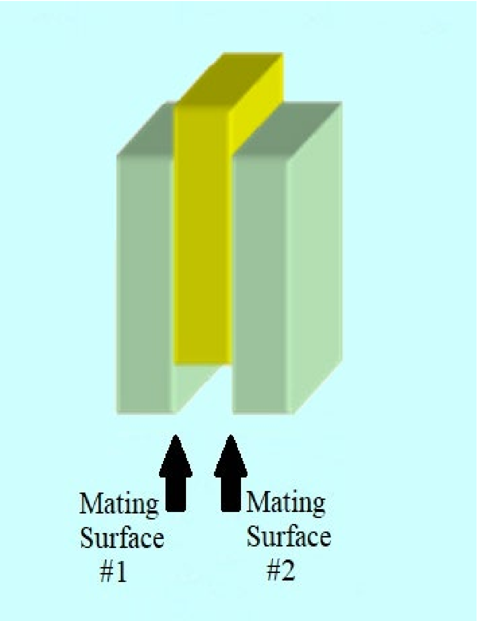
| | |
|---|---|
| Average Slip Coefficient: μ | 0.610 |

**KTA Form T7095A**

**Compression Slip Test Data**

| | |
|---|---|
| Project No. | 393000 |
| Client | Elzly Technology |
| Coating Manufacturer | N/A |
| Coating Name | Test 5: Zn-Al TSC / HDG |
| Technician A | SM |
| Technician B | CK |
| Panel Numbers or Set Number | Test 5; #65-72, 97-107 |

| | |
|---|---|
| Slip Testing Date | 2/21/2020 |
| Calibration (Cal Fig) Factor | 60.90 |
| Coating Application Date | N/A |
| Cure Time | N/A |
| Cure Location and Conditions | N/A |



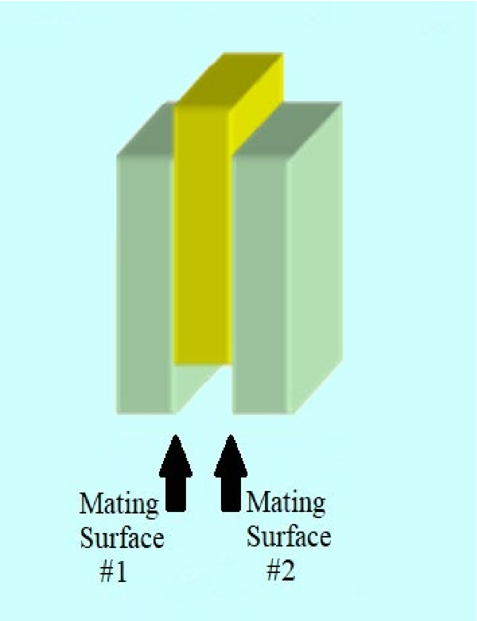
| Panel ID and Face Used | Replicate 1 | | Replicate 2 | | Replicate 3 | | Replicate 4 | | Replicate 5 | | Additional Replicate | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mating Surface #1 | 97F | 65F | 98F | 66F | 99F | 67F | 100F | 68F | 101F | 69F | | |
| DFT Mating Surface #1 (mils) | 10.2 | 4.9 | 9.2 | 4.9 | 10.9 | 4.8 | 7.9 | 4.7 | 9.4 | 5.0 | #N/A | #N/A |
| Mating Surface #2 | 65B | 102F | 66B | 103F | 67B | 104F | 68B | 105F | 69B | 106F | | |
| DFT Mating Surface #2 (mils) | 4.8 | 9.8 | 4.7 | 8.2 | 4.7 | 8.7 | 5.2 | 9.4 | 4.7 | 10.0 | #N/A | #N/A |
| Start Time | 0813 | | 0832 | | 0852 | | 0912 | | 0934 | | | |
| Stop Time | 0825 | | 0843 | | 0903 | | 0923 | | 0943 | | | |
| Target Clamping Force (kips) | 49.3 | | 49.3 | | 49.3 | | 49.3 | | 49.3 | | | |
| Clamping Force Deviation from Target (±, kips) | 0.2 | | 0.2 | | 0.2 | | 0.2 | | 0.2 | | | |
| Y-axis value at 0.020" deformation, from the initial 1 kip applied (cm) | 16.9 | | 17.1 | | 16.9 | | 16.8 | | 17.3 | | | |
| Slip load at 0.020" deformation, from the initial 1 kip applied (lb$_f$) | 67600 | | 68400 | | 67600 | | 67200 | | 69200 | | #NUM! | |
| Slip Coefficient (ks) | 0.686 | | 0.694 | | 0.686 | | 0.682 | | 0.702 | | #DIV/0! | |
| Post-Test Comments (fusion of surfaces, burnishing only, solvent smell, etc.): | | | | | | | | | | | | |
| Average Slip Coefficient: µ | 0.690 | | | | | | | | | | | |

## KTA Form T7095A

## Compression Slip Test Data

| | |
|---|---|
| Project No. | 393000 |
| Client | Elzly Technology |
| Coating Manufacturer | Sherwin Williams |
| Coating Name | Test 6: Zinc Clad 4100 / HDG |
| Technician A | DGC |
| Technician B | CMM |
| Panel Numbers or Set Number | Test 6: 73-80, 129-144 |

| | |
|---|---|
| Slip Testing Date | 3/16/2020 |
| Calibration (Cal Fig) Factor | 60.9 |
| Coating Application Date | 3/13/2020 |
| Cure Time | 72 Hours |
| Cure Location and Conditions | Norlake 25°C and 65% RH |

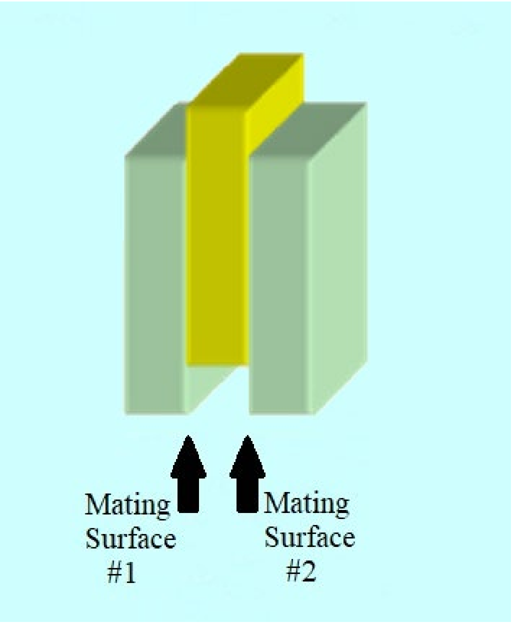


| Panel ID and Face Used | Replicate 1 | | Replicate 2 | | Replicate 3 | | Replicate 4 | | Replicate 5 | | Additional Replicate | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mating Surface #1 | 129F | 73F | 131B | 74F | 133F | 75F | 135B | 76F | 137B | 77F | | |
| DFT Mating Surface #1 (mils) | 7.4 | 3.3 | 7.1 | 3.0 | 7.5 | 3.3 | 6.5 | 3.1 | 5.9 | 3.0 | #N/A | #N/A |
| Mating Surface #2 | 73B | 130F | 74B | 132B | 75B | 134F | 76B | 136F | 77B | 138B | | |
| DFT Mating Surface #2 (mils) | 3.5 | 7.4 | 3.2 | 7.1 | 3.0 | 7.4 | 3.1 | 6.0 | 2.7 | 5.9 | #N/A | #N/A |
| Start Time | 1210 | | 1224 | | NR | | NR | | 1306 | | | |
| Stop Time | 1217 | | 1233 | | NR | | 1256 | | 1317 | | | |
| Target Clamping Force (kips) | 49.3 | | 49.3 | | 49.3 | | 49.3 | | 49.3 | | | |
| Clamping Force Deviation from Target (±, kips) | 0.2 | | 0.2 | | 0.2 | | 0.2 | | 0.2 | | | |
| Y-axis value at 0.020" deformation, from the initial 1 kip applied (cm) | 9.7 | | 12.3 | | 12.3 | | 9.1 | | 10.7 | | | |
| Slip load at 0.020" deformation, from the initial 1 kip applied ($\text{lb}_f$) | 39000 | | 49200 | | 49200 | | 36000 | | 42800 | | #NUM! | |
| Slip Coefficient (ks) | 0.39 | | 0.499 | | 0.499 | | 0.37 | | 0.434 | | #DIV/0! | |
| Post-Test Comments (fusion of surfaces, burnishing only, solvent smell, etc.): | fusion | | fusion | | fusion | | fusion | | fusion | | | |
| Average Slip Coefficient: μ | 0.44 | | | | | | | | | | | |

## KTA Form T7095B

## Tension Creep Test Data

| | |
|---|---|
| Project No. | 393000 |
| Client | Elzly Technology |
| Coating Manufacturer | N/A |
| Coating Name | Test 1: Zinc TSC / Zinc TSC |
| Technician A | SM |
| Technician B | RTW |
| Panel Numbers or Set Number | Test 1: 16-24 |



| | |
|---|---|
| Slip Testing Date | 1/8/2020 |
| Calibration (Cal Fig) Factor | 60.9 |
| Coating Application Date | N/A |
| Cure Time | N/A |
| Cure Location and Conditions | N/A |

| | | | | | |
|---|---|---|---|---|---|
| Test Start Date and Time | 1/8/2020 | Test End Date and Time | 2/19/2020 | Yoke Location | 3 |
| Slip Coefficient Category | B | Initial Applied Load (kips) | 34.7 | | |

| Bolt Calibration | | Clamping Force (*lbs.* ) | | | |
|---|---|---|---|---|---|
| | | Bolt #1 | Bolt #2 | Bolt #3 | Average |
| Bolt Lot No. | 792435 | 51,000 | 52,000 | 52,000 | 52,000 |

| Pane ID and Face Used | Replicate 1 | | Replicate 2 | | Replicate 3 | |
|---|---|---|---|---|---|---|
| Mating Surface #1 | 16F | 19F | 17F | 20F | 18F | 21F |
| DFT Mating Surface #1 (mils) | 13.2 | 14.4 | 10.9 | 10.9 | 11.6 | 11.6 |
| Mating Surface #2 | 19B | 22F | 20B | 23F | 21B | 24F |
| DFT Mating Surface #2 (mils) | 10.3 | 11.6 | 11.4 | 11.0 | 12.5 | 10.8 |

| Dial Micrometer Serial No. | 040073827 | 040073824 | 040073825 |
|---|---|---|---|
| Date | Micrometer Values (*inches* )* | | |
| 1/8/2020 | 0.0000 | 0.0000 | 0.0000 |
| 1/9/2020 | 0.0040 | 0.0029 | 0.0002 |
| 1/10/2020 | 0.0043 | 0.0031 | 0.0004 |
| 1/13/2020 | 0.0046 | 0.0034 | 0.0006 |
| 1/14/2020 | 0.0047 | 0.0034 | 0.0007 |
| 1/15/2020 | 0.0047 | 0.0034 | 0.0007 |
| 1/16/2020 | 0.0048 | 0.0035 | 0.0007 |
| 1/17/2020 | 0.0048 | 0.0035 | 0.0007 |
| 1/20/2020 | 0.0049 | 0.0036 | 0.0007 |
| 1/21/2020 | 0.0049 | 0.0036 | 0.0008 |
| 1/22/2020 | 0.0050 | 0.0036 | 0.0008 |

| Date | Micrometer Readings - Visual (*inches*) | | |
|---|---|---|---|
| | Replicate 1 | Replicate 2 | Replicate 3 |
| 1/23/2020 | 0.0050 | 0.0036 | 0.0008 |
| 1/24/2020 | 0.0050 | 0.0036 | 0.0008 |
| 1/27/2020 | 0.0050 | 0.0036 | 0.0009 |
| 1/28/2020 | 0.0050 | 0.0036 | 0.0009 |
| 1/29/2020 | 0.0050 | 0.0037 | 0.0009 |
| 1/30/2020 | 0.0051 | 0.0037 | 0.0009 |
| 1/31/2020 | 0.0051 | 0.0037 | 0.0010 |
| 2/3/2020 | 0.0051 | 0.0037 | 0.0010 |
| 2/4/2020 | 0.0051 | 0.0037 | 0.0010 |
| 2/5/2020 | 0.0052 | 0.0037 | 0.0010 |
| 2/6/2020 | 0.0052 | 0.0037 | 0.0010 |
| 2/7/2020 | 0.0052 | 0.0037 | 0.0010 |
| 2/10/2020 | 0.0052 | 0.0037 | 0.0010 |
| 2/11/2020 | 0.0052 | 0.0037 | 0.0010 |
| 2/12/2020 | 0.0052 | 0.0037 | 0.0010 |
| 2/13/2020 | 0.0052 | 0.0037 | 0.0010 |
| 2/14/2020 | 0.0052 | 0.0037 | 0.0010 |
| 2/17/2020 | 0.0052 | 0.0037 | 0.0010 |
| 2/18/2020 | 0.0052 | 0.0037 | 0.0010 |
| 2/19/2020 | 0.0052 | 0.0038 | 0.0010 |
| Final Load Applied (Post-Loading): | 52.0 kips | Final Load Calibration (Cal Fig) Factor: | 59.92 |
| Post-Load Deformation Measurements, inches | 0.0062 | 0.0049 | 0.0015 |
| Average Deformation (Post Load), inches | 0.0042 | | |
| Middle plate displacement with respect to drawn line: | Confirm | Confirm | Confirm |

* Micrometer display will decrease as deformation occurs; Record the distance of deformation (positive is read as the dial moves in the counter-clockwise direction, negative is read as the dial moves in the clockwise direction)

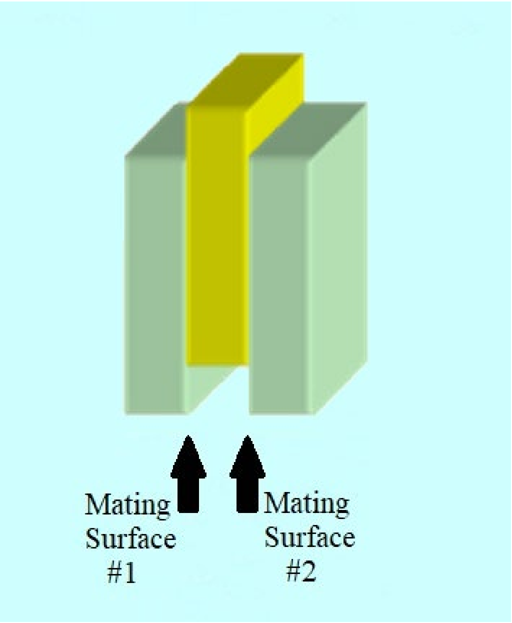
Comments

None

## KTA Form T7095B

## Tension Creep Test Data

| | |
|---|---|
| Project No. | 393000 |
| Client | Elzly Technology |
| Coating Manufacturer | NA |
| Interface | Test 2: Zn-Al TSC / Zn TSC |
| Technician A | SM |
| Technician B | RTW |
| Panel Numbers or Set Number | Set 2: 29-32 & 91-96 |



| | |
|---|---|
| Slip Testing Date | 1/9/2019 |
| Calibration (Cal Fig) Factor | 59.92 |
| Coating Application Date | NA |
| Cure Time | NA |
| Cure Location and Conditions | NA |

| | | | | | |
|---|---|---|---|---|---|
| Test Start Date and Time | 1/9/2020 | Test End Date and Time | 2/20/2020 | Yoke Location | 2 |
| Slip Coefficient Category | B | Initial Applied Load (kips) | 34.7 | | |

| | | Clamping Force (*lbs.*) | | | |
|---|---|---|---|---|---|
| Bolt Calibration | | Bolt #1 | Bolt #2 | Bolt #3 | Average |
| Bolt Lot No. | 792435 | 51,000 | 52,000 | 52,000 | 52,000 |

| Pane ID and Face Used | Replicate 1 | | Replicate 2 | | Replicate 3 | |
|---|---|---|---|---|---|---|
| Mating Surface #1 | 91F | 30F | 92F | 31F | 93F | 32F |
| DFT Mating Surface #1 (mils) | 10.8 | 9.9 | 12.3 | 9.8 | 8.9 | 10.0 |
| Mating Surface #2 | 30B | 94F | 31B | 95F | 32B | 96F |
| DFT Mating Surface #2 (mils) | 9.5 | 8.7 | 8.6 | 9.2 | 10.1 | 10.0 |
| Dial Micrometer Serial No. | 040073819 | | 040073818 | | 040073823 | |

| Date | Micrometer Values (*inches*)* | | |
|---|---|---|---|
| 1/9/2020 | 0.0000 | 0.0000 | 0.0000 |
| 1/10/2020 | 0.0003 | 0.0026 | 0.0016 |
| 1/13/2020 | 0.0003 | 0.0031 | 0.0020 |
| 1/14/2020 | 0.0003 | 0.0031 | 0.0020 |
| 1/15/2020 | 0.0003 | 0.0031 | 0.0020 |
| 1/16/2020 | 0.0003 | 0.0031 | 0.0020 |
| 1/17/2020 | 0.0004 | 0.0031 | 0.0020 |
| 1/20/2020 | 0.0010 | 0.0031 | 0.0020 |
| 1/21/2020 | 0.0010 | 0.0031 | 0.0020 |
| 1/22/2020 | 0.0010 | 0.0031 | 0.0020 |
| 1/23/2020 | 0.0010 | 0.0031 | 0.0020 |

| Date | Micrometer Readings - Visual (*inches*) | | |
|---|---|---|---|
| | Replicate 1 | Replicate 2 | Replicate 3 |
| 1/24/2020 | 0.0010 | 0.0031 | 0.0020 |
| 1/27/2020 | 0.0010 | 0.0031 | 0.0020 |
| 1/28/2020 | 0.0010 | 0.0031 | 0.0020 |
| 1/29/2020 | 0.0010 | 0.0031 | 0.0020 |
| 1/30/2020 | 0.0010 | 0.0031 | 0.0020 |
| 1/31/2020 | 0.0010 | 0.0031 | 0.0020 |
| 2/3/2020 | 0.0010 | 0.0031 | 0.0020 |
| 2/4/2020 | 0.0010 | 0.0031 | 0.0020 |
| 2/5/2020 | 0.0010 | 0.0031 | 0.0020 |
| 2/6/2020 | 0.0010 | 0.0031 | 0.0020 |
| 2/7/2020 | 0.0010 | 0.0031 | 0.0020 |
| 2/10/2020 | 0.0010 | 0.0031 | 0.0020 |
| 2/11/2020 | 0.0010 | 0.0031 | 0.0020 |
| 2/12/2020 | 0.0010 | 0.0031 | 0.0020 |
| 2/13/2020 | 0.0010 | 0.0031 | 0.0020 |
| 2/14/2020 | 0.0010 | 0.0031 | 0.0020 |
| 2/17/2020 | 0.0010 | 0.0031 | 0.0020 |
| 2/18/2020 | 0.0010 | 0.0031 | 0.0020 |
| 2/19/2020 | 0.0010 | 0.0031 | 0.0020 |
| 2/20/2020 | 0.0010 | 0.0031 | 0.0020 |
| Final Load Applied (Post-Loading): | 52.0 kips | Final Load Calibration (Cal Fig) Factor: | 59.92 |
| Post-Load Deformation Measurements, inches | 0.0010 | 0.0031 | 0.0020 |
| Average Deformation (Post Load), inches | 0.0020 | | |
| Middle plate displacement with respect to drawn line: | Confirm | Confirm | Confirm |

* Micrometer display will decrease as deformation occurs; Record the distance of deformation (positive is read as the dial moves in the counter-clockwise direction, negative is read as the dial moves in the clockwise direction)

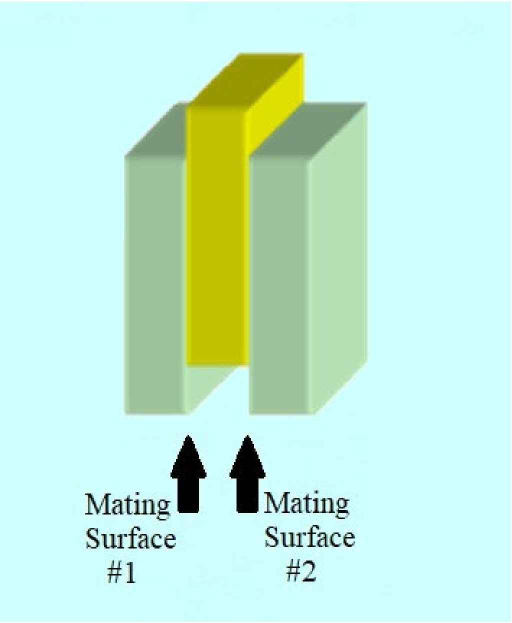
Comments

None

## KTA Form T7095B

## Tension Creep Test Data

| | |
|---|---|
| Project No. | 393000 |
| Client | Elzly Technology |
| Coating Manufacturer | N/A |
| Coating Name | Test 3: HDG / Zn TSC |
| Technician A | SM |
| Technician B | RTW |
| Panel Numbers or Set Number | Test 3: 33-40, 49-64 |



| | |
|---|---|
| Slip Testing Date | 2/20/2020 |
| Calibration (Cal Fig) Factor | 59.92 |
| Coating Application Date | N/A |
| Cure Time | N/A |
| Cure Location and Conditions | N/A |

| | | | | | |
|---|---|---|---|---|---|
| Test Start Date and Time | 2/20/20 | Test End Date and Time | 4/2/20 | Yoke Location | 2 |
| Slip Coefficient Category | B | Initial Applied Load (kips) | 34.7 | | |

| | | Clamping Force (*lbs.*) | | | |
|---|---|---|---|---|---|
| Bolt Calibration | | Bolt #1 | Bolt #2 | Bolt #3 | Average |
| Bolt Lot No. | 792435 | 51000 | 52000 | 52000 | 52000 |

| Pane ID and Face Used | Replicate 1 | | Replicate 2 | | Replicate 3 | |
|---|---|---|---|---|---|---|
| Mating Surface #1 | 59F | 38F | 60F | 39F | 61F | 40F |
| DFT Mating Surface #1 (mils) | 5.9 | 9.7 | 6.4 | 8.9 | 6.5 | 9.5 |
| Mating Surface #2 | 38B | 62F | 39B | 63F | 40B | 64F |
| DFT Mating Surface #2 (mils) | 9.5 | 6.1 | 10.0 | 6.1 | 9.3 | 6.3 |
| Dial Micrometer Serial No. | 040073819 | | 040073818 | | 040073823 | |

| Date | Micrometer Values (*inches*)* | | |
|---|---|---|---|
| 2/20/2020 | 0.0000 | 0.0000 | 0.0000 |
| 2/21/2020 | 0.0017 | 0.0026 | 0.0038 |
| 2/24/2020 | 0.0023 | 0.0031 | 0.0047 |
| 2/25/2020 | 0.0024 | 0.0032 | 0.0049 |
| 2/26/2020 | 0.0024 | 0.0032 | 0.0050 |
| 2/27/2020 | 0.0025 | 0.0033 | 0.0050 |
| 2/28/2020 | 0.0025 | 0.0034 | 0.0051 |
| 3/2/2020 | 0.0026 | 0.0034 | 0.0052 |
| 3/3/2020 | 0.0026 | 0.0034 | 0.0053 |
| 3/4/2020 | 0.0027 | 0.0034 | 0.0053 |
| 3/5/2020 | 0.0027 | 0.0034 | 0.0053 |

| Date | Micrometer Readings - Visual (*inches*) | | |
|---|---|---|---|
| | Replicate 1 | Replicate 2 | Replicate 3 |
| 3/6/2020 | 0.0027 | 0.0034 | 0.0054 |
| 3/9/2020 | 0.0028 | 0.0035 | 0.0055 |
| 3/10/2020 | 0.0028 | 0.0035 | 0.0055 |
| 3/11/2020 | 0.0028 | 0.0035 | 0.0056 |
| 3/12/2020 | 0.0028 | 0.0035 | 0.0056 |
| 3/13/2020 | 0.0029 | 0.0035 | 0.0056 |
| 3/16/2020 | 0.0029 | 0.0035 | 0.0056 |
| 3/17/2020 | 0.0029 | 0.0035 | 0.0056 |
| 3/18/2020 | 0.0029 | 0.0035 | 0.0057 |
| 3/19/2020 | 0.0029 | 0.0036 | 0.0057 |
| 3/20/2020 | 0.0030 | 0.0036 | 0.0058 |
| 3/23/2020 | 0.0029 | 0.0036 | 0.0058 |
| 3/24/2020 | 0.0029 | 0.0036 | 0.0058 |
| 3/25/2020 | 0.0029 | 0.0036 | 0.0058 |
| 3/26/2020 | 0.0029 | 0.0036 | 0.0058 |
| 3/27/2020 | 0.0029 | 0.0036 | 0.0058 |
| 3/30/2020 | 0.0030 | 0.0036 | 0.0058 |
| 3/31/2020 | 0.0030 | 0.0036 | 0.0058 |
| 4/1/2020 | 0.0030 | 0.0036 | 0.0058 |
| 4/2/2020 | 0.0029 | 0.0036 | 0.0058 |
| Final Load Applied (Post-Loading): | 52.0 kips | Final Load Calibration (Cal Fig) Factor: | 59.92 |
| Post-Load Deformation Measurements, inches | 0.0033 | 0.0039 | 0.0081 |
| Average Deformation (Post Load), inches | 0.0051 | | |
| Middle plate displacement with respect to drawn line: | Confirmed | Confirmed | Confirmed |

* Micrometer display will decrease as deformation occurs; Record the distance of deformation (positive is read as the dial moves in the counter-clockwise direction,

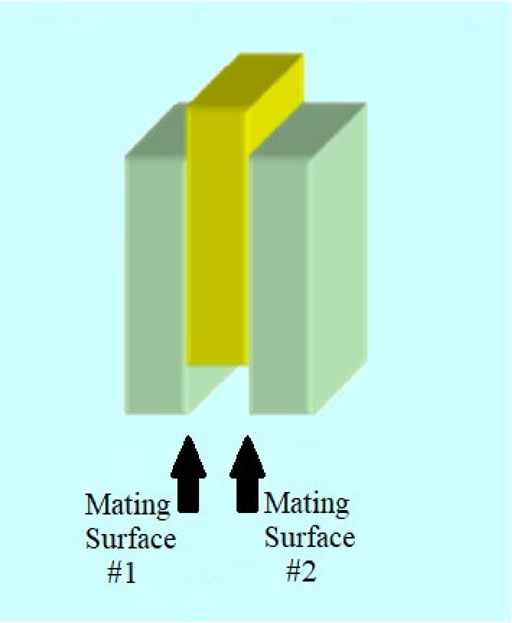
Creep chain was initially post loaded to the Class A slip coefficient category (31.2 kips) instead of Class B (52.0 kips) on 4/2/20. Chain was placed back under tension and allowed to stabilize for several weeks at the specified initial tension. Post-loading was then performed, and the difference in deformation was added to the deformation exhibited prior to the incorrect post-load tension.

**KTA Form T7095B**

**Tension Creep Test Data**

| | |
|---|---|
| Project No. | 393000 |
| Client | Elzly Technology |
| Coating Manufacturer | Sherwin-Williams |
| Coating Name | Test 4: Zinc Clad 4100 / Zinc TSC |
| Technician A | DGC |
| Technician B | RTW |
| Panel Numbers or Set Number | Test 4: 41-48, 113-128 |

| | |
|---|---|
| Slip Testing Date | 3/16/2020 |
| Calibration (Cal Fig) Factor | 59.92 |
| Coating Application Date | 3/13/2020 |
| Cure Time | 72 Hours |
| Cure Location and Conditions | Norlake 25°C and 65% RH |



| | | | | | |
|---|---|---|---|---|---|
| Test Start Date and Time | 3/16/2020 1330 | Test End Date and Time | 4/27/2020 0:00 | Yoke Location | 4 |
| Slip Coefficient Category | B | Initial Applied Load (kips) | 34.7 | | |

| | | Clamping Force (*lbs.* ) | | | |
|---|---|---|---|---|---|
| Bolt Calibration | | Bolt #1 | Bolt #2 | Bolt #3 | Average |
| Bolt Lot No. | 792435 | 51000 | 52000 | 52000 | 52000 |

| Pane ID and Face Used | Replicate 1 | | Replicate 2 | | Replicate 3 | |
|---|---|---|---|---|---|---|
| Mating Surface #1 | 123F | 46F | 125F | 47F | 127B | 48F |
| DFT Mating Surface #1 (mils) | 7.1 | 11.9 | 7.4 | 9.4 | 6.7 | 9.3 |
| Mating Surface #2 | 46B | 124F | 47B | 126B | 48B | 128F |
| DFT Mating Surface #2 (mils) | 9.1 | 7.3 | 9.7 | 7.5 | 8.5 | 7.0 |
| Dial Micrometer Serial No. | 040073821 | | 170255714 | | 162535771 | |

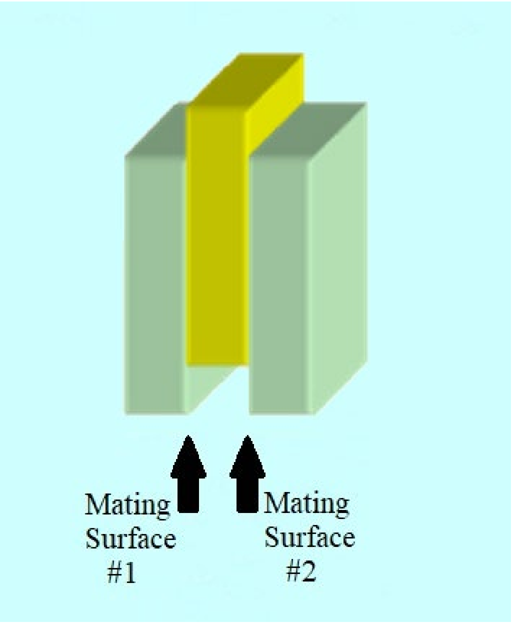
| Date | Micrometer Values (*inches* )* | | |
|---|---|---|---|
| 3/16/2020 | 0.0000 | 0.0000 | 0.0000 |
| 3/16/2020 | 0.0011 | 0.0015 | 0.0011 |
| 3/17/2020 | 0.0023 | 0.0030 | 0.0023 |
| 3/18/2020 | 0.0026 | 0.0034 | 0.0026 |
| 3/19/2020 | 0.0029 | 0.0037 | 0.0029 |
| 3/20/2020 | 0.0030 | 0.0039 | 0.0030 |
| 3/23/2020 | 0.0030 | 0.0040 | 0.0031 |
| 3/24/2020 | 0.0031 | 0.0041 | 0.0031 |
| 3/25/2020 | 0.0031 | 0.0041 | 0.0032 |
| 3/26/2020 | 0.0031 | 0.0041 | 0.0032 |
| 3/27/2020 | 0.0032 | 0.0042 | 0.0032 |

| Date | Micrometer Readings - Visual (*inches*) | | |
|---|---|---|---|
| | Replicate 1 | Replicate 2 | Replicate 3 |
| 3/30/2020 | 0.0032 | 0.0044 | 0.0034 |
| 3/31/2020 | 0.0032 | 0.0043 | 0.0035 |
| 4/1/2020 | 0.0032 | 0.0043 | 0.0034 |
| 4/2/2020 | 0.0032 | 0.0044 | 0.0034 |
| 4/3/2020 | 0.0032 | 0.0044 | 0.0034 |
| 4/6/2020 | 0.0033 | 0.0044 | 0.0035 |
| 4/7/2020 | 0.0033 | 0.0045 | 0.0035 |
| 4/8/2020 | 0.0033 | 0.0045 | 0.0035 |
| 4/9/2020 | 0.0034 | 0.0045 | 0.0035 |
| 4/10/2020 | 0.0034 | 0.0046 | 0.0036 |
| 4/13/2020 | 0.0034 | 0.0046 | 0.0036 |
| 4/14/2020 | 0.0034 | 0.0046 | 0.0036 |
| 4/15/2020 | 0.0034 | 0.0046 | 0.0036 |
| 4/16/2020 | 0.0034 | 0.0046 | 0.0036 |
| 4/17/2020 | 0.0034 | 0.0046 | 0.0036 |
| 4/20/2020 | 0.0034 | 0.0046 | 0.0036 |
| 4/21/2020 | 0.0034 | 0.0046 | 0.0036 |
| 4/22/2020 | 0.0034 | 0.0046 | 0.0036 |
| 4/23/2020 | 0.0034 | 0.0046 | 0.0036 |
| 4/24/2020 | 0.0034 | 0.0046 | 0.0036 |
| 4/27/2020 | 0.0034 | 0.0046 | 0.0036 |
| Final Load Applied (Post-Loading): | 52.0 kips | Final Load Calibration (Cal Fig) Factor: | 59.92 |
| Post-Load Deformation Measurements, inches | 0.0043 | 0.0055 | 0.0044 |
| Average Deformation (Post Load), inches | 0.0047 | | |
| Middle plate displacement with respect to drawn line: | confirm | confirm | confirm |
| * Micrometer display will decrease as deformation occurs; Record the distance of deformation (positive is read as the dial moves in the counter-clockwise direction, negative is read as the dial moves in the clockwise direction) | | | |
| Comments | | | |
| None | | | |

## KTA Form T7095B

## Tension Creep Test Data

| | |
|---|---|
| Project No. | 393000 |
| Client | Elzly Technology |
| Coating Manufacturer | N/A |
| Coating Name | Test 5: Zn-Al TSC / HDG |
| Technician A | SM |
| Technician B | RTW |
| Panel Numbers or Set Number | Test 5; #65-72, 97-107 |



| | |
|---|---|
| Slip Testing Date | 2/21/2020 |
| Calibration (Cal Fig) Factor | 59.92 |
| Coating Application Date | N/A |
| Cure Time | N/A |
| Cure Location and Conditions | N/A |

| | | | | | |
|---|---|---|---|---|---|
| Test Start Date and Time | 2/21/2020 | Test End Date and Time | 4/3/2020 | Yoke Location | 2 |
| Slip Coefficient Category | B | Initial Applied Load (kips) | 34.7 | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | Clamping Force (*lbs.*) | | | |
| Bolt Calibration | | | Bolt #1 | Bolt #2 | Bolt #3 | Average |
| Bolt Lot No. | 792435 | | 51000 | 52000 | 52000 | 52000 |

| Pane ID and Face Used | Replicate 1 | | Replicate 2 | | Replicate 3 | |
|---|---|---|---|---|---|---|
| Mating Surface #1 | 107F | 70F | 108F | 71F | 109F | 72F |
| DFT Mating Surface #1 (mils) | 9.1 | 5.4 | 11.3 | 5.5 | 8.3 | 5.4 |
| Mating Surface #2 | 70B | 110F | 71B | 111F | 72B | 112F |
| DFT Mating Surface #2 (mils) | 5.2 | 10.0 | 5.5 | 9.6 | 5.3 | 10.1 |
| Dial Micrometer Serial No. | 040073825 | | 040073824 | | 040073827 | |

| Date | Micrometer Values (*inches*)* | | |
|---|---|---|---|
| 2/21/2020 | 0.0000 | 0.0000 | 0.0000 |
| 2/24/2020 | 0.0018 | 0.0006 | 0.0014 |
| 2/25/2020 | 0.0018 | 0.0006 | 0.0015 |
| 2/26/2020 | 0.0018 | 0.0007 | 0.0015 |
| 2/27/2020 | 0.0019 | 0.0007 | 0.0015 |
| 2/28/2020 | 0.0019 | 0.0007 | 0.0015 |
| 3/2/2020 | 0.0020 | 0.0008 | 0.0016 |
| 3/3/2020 | 0.0020 | 0.0008 | 0.0016 |
| 3/4/2020 | 0.0021 | 0.0009 | 0.0017 |
| 3/5/2020 | 0.0021 | 0.0009 | 0.0017 |
| 3/6/2020 | 0.0021 | 0.0009 | 0.0017 |

| Date | Micrometer Readings - Visual (*inches*) | | |
|---|---|---|---|
| | Replicate 1 | Replicate 2 | Replicate 3 |
| 3/9/2020 | 0.0020 | 0.0010 | 0.0018 |
| 3/10/2020 | 0.0020 | 0.0010 | 0.0018 |
| 3/11/2020 | 0.0020 | 0.0010 | 0.0018 |
| 3/12/2020 | 0.0020 | 0.0010 | 0.0018 |
| 3/13/2020 | 0.0020 | 0.0010 | 0.0018 |
| 3/16/2020 | 0.0020 | 0.0010 | 0.0018 |
| 3/17/2020 | 0.0020 | 0.0010 | 0.0018 |
| 3/18/2020 | 0.0020 | 0.0010 | 0.0018 |
| 3/19/2020 | 0.0021 | 0.0010 | 0.0019 |
| 3/20/2020 | 0.0021 | 0.0011 | 0.0019 |
| 3/23/2020 | 0.0021 | 0.0010 | 0.0018 |
| 3/24/2020 | 0.0021 | 0.0010 | 0.0018 |
| 3/25/2020 | 0.0021 | 0.0010 | 0.0019 |
| 3/26/2020 | 0.0021 | 0.0010 | 0.0019 |
| 3/27/2020 | 0.0021 | 0.0011 | 0.0019 |
| 3/30/2020 | 0.0021 | 0.0011 | 0.0019 |
| 3/31/2020 | 0.0021 | 0.0011 | 0.0019 |
| 4/1/2020 | 0.0021 | 0.0011 | 0.0019 |
| 4/2/2020 | 0.0021 | 0.0011 | 0.0019 |
| 4/3/2020 | 0.0021 | 0.0011 | 0.0019 |
| Final Load Applied (Post-Loading): | 52.0 kips | Final Load Calibration (Cal Fig) Factor: | 59.92 |
| Post-Load Deformation Measurements, inches | 0.0032 | 0.0016 | 0.0022 |
| Average Deformation (Post Load), inches | 0.0023 | | |
| Middle plate displacement with respect to drawn line: | confirmed | confirmed | confirmed |

* Micrometer display will decrease as deformation occurs; Record the distance of deformation (positive is read as the dial moves in the counter-clockwise direction, negative is read as the dial moves in the clockwise direction)

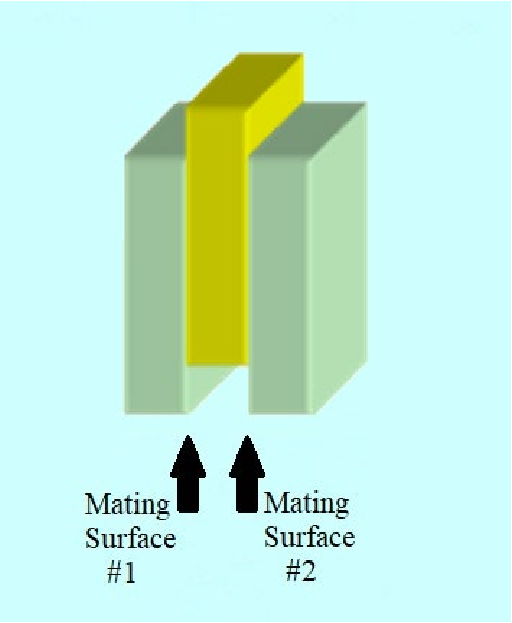
Comments

None

**KTA Form T7095B**

**Tension Creep Test Data**

| | |
|---|---|
| Project No. | 393000 |
| Client | Elzly Technology |
| Coating Manufacturer | Sherwin Williams |
| Coating Name | Test 6: Zinc Clad 4100 / HDG |
| Technician A | DGC |
| Technician B | RTW |
| Panel Numbers or Set Number | Test 6: 73-80, 129-144 |



| | |
|---|---|
| Slip Testing Date | 3/16/2020 |
| Calibration (Cal Fig) Factor | 59.92 |
| Coating Application Date | 3/13/2020 |
| Cure Time | 72 Hours |
| Cure Location and Conditions | Norlake 25°C and 65% RH |

| | | | | | |
|---|---|---|---|---|---|
| Test Start Date and Time | 3/16/2020 | Test End Date and Time | 4/27/2020 | Yoke Location | 1 |
| Slip Coefficient Category | A | Initial Applied Load (kips) | 20.8 | | |

| Bolt Calibration | | Clamping Force (*lbs.*) | | | |
|---|---|---|---|---|---|
| | | Bolt #1 | Bolt #2 | Bolt #3 | Average |
| Bolt Lot No. | 792435 | 51000 | 52000 | 52000 | 52000 |

| Pane ID and Face Used | Replicate 1 | | Replicate 2 | | Replicate 3 | |
|---|---|---|---|---|---|---|
| Mating Surface #1 | 139B | 78F | 141F | 79F | 143B | 80F |
| DFT Mating Surface #1 (mils) | 6.0 | 3.6 | 5.8 | 4.0 | 6.0 | 4.1 |
| Mating Surface #2 | 78B | 140F | 79B | 142F | 80B | 144F |
| DFT Mating Surface #2 (mils) | 4.0 | 7.5 | 3.8 | 7.2 | 3.5 | 6.1 |

| Date | Micrometer Values (*inches*)* | | |
|---|---|---|---|
| 3/16/2020 | 0.0000 | 0.0000 | 0.0000 |
| 3/16/2020 | 0.0000 | 0.0000 | 0.0000 |
| 3/17/2020 | 0.0001 | 0.0002 | 0.0000 |
| 3/18/2020 | 0.0002 | 0.0003 | 0.0000 |
| 3/19/2020 | 0.0002 | 0.0004 | 0.0000 |
| 3/20/2020 | 0.0003 | 0.0005 | 0.0000 |
| 3/23/2020 | 0.0002 | 0.0005 | 0.0000 |
| 3/24/2020 | 0.0002 | 0.0005 | 0.0000 |
| 3/25/2020 | 0.0002 | 0.0005 | 0.0000 |
| 3/26/2020 | 0.0002 | 0.0005 | 0.0000 |
| 3/27/2020 | 0.0002 | 0.0005 | 0.0000 |

| Date | Micrometer Readings - Visual (*inches*) | | |
|---|---|---|---|
| | Replicate 1 | Replicate 2 | Replicate 3 |
| 3/30/2020 | 0.0002 | 0.0005 | 0.0000 |
| 3/31/2020 | 0.0002 | 0.0005 | 0.0000 |
| 4/1/2020 | 0.0002 | 0.0005 | 0.0000 |
| 4/2/2020 | 0.0002 | 0.0005 | 0.0000 |
| 4/3/2020 | 0.0002 | 0.0005 | 0.0000 |
| 4/6/2020 | 0.0002 | 0.0005 | 0.0000 |
| 4/7/2020 | 0.0002 | 0.0005 | 0.0000 |
| 4/8/2020 | 0.0002 | 0.0006 | 0.0000 |
| 4/9/2020 | 0.0002 | 0.0006 | 0.0000 |
| 4/10/2020 | 0.0002 | 0.0006 | 0.0000 |
| 4/13/2020 | 0.0003 | 0.0006 | 0.0001 |
| 4/14/2020 | 0.0003 | 0.0006 | 0.0000 |
| 4/15/2020 | 0.0002 | 0.0006 | 0.0000 |
| 4/16/2020 | 0.0002 | 0.0006 | 0.0000 |
| 4/17/2020 | 0.0002 | 0.0006 | 0.0000 |
| 4/20/2020 | 0.0002 | 0.0006 | 0.0000 |
| 4/21/2020 | 0.0002 | 0.0006 | 0.0000 |
| 4/22/2020 | 0.0002 | 0.0006 | 0.0000 |
| 4/23/2020 | 0.0002 | 0.0006 | 0.0000 |
| 4/24/2020 | 0.0002 | 0.0006 | 0.0000 |
| 4/27/2020 | 0.0002 | 0.0006 | 0.0000 |
| Final Load Applied (Post-Loading): | 31.2 | Final Load Calibration (Cal Fig) Factor: | 59.92 |
| Post-Load Deformation Measurements, inches | 0.0002 | 0.0009 | 0.0001 |
| Average Deformation (Post Load), inches | 0.0004 | | |
| Middle plate displacement with respect to drawn line: | confirmed | confirmed | confirmed |

* Micrometer display will decrease as deformation occurs; Record the distance of deformation (positive is read as the dial moves in the counter-clockwise direction, negative is read as the dial moves in the clockwise direction)

Comments

None