Final Report for Project Entitled:

Survey and Investigation of Corrosion of Fasteners used to Secure Roofing Systems

Performance Period: 1/6/2014 – 6/30/2014

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Florida Building Commission
State of Florida Department of Business and Professional Regulation

by

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1. Disclaimer

This report presents the findings of research performed by the University of Florida. Any opinions, findings, and conclusions or recommendations expressed in this report are those of the authors and do not necessarily reflect the views of the sponsors, partners and contributors. The Roofing Technical Advisory Committee of the Florida Building Commission will provide a final disposition on the implications for the Florida Building Code.

2. Applicable Sections of the Code

1506.4 – 1506.7
1517.5.1 – 1517.5.2

3. Executive Summary

This is a draft final report. The final version will be submitted prior to the end of the project performance period after the Roofing Technical Advisory Committee provides feedback and the Building Officials of Florida tender survey results.

A questionnaire was developed to elicit observations from experienced roofing professionals and building officials regarding the corrosion of metal roof fasteners. The survey was administered by phone using a database of roofing contractors licensed in Florida. The calling was conducted by the University of Florida Survey Research Center. 1500 individuals were contacted, and 385 surveys were completed. The questions range from the general (have you observed corrosion in roof fasteners?) to the specific (fastener and roof system types more often experiencing corrosion). Both summary (Section 6.5) and detailed (Appendix A) results are presented in this report. In summary, it was found that corrosion is commonly observed, most frequently in coastal regions, most often on fasteners for ridge vent and penetration systems. Electrogalvinized fasteners were most likely to exhibit corrosion among the common corrosion resistant applications.

The phone survey results presented in this draft report focused on roofing contractors. A second round of surveys was recently administered to roofing inspectors at the June 9-11 BOAF conference. The results of this survey have not been processed as of the writing of this report, but will be included in the final report.

3.1. Description of Issues

- Anecdotal information indicates that corrosion of fasteners used to secure metal ridge vent system on shingle and tile roofs has been observed across a range of installations, specifically for electro-galvanized fasteners.
- The problem is significantly more serious in coastal environments due to presence of chloride ions
- Increased manufacturing of these products outside the United State may be attributing to the problem

4. Scope of Work

- Consult with the Roofing TAC on writing questions and identifying audience
- Perform literature search for relevant context on the problem
- Locate and hire a professional survey company to conduct the survey. This survey may be administered by one or more forms of communication (mail, email or phone), depending on cost and anticipated effectiveness

- Interpret results, determine whether the problem requires action, and produce a report that explains the results and implications for the Code
- Develop a scope of work for the 2014-2015 fiscal year, if warranted

5. Deliverables

- A report providing technical information on the problem background, results and implications to the Code submitted to the Program Manager by June 15, 2014
- A proposed scope of work for 2014-2015 funding cycle, if warranted
- A breakdown of the number of hours or partial hours, in increments of fifteen (15) minutes, of work performed and a brief description of the work performed. The Contractor agrees to provide any additional documentation requested by the Department to satisfy audit requirements

6. Detailed Project Description

6.1. Literature review

A review of relevant literature was conducted to inform the project regarding scope, evidence, standards, and related studies. The reviewed literature includes:

- A position statement (NRCA)
- A letter to the DBPR from the County of Palm Beach
- ASTM and TAS standards,
- Peer reviewed journal articles on modeling the corrosivity of the coastal atmosphere (Mikhailov et al., 2004; Slamova et al. 2012),
- A FRSA article that helped motivate the study that is the subject of the report (Zehnal, 2013),
- A NIST Interagency Report that describes a study that was conducted to determine the extent of metallic roof fastener corrosion (Rossiter et al. 1989).
- Peer reviewed journal article on weather factors affecting corrosion of metals (Sereda, 1974),
- A USAF Aeronautical System Division technical report on the creation of an environmental corrosion severity classification system
- Recommendations on fastener use made by Simpson Strong-Tie, a major fastener manufacturer

In July of 2012, the County of Palm Beach sent a letter to the Florida Department of Business and Professional Regulation in regards to concerns being raised about the extent of corrosion in electro-galvanized roof fasteners. The concerns were that fasteners were experiencing accelerated corrosion due to a galvanic process between the fasteners and approved metallic roofing accessories. This process is suspected to be facilitated by chloride ions, potentially making coastal areas more susceptible. The implications of this are that structures may become highly susceptible to wind damage and leaks although the fasteners were installed and used in accordance with the manufacturers' recommendations. At the time, corrosion reports were anecdotal. Palm Beach County reached out to the DBPR in order to perform a formal study into the matter. Of particular concern was the widespread use of electro-galvanized fasteners and the increasing manufacture of such fasteners outside of the U.S.

Sereda (1974) examined weather factors associated with atmospheric corrosion. Relative humidity, time of wetness, anthropogenic pollutants, and naturally occurring particulates facilitate this type of corrosion. Because of the many variables involved, testing that aims to recreate a natural outdoor environment is challenging. Of the atmospheric pollutants, sulfur dioxide (SO_2), which is largely anthropogenic, and chloride-salts, a natural aerosol, are the two main contributors. SO_2 is an industrial byproduct and a contributor to acid rain where chlorides are a major factor in coastal regions due to sea-salt spray.

The corrosive effects of atmospheric chloride was demonstrated by two sets of test specimens at Kure Beach, North Carolina. Each specimen was placed at a distance of 80 feet or 800 feet inland. After a year's exposure, the 80 ft sample experienced a reduction in weight of 70.5 grams, where the 800 ft specimen lost 5.8 grams. This result illustrates the reduction in sea-salt corrosivity over only a short distance inland. The chloride concentration in the corrosion products at Kure Beach was found to be 1746 ppm and 1225 ppm for the 800 ft and 80 ft samples respectively.

While atmospheric chloride particles have a deleterious effect on structures adjacent to the coast, it is expected that chlorides also play a role in inland corrosion. The collected corrosion products in coastal regions such as Halifax City, Nova Scotia, and Esquimalt, Vancouver Island, reported chloride concentrations of 796 ppm and 307 ppm respectively, where the inland regions of Ottawa, Ontario, Saskatoon, Saskatchewan, Cleveland, Ohio, and South Bend, Pennsylvania showed concentrations of 640 ppm, 359 ppm, 447 ppm, and 507 ppm respectively. While these reported areas did not exhibit the chloride concentrations present at Kure Beach, the inland concentrations were very near the other coastal concentrations. This suggests that while chloride concentrations are drastic in areas adjacent the coast, there seems to be a common concentration plateau that covers all inland areas.

According to Syed (2006), sea salt particulates are of primary concern when regarding carbon steel such as galvanized steel fasteners. The full range of sea salt fallout was reported to be from 4000 lb/acre/yr in the most extreme coastal environments to 3 lb/acre/yr in rural, inland areas. The high end of this range, when combined with sulfur dioxide and 90% relative humidity can, result in an environment that is 14 times more corrosive than when sodium chloride alone is present. This indicates that roof fastener corrosion could be highly prevalent in humid, coastal-industrial areas.

Fink (1980), the final report to the United States Air Force, states, "The presence of salt greatly increases corrosion rates for nearly all metals, hence the proximity of salt sources will be of much concern." (9) The program sought to explain levels of risks associated with industrial, marine, rural, and urban corrosivity classifications. Particularly looking at sea salt and sulfur dioxide concentrations. The Air Force Logistics Command developed a program in 1971 that incorporates weather and location to produce an algorithm that would issue a corrosion classification number for a given site. The initial algorithm would then be modified based on site testing data.

The study suggests there may be a critical distance from the source of an aerosol (i.e. a large body of salt water) that can be deduced from sodium chloride concentrations in rainwater. In the United States there is a logarithmic decrease in sodium chloride concentrations for up to 500 km inland; a constant chloride concentration is measured beyond this distance. While there is no point in Florida that is beyond 500 km from either the Atlantic Ocean or the Gulf of Mexico, corrosion rates as little as 10 km inland are comparable to those much further inland.

The study included experiments run in Hawaii, Massachusetts, and Nigeria. They all relayed that while the day to day weather greatly affects atmospheric chloride particulates, there is a sharp drop in concentrations in as little as 1.5 km from the coast. Beyond this, particulate concentrations reach a near-constant level.

For the resulting algorithms, the Aircraft Corrosion Damage Algorithm suggests a rating of AA for air bases within 4.5 km of the sea or salt flats. The rating scale is as follows: AA – very severe, A – severe, B – moderate, and C – mild.

Mikhailov et al. (2004) sought ways to improve the standard ISO 9223, Corrosion of Metals and Alloys-The Corrosivity of Atmosphere-Classificaion. The standard is a quantitative corrosivity classification system for carbon steel, zinc, copper, and aluminum. Using this code, corrosion rates can be compared to corrosion standards for various materials, or tables can be used to define the classification based on aspects of the local environment. Corrosion rates are categorized from C1 –very low to C5 – very high. For steel, rates less than 1.3 μm/year constitute a category of C1. The other ranges are from 1.2-25, 25-50, 50-80, and 80-200, all in μm/year. Atmospheric parameters such as time of wetness, sulfur dioxide concentrations, and air salinity are also categorized. As temperature was not included in ISO 9223, the study examined their effects on corrosion rates.

The study states that for chloride-rich atmospheres, temperature increases have been shown to increase the rate of corrosion. A tropical coastal environment will facilitate steel corrosion rates that are an order of magnitude greater than rates in a temperate coastal environment, suggesting that Florida, due to its high relative humidity and higher annual temperatures, may experience greater corrosion rates due to chloride than other parts of the United States.

In 1986, the National Roofing Contractors Association (NRCA) released a bulletin stating their position on fastener corrosion. Their concerns were shared by the Asphalt Roofing Manufactures Association (ARMA), The Roof Insulation committee of the Thermal Insulation Manufacturers Association (RIC/TIMA) and the Single-Ply Roofing Institute (SPRI). The NRCA was concerned particularly about the corrosion resistance of galvanized steel screws, and the associated risk of loss of roof securement. The bulletin proposes that only long term corrosion resistant fasteners be used for both new roof and reroofing construction projects. These concerns parallel those raised by Zehnal (2013): (a) data on the extent of corrosion is still hard to come by, (b) the cases referenced are largely anecdotal as they were 25 years ago, and (c) galvanized steel fasteners are still at the forefront of the corrosion discussion.

For roofing applications, Simpson Strong-Tie (2014) only offers stainless steel, copper, and aluminum fasteners. Where non-stainless steel fasteners are used for outdoor projects, Simpson Strong-Tie recommends that fasteners are periodically inspected. A recommendation on how often is not given and it is stated that due to the unpredictable nature of an outdoor environment, they do not provide a service life estimate on outdoor fasteners. As a guide to selecting a fastener coating, exposure level descriptions are provided with Higher Exposure Use including environments exposed to sea-salt laden air, fertilizers, acid-rain, and fire retardants to name a few. Mechanically galvanized fasteners, including hot-dip galvanized, Class 55 mechanically Galvanized, C-3 Mechanically Galvanized, and N200® Mechanically Galvanized, are recommended for medium levels of corrosion resistance. When subjected to the ASTM B117 salt spray (fog) apparatus, the C-3 fastener showed less than 0.1% of surface rust after 1000 hours, and the N200® displayed 10% surface rust when exposed for 950 hours. It is not stated if the other coatings are subjected to the salt spray test, however, fasteners coated in this manner are not recommended for roofing applications. The salt spray test does not strive to represent a natural environment but is intended to be used to compare the corrosion resistance of two materials.

For fasteners used in Higher Exposure environments, such as roofing, stainless steel, copper, and silicon bronze coatings are recommended. Types 304, 305, and 316 stainless steel fasteners provide the most protection against corrosion, where type 316 stainless steel is recommended for use in chloride environments. Simpson Strong-Tie manufactures fasteners both in and outside of the U.S.

Rossiter et al. (1989) is a report that was commissioned by the U.S. Department of Commerce in February, 1989. The study was conducted to determine the extent of metallic roof fastener corrosion and provide a future course of action. Data on the extent of corrosion was determined to be lacking and the majority of information was anecdotal. To compensate for the lack available data, the study was conducted via questionnaire distributed to roofing contractors and inspectors. Of the sent questionnaires, 45 were returned. In total, 1300 roofs were inspected, 15% of which exhibited fastener corrosion. It was determined that the main cause for corrosion was moisture and corrosion was predominantly found present in zinc coated carbon steel fasteners. Roofs that were observed to exhibit corrosion had been in service from one to ten years. Corrosion was observed on carbon steel fasteners with all types of coatings, however corrosion was predominantly found present on zinc coated carbon steel fasteners. While the study states that chloride exposure is a known problem, it is not addressed as a cause for corrosion. It is also not stated where the 1300 roofs were located in relation to corrosion classification areas such as coastal, industrial, or rural.

The available fasteners for the study were as follows:

- Carbon steel – AISI 1020 carburized and hardened with no coating or oil coated (dipped chromate)
- Carbon steel – AISI 1020 carburized and hardened, electro-galvanized

- Carbon steel – AISI 1020 carburized and hardened, polymer coated (fluorocarbon and epoxy)
- Stainless steel – AISI 410, 12% chromium, heat hardened, no coating
- Stainless steel – AISI 304, cold hardened, 18% Chromium, 8% nickel, hardened carbon steel tip
- Aluminum-magnesium non threaded alloy.

Moving forward, the study suggests that testing of fasteners needs to account for chloride exposure and abrasion resistance, in-service fasteners should be monitored regularly, and non-destructive monitoring technology should be developed to record the condition of inaccessible fasteners.

6.2. Survey construction and IRB approval

The PI coordinated with Mark Zehnal and Scott Richards, the Coordinator of Programming & Research at the University of Florida Survey Research Center (UFSRC, www.bebr.ufl.edu/survey) to construct the questionnaire. The initial draft was provided by the Roofing TAC as an attachment to the project scope of work. The questionnaire was then distributed to the Roofing TAC for comment and revision prior to finalizing. The questionnaire is provided in Appendix A in the form it was administered to the subjects. The required approval from the UF Institutional Review Board (IRB) for research involving human subjects was secured shortly thereafter.

6.3. Construction of survey subject database

A database was constructed containing the names and contact information (business name and phone number) for the survey subjects. The survey subjects were licensed roofing contractors, inspectors and building officials. DBPR hosts public data records at www.myfloridalicense.com, which provided licensed and certified contractors of all categories. A data request was filed with DBPR to attain name and contact information for building officials. A response was received within one week of the request. The complete database consists of 6500 potential survey subjects. 4000 of these entries include a contact phone number.

6.4. Methodology of phone survey

Phone surveys were selected as the most reliable and likely method of administration. The University of Florida Survey Research Center (UFSRC) collected data beginning on May 13, 2014 and concluding on May 30, 2014. 1500 persons were randomly selected from 4000 person list of licensed roofing contractors and contacted. It was initially projected by UFSBR that the budget and time frame would produce 240 completed surveys. The very high response rate (25.7% of those contacted completed the phone survey) resulted in the completion of 385 surveys, which corresponds to a desirable margin of error of +/- 5.0%. Survey figures through the end of data collection follow:

<u>Call Statistics</u>

Completes (Total)	385
Avg. completed Interview length:	10.5 min
Total Interviewing Hours:	332 hrs.
Total dialing attempts:	7309 dials
Avg. Dials per hour:	22.0 dials/hr.
Dials per complete:	19.0 dials/complete
Margin of Error (Full Survey)	+/- 5.0%
Response Rate	25.7%

Dialing was conducted from 9:00am to 5:00pm Monday-Friday. Additional dialing occurred after 5:00pm and on weekends at the request of the respondent. Records were set for a maximum of 7 contact attempts.

The sample file was comprised of a list of licensed contractors and building inspectors that have worked in Florida. Records without phone numbers were removed, then random numbers were generated and attached to each record. The sample file was then sorted, and records were pulled in order of randomization. In this manner, the results of the survey are anonymous.

Per instructions from the PI, only records listed as contractors were included in the sample for the telephone survey. This was done to maximize the number of responses within the survey execution period. Inspectors are typically not available for phone surveys during business hours when the calling was conducted. In order to capture the input from roofing inspectors, a paper version of the survey was included in the registration materials at the Building Officials Association of Florida (BOAF) 2014 Educational Conference and Trade Expo (June 9 – 11). The response was not sufficient for a statistical analysis. Thus the responses discussed in this report are almost exclusively those of roofing contractors.

6.5. Summary of findings

The following is a selection of highlights from the survey results. Complete results are provided in Appendix A. Refer to the question number (Q#) in Appendix A for further details on these results.

About the 385 respondents:

- Q1: Nearly 88% of respondents identified themselves as roofing contractors
- Q2: Mean years of experience as a roofing professional: 18.9
- Q2: Experience Range: 1 year to 50 years
- Q4/5: 85% of respondents have worked on buildings within 10 mi. of Florida's coast. Of this 80%, 34% report that at least 50% of their work is within 10 miles of the coast.

Key findings from the 385 respondents:

- Q6: 80% of respondents stated they have seen corrosion on the "exposed portion of metal fasteners."

- Q7: Frequency of corrosion on various fasteners: % of respondents who have "usually" or "always" seen corrosion on:

  - Shingle fasteners 34%
  - Tile fasteners 16%
  - Metal roof fasteners 28%
  - Ridge vent fasteners 42%
  - Penetration fastener 24%

- Q8: Frequency of corrosion on building types: % of respondents who have "usually" or "always" seen corrosion on:

  - Single family structures 33%
  - Multi family structures 27%
  - Commercial structures 29%

- Q9: 58% report corrosion was "usually" or "always" seen on structures within 10 miles of the coast

- Q9: 17% report corrosion was "usually" or "always" seen on inland structures

- Q10: Frequency of corrosion by fastener type: % of respondents who have "usually" or "always" seen corrosion on:
    - Smooth nail fasteners 35%
    - Ring shank fasteners 16%
    - Barbed fasteners 13%
    - Screw fasteners 16%

- Q11: Corrosion by age of installation: % of respondents who have "usually" or "always" seen corrosion on:
    - Installations less than 5 yrs. old 6%
    - Installations 5-10 yrs. old 29%
    - Installations 11-15 yrs. old 62%
    - Installations more than 15 yrs. old 75%

- Q12: Corrosion by application type: % of respondents who had "usually" or "always" seen corrosion on:
    - Electrogalvanized applications 23%
    - Hot dipped galvanized applications 9%
    - Non-ferrous applications 15%
    - Stainless steel applications 3%

- Q13: Is a fastener manufactured outside the U.S. more likely to show corrosion?
    - Yes 51%
    - No 9%
    - No Opinion 39%

- Q14: Should the FBC seek additional remedies for corrosion of metal roof fasteners?
    - Yes 38%
    - No 40%
    - No Opinion 22%

- Q15: Yes, corrosion is a significant issue with
    - Shingles fasteners 37%
    - Tile fasteners 27%
    - Ridge vent fasteners 57%
    - Penetration fasteners 47%

- Q16: 70% report corrosion is a significant issue in coastal locations

- Q16: 30% report corrosion is a significant issue inland

- Q17: Yes, corrosion is a significant issue with
    - Electrogalvanized fasteners 39%
    - Hot dipped galvanized fasteners 19%
    - Non-ferrous fasteners 21%
    - Stainless steel fasteners 7%

- Q18: Almost 2/3 of the respondents check fastener packages for code compliance

- Q19: 54% say fastener packages do have marks & labels for code compliance

- Q19/20: 40% say fastener packages “sometimes” have marks & labels for code compliance. Among this 40%, 29% report that labels are “frequently” missing

- Q21: 41% of respondents said foreign manufactured products are more likely to have missing labels; 51% hadn’t noticed.

6.6. Interpretation of findings

The survey results must be interpreted within the context of the questions asked, as well as the questions not asked. Importantly, the respondents were not asked to provide input as to the severity of the observed corrosion. The respondents are free to separate the observation of corrosion from the implication that corrosion is an issue to be addressed. This separation was the intention of Questions 7 – 12 (frequency of observations) and Questions 14 – 14 (significant issue). The severity of corrosion is better evaluated via field investigations specifically addressing the corrosion issue, using a pre-determined ranking method that all participants are trained to use consistently. Such an effort is proposed for a future study.

The detailed presentation of responses in Appendix A includes the delineations of never, almost never, sometimes, usually and always as response options. Combining sometimes, usually and always produces the following four most significant findings from the survey:

- Non U.S. manufactured fasteners appear to be less reliable with regard to corrosion resistance (51% of respondents concur)
- The observation of corrosion of electrogalvanized fasters is common (66% observed sometimes or more frequently)
- Observation of corrosion in coastal communities is prevalent (87% observed sometimes of more frequently)
- Observation of corrosion in inland communities is not uncommon (77% observed sometimes of more frequently)

The results indicate that further study is justified to investigate potential code modifications regarding control of corrosion of metal roof fasteners.

6.7. Code modifications for consideration

In this section potential solutions are proposed for consideration. At this stage, these should not be considered recommendations. Each of the proposed solutions require further study to investigate their feasibility, cost implications, effectiveness, impact on the ease of installation, availability, and unintended consequences. The means of investigation of these issues are discussed in section 6.8.

The focus is with regard to electrogalganized fasteners, as the study indicates this corrosion resistance method is the least effective among those commonly used. A primary motivator for the following proposed solutions is to avoid the development of new fastener products.

6.7.1. Quality control of non-U.S. made fasteners

Quality control of non-U.S. manufactured fasteners should be investigated. Although any approved electrogalvanized fastener is required to conform to the prescriptions in ASTM A 641, it is unclear whether the verification of the zinc coating via ASTM A 90 is conducted overseas of within the U.S. The survey investigation was not an appropriate means to determine whether the propensity of observed corrosion was associated with non-U.S. manufacturers. Thus it is unclear whether improved quality control will mitigate corrosion. This can be investigated in a follow up study that includes testing of randomly selected U.S. and non-U.S. manufactured fasteners that have been approved as conforming to ASTM A 641 (see section 6.8).

6.7.2. Restriction, elimination or upgrade of the use of electrogalvanized fasteners

There are several variations of this suggested solution

- The use of currently approved ASTM A 641 Class 1 one fasteners may be restricted to inland locations. The specific division between coastal and inland is a matter of further study, as is the efficacy of this solution.
    - The use of electrogalvinized fasteners in coastal regions may be either eliminated, or the requirement upgraded to require ASTM A 641 Class 2 fasteners (thicker zinc application).
- The use of currently approved ASTM A 641 Class 1 electrogalvanized fasteners may be eliminated statewide
- The use of currently approved ASTM A 641 Class 1 electrogalvanized fasteners may be replaced statewide with Class 2 fasteners

Other combinations of elimination, regional restriction, or upgrading to Class 2 fasteners may be considered.

6.7.3. Statewide requirement for TAS 114

TAS 114 Appendix E is a performance based corrosion standard that is currently required in the HVHZ. The rest of the state requires the ASTM A 641 prescriptive standard. A solution under consideration is to expand the TAS 114 requirement statewide, to ensure that all fasteners meet a performance based standard. At this time, it appears that this solution may not be effective. Section 2.6.2 in TAS 114 Appendix E appears to set the minimum standard of corrosion performance to that of an ASTM A 641 prescribed fastener. Thus the performance standard is pegged to the prescriptive standard. However, this interpretation is subject to correction, and it is proposed to investigate this further in the next year before eliminating this solution from consideration. It is also possible to consider removing the 6.2.2 performance metric, and rely instead exclusively on the section 6.2.1 performance requirement, which does not use ASTM A 641 prescriptive fasteners as a pass/fail baseline.

6.8. Proposed research for the 2014-2015 fiscal year

Each of the proposed solutions in section 8.7 requires follow up study to investigate their feasibility, cost implications, effectiveness, impact on the ease of installation, availability, and unintended consequences. At this time a specific Scope of Work is not proposed, as the Roofing TAC is likely to set priorities that will help guide the contents of a Scope of Work. The following is an outline of the research that is proposed from a conceptual standpoint. A detailed proposal, Scope of Work and budget will follow further input from the Roofing TAC.

6.8.1. Quality control of non-U.S. made fasteners

Although the survey indicates that electrogalvanized fastener corrosion is commonly observed, the survey investigation was not an appropriate means to determine whether the propensity of observed corrosion was associated with non-U.S. manufacturers. Thus it is unclear whether improved quality control will mitigate corrosion. This can be investigated in a follow up study that includes testing of randomly selected U.S. and non-U.S. manufactured fasteners that have been approved as conforming to ASTM A 641 (see section 6.8). The testing would consist of applying ASTM A 90 to these random samples to evaluate their actual conformity to ASTM A 641. The number of samples, their sources, the means of testing (in-house UF or certified test lab), and budget are to be determined.

The outcome of the testing is intended to identify whether a statistically verifiable discrepancy can be shown between U.S. and non-U.S. manufacturers of electrogalvalized roof system fasteners with respect to ASTM A 641 conformity.

6.8.2. Restriction, elimination or upgrade of the use of electrogalvanized fasteners

The TAS 114 Appendix E test protocol (6.2.1 performance metric) will be applied to electrogalvanized ASTM A 641 Class 1 and Class 2 fasteners as well as hot dip galvanized fasteners to provide a side by side performance evaluation. A series of specimens will first be tested out of the box to provide a baseline. A second series of tests will be performed in which the fasteners will be tested in an as-installed condition. That is, the specimens will be driven as per intended field application prior to testing. There is a question as to whether damage to the zinc protection is imparted by the process of installation. The as-installed test results will be contrasted with the out of the box baseline tests. The number of samples, their sources, the means of testing (in-house UF or certified test lab), and budget are to be determined.

The outcome of the testing is intended to identify whether current ASTM A 641 Class 1 fasteners meet the corrosion performance standard in TAS 114 Appendix E section 6.2.1, whether Class 2 fasteners and hot dip galvanized fasteners perform better, and whether these findings still hold with as-installed fasteners. For example, it is possible that the as-installed Class 2 fastener performs no better than the as-installed Class 1 fastener, thus eliminating the upgrade to Class 2 as a potential solution, and indicating elimination of electrogalvanized fasteners as a more appropriate solution. Further, this testing will clarify whether restricting the use of TAS 114 Apendix E to the 6.2.1 metric (eliminate the alternate 6.2.2 metric) and expanding it statewide is a viable solution.

When coupled with the result of the testing in section 6.8.1, the overall test program should provide guidance as to the most cost-effective code modification, if any.

If different requirements are to be sought for coastal and inland locations (section 6.7.2 I this report), the specific division between coastal and inland is a necessary matter of further study. This will be guided by previous studies in the literature that investigated corrosive chemical concentrations as a function of distance from the ocean. For example, Fink (1980, see section 6.1 in this report) identified a sharp drop in concentrations in as little as 1.5 km from the coast.

6.8.3. Statewide requirement for TAS 114

The interpretation of TAS 114 Appendix E presented in section 6.7.3 requires further consideration to verify or falsify the conclusion that this performance standard is not an improvement upon ASTM A 641. The testing proposed in sections 6.8.1 and 6.8.2 will inform further consideration of expanding TAS 114 statewide and /or eliminating the use of section 6.2.2 in that standard.

6.8.4. Field study of corrosion

The survey did not ascertain the severity of the corrosion that the respondents reported. A field study of coastal and inland structures of various ages is proposed in order to better delineate the occurrence and severity of corrosion on metal fasteners of roofing systems. This should be conducted with the accompaniment of or training from trained roofing inspectors to ensure a uniform application of the criteria established to quantify severity of corrosion. Logistics, locations, number of structures, budget are to be determined. The outcome is intended to complement the findings of the survey study in this report, providing additional evidence to determine the severity of the corrosion problem, and helping to determine whether it is prudent to separate potential solutions regionally (coastal / inland).

6.8.5. Additional issues for study

Sections 6.8.1 through 6.8.4 will provide support for the identification of solutions from the standpoint of further isolating the primary cause and extent of the problem, and the effectiveness of the potential solutions. However, the consequences of code modifications must also be investigated with respect to feasibility, cost implications, impact on the industry, and unintended consequences. For example, the elimination of electrogalvanized fasteners, or upgrading the requirement to ASTM A 641 Class 2 fasteners may have significant impact on cost in several ways. The per-unit cost, availability and ease of installation of Class 2 vs. Class 1 fasteners for roofing systems has not been evaluated. It is not known (by the author at this time) if the same or any nail gun can be used to install Class 2 fasteners. It is not known if the cost of a Class 2 fastener, even if readily available and easy to install, would drive the market to non-ferrous, hot dip, or stainless alternatives. All such considerations must be studied and weighed against the potential benefits of any proposed solution.

At this time the specific approach to address these issues is less clear than the experimental and field studies, but the importance of this aspect of the proposed research is not in doubt.

7. References

ASTM designation: B117 – 11. Standard practice for operating salt spray (fog) apparatus.

ASTM designation: D610 – 08. Standard practice for evaluating degree of rusting on painted steel surfaces.

ASTM designation: F1136/F1136M – 11. Standard specification for zinc/aluminum corrosion protective coatings for fasteners.

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8. Appendix A: Table of survey responses from roofing contractors

General notes: Multiple response ("Select All That Apply") questions may have percentages that exceed 100%. They are identified on the Survey Tables spreadsheet with a single asterisk (*). Questions that were only answered by a subset of respondents due to respondent choices, skip patterns, etc. are identified with a double asterisk (**). DK/REF indicates Don't Know or Refused to answer.

	Frequency Tables		
	* = multiple selection questions; percentages may total more than 100%		
	** A subset of respondents answered this question		
	DK/REF: don't know / refused to answer		
Question			
Q1	*Are you currently a roofing contractor, roofing inspector, building official, or other roofing related professional?	(N)	(%)
	Roofing contractor	370	87.9%
	Roofing inspector	27	6.4%
	Building official	5	1.2%
	Other roofing related professional (please specify)	16	3.8%
	DK/REF	3	0.7%
	Total	421	
Q2	How many years have you worked as a roofing related professional?	(N)	(%)
	Range: 1 - 50 years		
	Mean: 18.9 yrs		
	Median: 19 yrs		
	DK/REF	2	
	Total	385	
Q3	*In which Florida Counties have you primarily worked in the past and currently?	(N)	(%)
1	Alachua	12	1.1%
2	Baker	3	0.3%
3	Bay	10	1.0%
4	Bradford	4	0.4%
5	Brevard	23	2.2%
6	Broward	95	9.1%
7	Calhoun	1	0.1%
8	Charlotte	18	1.7%
9	Citrus	11	1.0%
10	Clay	16	1.5%
11	Collier	18	1.7%
12	Columbia	4	0.4%
13	Miami-Dade	102	9.7%
14	De Soto	3	0.3%

15	Dixie	3	0.3%
16	Duval	43	4.1%
17	Escambia	10	1.0%
18	Flagler	7	0.7%
19	Franklin	3	0.3%
20	Gadsden	6	0.6%
21	Gilchrist	2	0.2%
22	Glades	1	0.1%
23	Gulf	1	0.1%
24	Hamilton	2	0.2%
25	Hardee	3	0.3%
26	Hendry	2	0.2%
27	Hernando	9	0.9%
28	Highlands	1	0.1%
29	Hillsborough	55	5.2%
30	Holmes	3	0.3%
31	Indian River	10	1.0%
32	Jackson	3	0.3%
33	Jefferson	1	0.1%
34	Lafayette	2	0.2%
35	Lake	16	1.5%
36	Lee	26	2.5%
37	Leon	10	1.0%
38	Levy	4	0.4%
39	Liberty	1	0.1%
40	Madison	3	0.3%
41	Manatee	22	2.1%
42	Marion	11	1.0%
43	Martin	21	2.0%
44	Monroe	13	1.2%
45	Nassau	7	0.7%
46	Okaloosa	7	0.7%
47	Okeechobee	3	0.3%
48	Orange	63	6.0%
49	Osceola	14	1.3%
50	Palm Beach	71	6.8%
51	Pasco	21	2.0%
52	Pinellas	42	4.0%
53	Polk	19	1.8%
54	Putnam	6	0.6%
55	St. Johns	25	2.4%
56	St. Lucie	22	2.1%
57	Santa Rosa	9	0.9%
58	Sarasota	31	3.0%
59	Seminole	34	3.2%

60	Sumter	2	0.2%
61	Suwannee	4	0.4%
62	Taylor	0	0.0%
63	Union	0	0.0%
64	Volusia	35	3.3%
65	Wakulla	3	0.3%
66	Walton	10	1.0%
67	Washington	3	0.3%
	DK/REF	4	0.4%
	Total	1049	
Q4	Have you worked on buildings within 10 miles of any Florida coast?	(N)	(%)
	1 Yes	327	84.9%
	2 No	58	15.1%
	DK/REF		
	Total	385	
Q5	**Thinking of the buildings you have worked on, would you say that your work is primarily or exclusively coastal, less than 75% coastal, less than 50% coastal, or less than 10% coastal?	(N)	(%)
	1 Primarily or exclusively coastal (within 10 miles of the Florida coast)	54	16.5%
	2 Less than 75% coastal	58	17.7%
	3 Less than 50% coastal	120	36.7%
	4 Less than 10% coastal	91	27.8%
	DK/REF	4	1.2%
	Total	327	
Q6	Metal fasteners are used to secure numerous components to a roof system. These include, but are not limited to, asphalt shingles, clay or concrete tiles, metal roof covers, ridge and off-ridge vents, and roof penetrations. In your experience, have you observed corrosion in the exposed portion of any metal fasteners?	(N)	(%)
	1 Yes	306	79.5%
	2 No	76	19.7%
	DK/REF	3	0.8%
	Total	385	
Q7.1	** How often have you seen corrosion on Shingle fasteners?	(N)	(%)
	1 Never	9	2.9%
	2 Almost never	43	14.1%
	3 Sometimes	134	43.8%
	4 Usually	75	24.5%
	5 Always	29	9.5%
	6 No experience	13	4.2%
	DK/REF	3	1.0%
	Total	306	

Q7.2	** How often have you seen corrosion on Tile fasteners?	(N)	(%)
	1 Never	26	8.5%
	2 Almost never	54	17.6%
	3 Sometimes	113	36.9%
	4 Usually	37	12.1%
	5 Always	12	3.9%
	6 No experience	61	19.9%
	DK/REF	3	1.0%
	Total	306	
Q7.3	** How often have you seen corrosion on Metal roof cover fasteners?	(N)	(%)
	1 Never	25	8.2%
	2 Almost never	44	14.4%
	3 Sometimes	119	38.9%
	4 Usually	67	21.9%
	5 Always	19	6.2%
	6 No experience	28	9.2%
	DK/REF	4	1.3%
	Total	306	
Q7.4	** How often have you seen corrosion on Ridge vent fasteners?	(N)	(%)
	1 Never	14	4.6%
	2 Almost never	30	9.8%
	3 Sometimes	115	37.6%
	4 Usually	95	31.0%
	5 Always	33	10.8%
	6 No experience	17	5.6%
	DK/REF	2	0.7%
	Total	306	
Q7.5	** How often have you seen corrosion on Penetration fasteners?	(N)	(%)
	1 Never	19	6.2%
	2 Almost never	59	19.3%
	3 Sometimes	137	44.8%
	4 Usually	57	18.6%
	5 Always	16	5.2%
	6 No experience	12	3.9%
	DK/REF	6	2.0%
	Total	306	
Q7oth1	** Have you seen corrosion on any other type of roof fastener or installation that we haven't mentioned yet?	(N)	(%)
	1 Yes	95	31.0%
	2 No	209	68.3%
	DK/REF	2	0.7%

	Total	306	
Q7oth1a	** What type of roof fastener or installation was it?	(N)	(%)
	Deck fasteners/Nails	11	
	Flashing	11	
	Metal	9	
	Tin	5	
	Screws	4	
	Hurricane	3	
	Lightweight Concrete	3	
	Total Responses, Q7oth1a	94	
Q8.1	How often have you seen roof fastener corrosion on Single family residential structures?	(N)	(%)
	1 Never	7	2.3%
	2 Almost never	23	7.5%
	3 Sometimes	159	52.0%
	4 Usually	77	25.2%
	5 Always	24	7.8%
	6 No experience	15	4.9%
	DK/REF	1	0.3%
	Total	306	
Q8.2	** How often have you seen roof fastener corrosion on Multi-family residential structures (apartments, condominiums)?	(N)	(%)
	1 Never	8	2.6%
	2 Almost never	24	7.8%
	3 Sometimes	153	50.0%
	4 Usually	64	20.9%
	5 Always	19	6.2%
	6 No experience	37	12.1%
	DK/REF	1	0.3%
	Total	306	
Q8.3	** How often have you seen roof fastener corrosion on Commercial structures?	(N)	(%)
	1 Never	13	4.2%
	2 Almost never	38	12.4%
	3 Sometimes	126	41.2%
	4 Usually	65	21.2%
	5 Always	23	7.5%
	6 No experience	37	12.1%
	DK/REF	4	1.3%
	Total	306	

Q9.1	** How often have you seen roof fastener corrosion in Coastal building locations (within approximately 10 miles from any Florida coast)?	(N)	(%)
	1 Never	8	2.6%
	2 Almost never	8	2.6%
	3 Sometimes	89	29.1%
	4 Usually	112	36.6%
	5 Always	65	21.2%
	6 No experience	24	7.8%
	DK/REF	0	0.0%
	Total	306	
Q9.2	** How often have you seen roof fastener corrosion in Inland building locations (more than 10 miles from any Florida coast)?	(N)	(%)
	1 Never	8	2.6%
	2 Almost never	47	15.4%
	3 Sometimes	182	59.5%
	4 Usually	37	12.1%
	5 Always	16	5.2%
	6 No experience	15	4.9%
	DK/REF	1	0.3%
	Total	306	
Q10.1	** How often have you seen roof fastener corrosion on Smooth nail fasteners?	(N)	(%)
	1 Never	11	3.6%
	2 Almost never	27	8.8%
	3 Sometimes	142	46.4%
	4 Usually	84	27.5%
	5 Always	24	7.8%
	6 No experience	16	5.2%
	DK/REF	2	0.7%
	Total	306	
Q10.2	** How often have you seen roof fastener corrosion on Ring shank nail fasteners?	(N)	(%)
	1 Never	28	9.2%
	2 Almost never	71	23.2%
	3 Sometimes	147	48.0%
	4 Usually	38	12.4%
	5 Always	12	3.9%
	6 No experience	10	3.3%
	DK/REF	0	0.0%
	Total	306	

Q10.3	** How often have you seen roof fastener corrosion on Barbed fasteners?	(N)	(%)
	1 Never	28	9.2%
	2 Almost never	36	11.8%
	3 Sometimes	132	43.1%
	4 Usually	27	8.8%
	5 Always	14	4.6%
	6 No experience	64	20.9%
	DK/REF	5	1.6%
	Total	306	
Q10.4	** How often have you seen roof fastener corrosion on Screw fasteners?	(N)	(%)
	1 Never	19	6.2%
	2 Almost never	56	18.3%
	3 Sometimes	170	55.6%
	4 Usually	41	13.4%
	5 Always	9	2.9%
	6 No experience	9	2.9%
	DK/REF	2	0.7%
	Total	306	
Q11.1	** How often have you seen roof fastener corrosion in installations that were Less than 5 years old?	(N)	(%)
	1 Never	56	18.3%
	2 Almost never	117	38.2%
	3 Sometimes	101	33.0%
	4 Usually	14	4.6%
	5 Always	3	1.0%
	6 No experience	12	3.9%
	DK/REF	3	1.0%
	Total	306	
Q11.2	** How often have you seen roof fastener corrosion in installations that were 5-10 years old?	(N)	(%)
	1 Never	13	4.2%
	2 Almost never	35	11.4%
	3 Sometimes	163	53.3%
	4 Usually	75	24.5%
	5 Always	13	4.2%
	6 No experience	7	2.3%
	DK/REF	0	0.0%
	Total	306	

Q11.3	** How often have you seen roof fastener corrosion in installations that were 11-15 years old?	(N)	(%)
	1 Never	1	0.3%
	2 Almost never	9	2.9%
	3 Sometimes	101	33.0%
	4 Usually	129	42.2%
	5 Always	61	19.9%
	6 No experience	5	1.6%
	DK/REF	0	0.0%
	Total	306	
Q11.4	** How often have you seen roof fastener corrosion in installations that were More than 15 years old?	(N)	(%)
	1 Never	1	0.3%
	2 Almost never	6	2.0%
	3 Sometimes	61	19.9%
	4 Usually	116	37.9%
	5 Always	113	36.9%
	6 No experience	9	2.9%
	DK/REF	0	0.0%
	Total	306	
Q12.1	** How often have you seen roof fastener corrosion on fasteners with Electrogalvanized corrosion resistant applications?	(N)	(%)
	1 Never	26	8.6%
	2 Almost never	59	19.4%
	3 Sometimes	131	43.1%
	4 Usually	54	17.8%
	5 Always	17	5.6%
	6 No experience	14	4.6%
	DK/REF	3	1.0%
	Total	304	
Q12.2	** How often have you seen roof fastener corrosion on fasteners with Hot dipped galvanized corrosion resistance applications?	(N)	(%)
	1 Never	42	13.8%
	2 Almost never	100	32.9%
	3 Sometimes	121	39.8%
	4 Usually	22	7.2%
	5 Always	4	1.3%
	6 No experience	13	4.3%
	DK/REF	2	0.7%
	Total	304	

Q12.3	** How often have you seen roof fastener corrosion on fasteners with Non-ferrous metal corrosion resistance applications?	(N)	(%)
	1 Never	49	16.1%
	2 Almost never	61	20.1%
	3 Sometimes	94	30.9%
	4 Usually	30	9.9%
	5 Always	14	4.6%
	6 No experience	45	14.8%
	DK/REF	11	3.6%
	Total	304	
Q12.4	** How often have you seen roof fastener corrosion on fasteners with Stainless steel corrosion resistance applications?	(N)	(%)
	1 Never	154	50.7%
	2 Almost never	92	30.3%
	3 Sometimes	38	12.5%
	4 Usually	7	2.3%
	5 Always	3	1.0%
	6 No experience	9	3.0%
	DK/REF	1	0.3%
	Total	304	
Q12oth1	** Have you seen roof fastener corrosion on fasteners with any other type of corrosion resistance application that we haven't mentioned yet?	(N)	(%)
	1 Yes	53	17.3%
	2 No	252	82.4%
	DK/REF	1	0.3%
	Total	306	
Q12oth1a	** What type of corrosion resistance application was it?	(N)	(%)
	Copper/Copper Nails	7	
	Ceramic Coated	6	
	Zinc/Zinc Coated	6	
	Aluminum	5	
	Paint/Paint Coating	5	
	Screws/Staples	3	
	Total Responses, Q12oth1a	49	
Q13	** Based only on your experience, is a Florida approved fastener manufactured outside of the United States more likely to show corrosion than a U.S. manufactured equivalent fastener?	(N)	(%)
	1 Yes	156	51.0%
	2 No	26	8.5%
	3 No Opinion	120	39.2%
	DK/REF	4	1.3%

	Total	306	
Q14	Based on your experience, do you think that corrosion of metal roof fasteners is an issue the Florida Building Commission should seek additional remedies for?	(N)	(%)
	1 Yes	147	38.2%
	2 No	152	39.5%
	3 No Opinion	85	22.1%
	DK/REF	1	0.3%
	Total	385	
Q15.1	Is corrosion a significant issue with Shingles fastener applications?	(N)	(%)
	1 Yes	144	37.4%
	2 No	177	46.0%
	3 No Opinion	64	16.6%
	DK/REF	0	0.0%
	Total	385	
Q15.2	Is corrosion a significant issue with Tiles fastener applications?	(N)	(%)
	1 Yes	104	27.0%
	2 No	172	44.7%
	3 No Opinion	106	27.5%
	DK/REF	3	0.8%
	Total	385	
Q15.3	Is corrosion a significant issue with Ridge vents fastener applications?	(N)	(%)
	1 Yes	219	56.9%
	2 No	123	31.9%
	3 No Opinion	42	10.9%
	DK/REF	1	0.3%
	Total	385	
Q15.4	Is corrosion a significant issue with Penetrations fastener applications?	(N)	(%)
	1 Yes	179	46.5%
	2 No	153	39.7%
	3 No Opinion	50	13.0%
	DK/REF	3	0.8%
	Total	385	
Q15oth1	Is corrosion a significant issue with any other type of fastener application that we haven't mentioned yet?	(N)	(%)
	1 Yes	69	17.9%
	2 No	314	81.6%
	DK/REF	2	0.5%
	Total	385	

Q15oth1a	** What type of fastener application is it?	(N)	(%)
	Metal Roof	15	
	Screws/Nails	7	
	Exposed fasteners	3	
	Total Responses, Q15oth1a	69	
Q16.1	Is corrosion a significant issue with Coastal building locations?	(N)	(%)
	1 Yes	271	70.4%
	2 No	38	9.9%
	3 No Opinion	76	19.7%
	DK/REF	0	0.0%
	Total Responses, Q17oth1a	385	
Q16.2	Is corrosion a significant issue with Inland building locations?	(N)	(%)
	1 Yes	116	30.1%
	2 No	185	48.1%
	3 No Opinion	84	21.8%
	DK/REF	0	0.0%
	Total	385	
Q17.1	Is corrosion a significant issue with Electrogalvanized fasteners?	(N)	(%)
	1 Yes	149	38.7%
	2 No	158	41.0%
	3 No Opinion	75	19.5%
	DK/REF	3	0.8%
	Total	385	
Q17.2	Is corrosion a significant issue with Hot dipped galvanized fasteners?	(N)	(%)
	1 Yes	74	19.2%
	2 No	236	61.3%
	3 No Opinion	74	19.2%
	DK/REF	1	0.3%
	Total	385	
Q17.3	Is corrosion a significant issue with Non-ferrous fasteners?	(N)	(%)
	1 Yes	79	20.5%
	2 No	176	45.7%
	3 No Opinion	126	32.7%
	DK/REF	4	1.0%
	Total	385	

Q17.4	Is corrosion a significant issue with Stainless steel fasteners?	(N)	(%)
	1 Yes	27	7.0%
	2 No	320	83.1%
	3 No Opinion	38	9.9%
	DK/REF	0	0.0%
	Total	385	
Q17oth1	Is corrosion a significant issue with any other type of fastener that we haven't mentioned yet?	(N)	(%)
	1 Yes	33	8.6%
	2 No	349	90.6%
	DK/REF	3	0.8%
	Total	385	
Q17oth1a	What type of fastener is it?	(N)	(%)
	Screws/Nails	6	
	Zinc	3	
	Total	29	
Q18	Do you check to see that fastener packages have the manufacturer's identifying marks and approved testing-agency labels for code compliance?	(N)	(%)
	1 Yes	249	64.7%
	2 No	39	10.1%
	3 Sometimes	97	25.2%
	DK/REF	0	0.0%
	Total	385	
Q19	** Do the packages ACTUALLY have identifying marks and labels for code compliance?	(N)	(%)
	1 Yes	186	53.8%
	2 No	15	4.3%
	3 Sometimes	138	39.9%
	DK/REF	7	2.0%
	Total	346	
Q20	** How often are the identifying marks and code compliance labels missing?	(N)	(%)
	1 Frequently (more than 10% missing)	40	29.0%
	2 Infrequently (less than 10% missing)	91	65.9%
	DK/REF	7	5.1%
	Total	138	

Q21	** Have you noticed whether non-US manufactured products are more or less likely to have missing labels? Would you say...	(N)	(%)
	1 Non-US manufactured products are MORE likely to have missing labels.	57	41.3%
	2 Non-US manufactured products are LESS likely to have missing labels.	8	5.8%
	3 I have not noticed.	71	51.4%
	DK/REF	2	1.4%
	Total	138	