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Coating of Metal Roofs

White Paper
For
Metal Building Manufacturers Association

By

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Introduction

The objective of this white paper is to present building owners, architects, designers and facility managers with a summary of metal roof coating limitations, concerns, and appropriate uses.

Coating types are defined by resin type. There are essentially three types of coatings that are used on metal roof systems.

1. Paint which is used for aesthetic purposes and is outside the scope of this paper.
2. Liquid Applied Roofing, such as polymethyl methacrylate PMMA, is outside the scope of this paper.
3. Coatings that are used to ‘waterproof’ the substrate and which often requires seam and laps repairs prior to application.

For the purposes of this paper, coating is any material used to extend the life of the existing metal panel by protecting the core metal of the panel from the effects of the climate.

Every year millions of square feet of metal roofs are coated to primarily address two conditions:

1. Moisture intrusion.
2. Extend the service life of the metal.

While these are laudable goals, the use of coatings on metal roofing is often the result, not of an analysis of the condition and integrity of the metal roof panel system, but of the promise of:

1. Improved thermal efficiency of the roof system.
2. Elimination of all the leaks.
3. Adding years to your roof panels.
4. It is affordable and easy to apply.

This paper will review the reason you may want to coat a metal roof. In addition, it will discuss types of coatings, preparation requirements, concerns to consider, potential detrimental effects of a coating, and life-safety issues related to coating

versus retrofitting with a new metal roof, repairs that do not include coatings, code implications, other standards and references.

Metal Roofing Today

Commercial metal roofing includes the following panel types:

1. 'R' Panel: Typically, corrugated sheets (rounded and fluted) that lap at the ends and side laps. The panel is secured to the structure with exposed screws (see photo A).

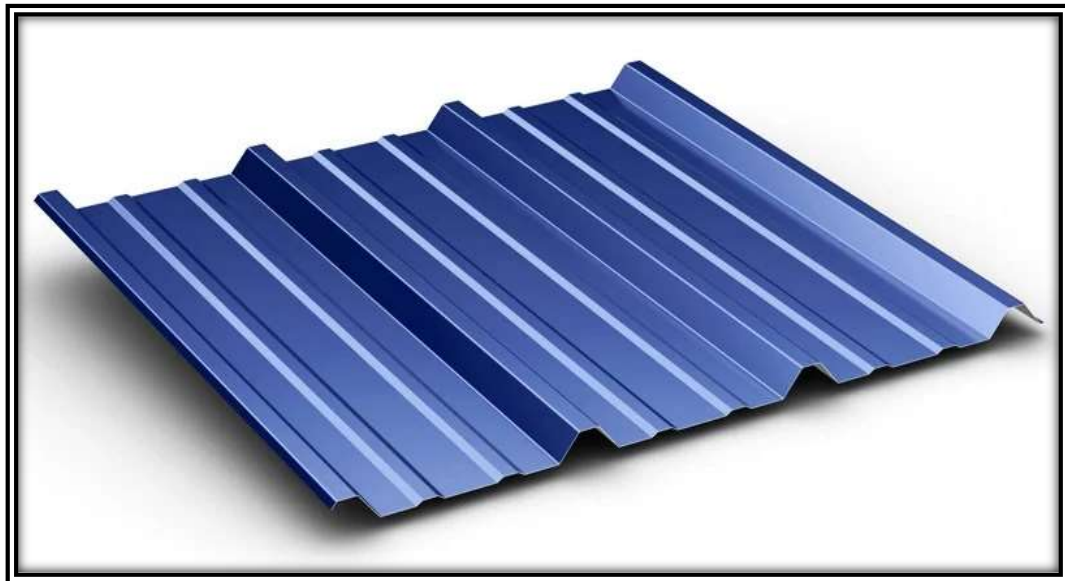


Photo A: Metal 'R' Panels are an economical metal roofing solution.

2. Trapezoidal Standing Seam Panels: The heavy lifter in the commercial and industrial markets, trapezoidal panels are typically 24" wide and mechanically seamed to clips concealed in the seams, which are fastened to the structure (see photos B and C).



Photo B: This thirty year plus trapezoidal standing seam roof still performing.



Photo C: This trapezoidal seam roof panel, with a pre-finished coating is a recent installation.

3. Standing Seam: Traditional standing seam roofing seams have morphed over time from hand folded seams to include panels with vertical legs that are mechanically seamed by a traveling seaming machine, to panels with a seam cover placed on the panel legs and panels with seams that are snapped together. There are numerous alternates to these main types (see photo D).



Photo D: This shop fabricated standing seam roof panel is composed of terne coated stainless roof panels with machine locked seams.

Finishes: There are basically four types of materials/finishes used in metal roofing, each with their own benefits, service life and application requirements:

1. Galvanized steel.
2. Galvalume[®] steel (55% Al-Zn alloy-coated steel).
3. Pre-finished painted aluminum and steel.
4. Natural metals: Copper, zinc, zinc coated copper.

Why Coat a Metal Roof?

There are correct and incorrect reasons to coat an existing metal roof:

Correct Reasons:

1. To maintain the existing condition of the roof system.
 - a. It is not a replacement for a properly functioning roof system.
2. To protect/repair metal or finish.
3. Time savings.
4. Cost.
5. Minimize disruption of the interior operations.
6. Improve the reflectivity of the roof surface (if desired).
7. Possibly improve the interior environment.
8. Improve aesthetics if visible from grade or above.

Incorrect Reasons:

1. To stop leaks at fasteners or panel end laps.
2. To enhance the integrity of severely deteriorated roof panels.
3. Weatherproofing to remedy improper installation.
4. To provide long-term service without maintenance or continued restoration.
5. To meet or exceed current code requirements.
 - a. Coatings will have no effect on code compliance.

To Recoat or Not

The decision to recoat a metal roof is not to be taken lightly. In a perfect world the coating of a metal roof panel should take place well before the deterioration of the base metal commences. Roof panels that have substantial rusting and loss of section (the thickness of the panel) of 30% or more should not be coated. Thus, the first consideration is to determine the structural integrity of the metal roof panels. This may require several coupons (samples of the roof panel) in areas of deterioration for analysis.

Other considerations that need to be reviewed are:



1. Remember roof coating is a preventative maintenance measure that often requires subsequent coating applications.
2. Is the existing roof past its service life? The application of a roof coating to a metal roof system that is at the end or past its service life can potentially conceal performance issues.
 - a. The roof must be performing and functioning on its own prior to the application of a coating.
 - b. No expectation should be implied by sales forces or coating suppliers that a roof coating can restore a failing roof.
3. Long-term moisture intrusion: How has this long-term intrusion affected the underside of the roof panel, structure (see photo E) and the panel attachment? Has saturated insulation resulted in deterioration on the underside of the metal panel, creating a dangerous ‘trapdoor’?



Photo E: Long-term moisture intrusion can have hidden life safety concerns as see in the photo above where the steel purlin has no structural integrity.

4. Backing out of exposed fasteners: Backing out of fasteners: Loose or unseated fasteners should not be driven down but removed and replaced with a new larger diameter, corrosive-resistant, long-life fastener with

- sealing washers. Fasteners with deteriorated sealing washers should also be replaced with new larger diameter fasteners with sealing washers.
5. Physical damage to panels and/or seams by expansion and contraction: Damaged panels need to be removed and replaced and the required expansion and contraction accounted for before coating can be applied.
 6. Inappropriate or improper initial installation: Details that are inappropriate must be rectified prior to coating. The following are often an issue:
 - a. Perimeter trim and flashing details such as roof-to-wall conditions.
 - b. Roof penetrations.
 7. Structural framing concerns: Has long-term moisture intrusion resulted in the deterioration of structural framing and loss of integrity?
 8. Panel length and expected expansion and contraction: Roof panel expansion and contraction needs to be taken into consideration when designing the coating system.
 9. If the existing metal roof exhibits any of the items above, repairs are required prior to coating. If not, coating of the roof may be detrimental.

Additional items to consider and review:

1. Code change impacts: Codes are revised over time and new requirements may affect if a coating may be used, and if so, the qualities that coating must have.
2. Building additions that rise above the roof in question result in snow drift loading. Coatings light in color, over one that was dark, may reduce solar snow melting and increase the retained snow, which when wet, could be a structural-loading concern.
3. Some coatings are very difficult to adhere to making the installation of roofing base flashing tie-ins on roof curbs or penetrations installed after the coating a challenge to waterproof.
4. Often coating warranties can be more of a sales tool than an actual warranty of performance. The warranty terms and conditions greatly limit liability for the coating manufacturer.

Detrimental Effects of Coating over Metal Roofs

Coating a metal roof can have several detrimental effects, such as:

1. The coating can create a slippery surface on which to walk, creating a life-safety issue.
2. Coating can create an enhance slip plane and snow sliding.
3. A light-colored coating may result in frost when ambient temperatures at night are above 32°F, creating an unexpected slippery surface for maintenance staff.
4. Potential condensation below the roof panel if a reflective color coating is applied.
5. Mechanical stresses, induced by expansion and contraction of the roof panel, in association with inevitable changes in a coating's physical properties over time, can lead to failures at parapets, roof edges, roof curbs, transverse seams, protrusions, and other conditions where movement of the panel takes place.
6. Coating that splits due to expansion and contraction can trap water and result in accelerated deterioration of the roof panel (see photo F).



Photo F: Coatings that de-bond from the metal below can crack, allowing water to enter in below the coating and deteriorate the metal panel below.

7. Advancing structural deficiencies can be concealed (see photo G).



Photo G: The coating in this photo concealed a nearly rusted out panel that created a life-safety concern. The panel should have been repaired prior to coating.

8. Trapping moisture inside end laps that were previously leaking can lead to extensive corrosion of the panel end laps, not visible due to the coating (see photo H).



Photo H: Coating applied to the transverse lap seam, peeled and allowed moisture to enter under the coating, but not out. This resulted in the deterioration of metal roof panel.

Preparation of the Metal Roofing for Coating

The success of a coating can be summed up in three words: Preparation, preparation, and preparation! A successful coating application project is the result of proper surface preparation and application. This cannot be emphasized enough.

Every coating manufacturer will have their own requirements, but at the very least, the following metal roof panel surface preparations should be specified depending on material and finish. Also see Chapter 6 of the NRCA's Guidelines for the Application of Coatings:

1. Removal of all debris.
2. Repair of any deficient roof panel conditions.
3. Removal of all loose paint and/or finish.
 - a. Be cognizant of the paint type and if it may contain lead.
4. Removal of all loose scale, rust, and other foreign elements.
5. Remove all oils, grease, dirt, dust, and salts.

6. Removal and replacement of all loose screws with new larger diameters ones with EPDM clad washers and pre-treatment on the screws prior to coating.

A mock-up should be prepared. After preparation of the metal surface and application of a primer if required and coating, adhesion testing should be performed.

Currently there is no ASTM standard pertaining to coatings on existing metal roofs which can be prescribed and followed to determine the appropriate adhesion. The NRCA, in their Application of Roof Coatings Guide, suggest a ‘Peel’ test.

1. Using the same methods as prescribed in the contract documents, clean and prepare a representative area of roof panel, 12” x 12” or so.
2. Apply the primer and a first layer of the coating to be tested to the test area and place a strip of fabric about 1” wide, 6” to 8” long into the coating. Brush the fabric into the first coating and make sure it is flat. Apply a second coat.
3. Allow the coating to cure to provide sufficient adhesion strength. Consult with the manufacturer for a time length.

To test the adhesion strength, pull the fabric tail in a smooth peeling motion at an angle of 45 to 90 degrees with a consistent force of two to five pounds force per inch. A fish scale can be used to obtain accurate results. The NRCA’s Guide in Chapter 6 – Adhesion, reviews this test and describes the various modes of failure.

Coating Application Quality

Proper application of the coating is paramount to achieving success. Coating applicators should have experience with coating metal roofs with the product specified. Their work force should have knowledge of the equipment required, surface preparation techniques and requirements, and application means and methods. They should also be certified by the coating manufacturer for the application of their product on various substrates.

Prior to commencing a coating project, the roof should be photo documented, as should the substrate preparation and the entire application of the coating. Records



of wet mil thickness and product batch numbers should be recorded by the applicator and verified by a third party.

Workmanship defects are often responsible for roof system failures and no less so with coatings. Storage of the coating can affect the viscosity of the product and affect application and performance. Material substitutions (grade, brand or supplier) specified incorrectly or errors in delivery (e.g., materials kept warm or allowed to freeze) can result in failure.

The timing of the coating application after primer application should closely follow the manufacturer's requirements. Leaving the primer exposed too long allows for foreign contaminants to accumulate and can result in ultraviolet light degradation of the primer and could result in adhesion concerns. The application of the coating to the manufacturer's requirements is very important. Applying the coating too thin or too thick can result in the failure of the coating.

NRCA Guidelines for the Application of Roof Coatings

In 2020, the National Roofing Contractors Association (NRCA) published Guidelines for the Application of Roof Coatings. The goal of this guide is education and information and has met this goal full throttle. It has excellent sections on:

1. Roof Coating Types.
2. Roof Coating Properties and Comparisons.
3. Substrate and Surface Evaluation.
4. Roof Coating Selection.
5. Primers.
6. Adhesion.
7. Coating Application.
8. Handling, Safety, and Transportation Precautions.

Within these headings are several topics pertinent to the application of coatings to metal roofs.

In Chapter 3 – Substrate and Surface Preparation, it is emphasized that surface preparation is one of the key aspects of the coating's performance. Expectations of

the coating's performance will not be met if insufficient attention is paid to the preparation of the existing surface. Surface preparation of the existing roof panel surface is carried out to improve the contact zone between the coating and the existing roof panel. This starts with investigation and evaluation of the existing roof system so that proper primers and coatings can be selected. Questions such as "Does the existing roof panel have a pre-finished paint application that will inhibit bonding?", "Is there damage to the roof panels that requires repair or replacement?", "What is the condition of the underside of the panel?" should be asked. Coatings will not eliminate the damaging effects of corrosion on the bottom side of the metal roof panels. Only coatings and primers specifically designed to adhere to the specific finishes should be used.

Chapter 6 – Adhesion, is dedicated to this topic. Surface preparation and adhesion go hand in hand. The ability of the coating to tenaciously bond to the substrate is required for successful performance. This bond strength is achieved through the adhesion properties of the coating and ability of the substrate to accept the coating. Ideally the substrates need to be free of moisture and foreign contaminants.

This guide is a valuable resource for design professionals, contractors, and manufacturers when working on coating projects.

Life Safety Issues Related to Coating vs. Retrofitting

Coating systems, if applied over deteriorated metal roof panels contrary to manufacturers' applications instructions, create a hidden condition that creates a trapdoor for anyone walking the roof and can result in severe injury or death if one's foot or person goes through the roof.

Inappropriate coatings that split and trap water below them, can accelerate the deterioration of the metal panel (see photos F and G), not only shortening the service life of the roof, but also resulting in potential structurally compromised roof panel.

Repair Methods for Metal Roofs that Do Not Involve Coatings

After assessing the condition of the roof, an owner may wish to consider long-term repairs that do not involve coatings.

Prior to retrofitting an existing metal roof, it may require an analysis of the existing structure and updating to the current codes (for items such as new snow loading) and wind uplift requirements which may be more restrictive than when the building was constructed. Coating a metal roof would not typically be considered a retrofit.

There are basically six options for the owner to consider:

Exposed Fastener Roof Panels, Fastener and Panel End Lap Repair: Evaluation of the existing fasteners and panel end laps: Many older roofs were installed with fasteners that had a useful life much shorter than the life of the roof panels they are securing. Existing fasteners can be upgraded to a new larger diameter, long-life fasteners of stainless steel or hot dipped galvanized (zinc-aluminum alloy). End lap conditions can also be repaired without the application of unnecessary surface coatings that could potentially reduce the useful life of the roof panels: An example of an ill-advised coating repair can be seen in photo F.

Removal and Replacement of the Existing Roof Panels: As the name suggests, this involves the removal of the existing metal roof panel and replacement with a new similar-profiled panel. This type of repair may involve the replacement or enhancement of the underlayments and/or insulation below the panels. It will involve protection of the interior space below to varying degrees during the work: An example can be seen in photo I.



Photo I: The existing metal roof panels have been removed and underlayment installed. The bundled new metal roof panels have already been lifted to the roof and are ready for installation.

Direct Panel Overlay: This is a profile specific system used to overlay an existing through fastened roof panel with a similar profiled panel that has a much larger rib and a condensation backing. The new panel is laid directly on top of and fastened through the old panel into the existing purlins. An example can be seen in photo J.



Photo J: A direct panel overlay as seen in the photo above is easily accomplish with “R” Panels.

Direct Panel Overlay using Notched Sub-Purlins: This system has become very popular. This retrofit involves placing a metal-notched sub-purlins over the existing metal roof panel, nested in-between the standing metal roof panel ribs, parallel to the purlins below, anchoring the sub-purlin to the existing roof framing and then connecting the new roof panel to this sub-framing. Additional insulation can be added between the panels as well. Examples can be seen in photos K and L.

These systems can also be produced in various heights to add insulation, remove roof steps and integrate with upslope framing members to reduce the existing purlin spacing when required for building code compliance.



Photo K: Notched purlins placed over the existing standing seams in line with the purlins below is an efficient method to install a new roof panel.



Photo L: Here a tall clip is being use in association with the notched purlin so that insulation can be incorporated into the new roof system.

Tall Clip Recover: This system involves the placement of hold down clips that have been fabricated to extend above the existing metal roof panel rib. For high wind conditions some manufacturers can provide a continuous tall clip to allow the metal roof retrofit system to meet current code requirements. Both tall and continuous clips are attached to the existing purlins. Additional insulation can also be added in this system: An example can be seen in photo M.

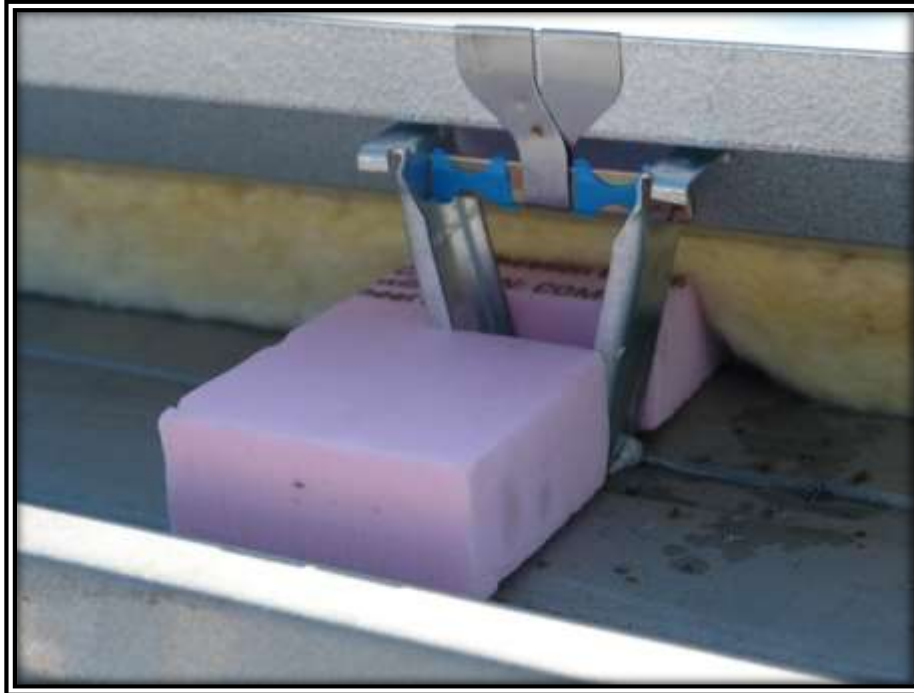


Photo M: Tall clips are being used to raise the height of the roof panel so that a layer of insulation can be installed.

Sub-Purlin Retrofit System: This system utilizes light-gauge steel structural framing that is installed over the existing roof panels, perpendicular to the existing

structural framing below. This new sub-purlin framing system can maintain the existing slope of the roof or can increase the slope. It can also remove small step-downs in the roof plane, such as where lean-to additions were installed, typically not exceeding 12 inches. Additional insulation can also be placed in the new cavity: An example can be seen in photo N below.



Photo N: New sub-purlins and insulation have been installed, which is then followed by the placement of the new roof panels.

Coating Code Implications: IBC 2018

The International Building Code (IBC) is now the generally adopted building code across the nation and the first place design professionals and contractors should look for code compliance.

Chapter 2 – Definitions, defines roof coating as a fluid-applied, adhered coating used for roof maintenance or roof repair, or a component of a roof covering or roof assembly. Coatings themselves are not defined.

Chapter 15 – Roof Assemblies and Rooftop Structures, does not have a paragraph that lists roof coating products that are acceptable to be applied to metal roof systems. A reasonable interpretation of this omission is that roof-coating application over a metal roof system is not code approved.

When approved coating(s) are listed in the code as they are for other roof covers, they will need to be included in a roof assemblies fire classification listing to comply with the IBC Section 1505 – Fire Classification. Approved testing agencies’ testing guidelines typically require listed products to bear the testing agency’s label on the product package, i.e., UL mark or FM Approvals diamond.

A review of several Product Data Sheets (PDS) from well-known coating manufacturers advertising its applicability to metal do not list an ASTM standard, though they may have the UL or FM label.

Coating Code Implications: IEBC 2015

Chapter 7 - Alterations - Level 1: Section 706 Reroofing does not address roof coating products that are to be applied to metal roof systems. As with the IBC, reasonable interpretation of this omission is that roof-coating application over a metal roof system is not code approved.

2021 International Property Maintenance Code (IPMC)

Coating application may often be recommended or sold under “Maintenance.” Section 304 Exterior Structure, in paragraph 304.1.1 Unsafe Conditions states:

“The exterior of a structure shall be determined as unsafe and shall be repaired or replaced to comply with the *International Building Code* or the *International Existing Building Code* as required for existing buildings.”

As noted above in regard to coating metal roofing, complying with the code will be challenging.



ASTM Standards

The 2018 IBC does not list any approved coatings for metal roof systems. This may be in part because there are no ASTM standards that pertain to coating metal roof systems. Thus, without an ASTM standard pertaining to coating metal roofs, there is no testing data for coating adhesion, peel, elongation, contractions, abrasion, impact and loading, as well as fire.

FM Global Property Loss Prevention Data Sheet 1-31 Panel Roof Systems

Section 2.2.4.6 Re-Cover of Existing Metal System deals with liquid applied coatings over polyurethane foam systems.

They do have select recommendations for **FM Approved** (emphasized added) liquid applied roof covers direct to steel deck (panels), which are prudent and should be heeded.

1. Re-tighten existing exposed fasteners.
 - a. Analyze the existing deck and install additional fasteners if needed to meet wind load requirements.

Note: The analysis of the existing roof deck and how it relates to meeting the current code should be undertaken by a licensed design professional.

2. If required by the FM Approval of the liquid applied coating, reinforce the joints with fabric.
3. Wire brush lightly rusted areas and replace severely deteriorated areas.
4. Power wash the existing roof just prior to the coating application, if required by the FM Approval or by the coating manufacturer.

FM Approval requirements for minimum and maximum slope and application rates should be followed. Additionally, roof coating applications, should at a minimum, meet the wet film thickness (WFT) and/or dry fill thickness (DFT) per the FM Approval.

Miami-Dade Approvals

To achieve Miami-Dade approval, a coating must comply with the Florida Building Code (FBC), including the High Velocity Hurricane Zone Requirements of the FBC. As with the IBC, the FBC requires the material to meet certain ASTM Standards, none of which specifically test the adhesion to metal roofing.

The code does not address long-term performance but is mostly concerned with wind uplift. Aside from a minor weight effect, coatings do not improve wind-uplift performance.

Summary

Properly designed and installed modern metal roof systems will have a service life of 40 to 60 years and is the only roof system that has a service life longer than the typical 25- to 35-year service life of photovoltaic panels. The best method for building owners to achieve long-term service life of their metal roofs is for the building owners to take a proactive approach to the maintenance of their metal roof and have repairs made when localized issues arise, before pervasive deterioration occurs. Structural integrity loss cannot be coated, and more aggressive repairs are required. It is difficult to recommend a coating repair to metal roofing when it may not be a code compliant solution. Budgeting for roof replacement or recover should be in the long-term planning.

When concerns become overwhelming, owners should retain the appropriate design professional to evaluate the existing roof metal roof system:

1. Evaluate the metal roof panels and their integrity.
2. Review past and current leak locations and the integrity of the underside of the roof panel and adjacent structure.

3. Determine if a coating would be applicable or if other solutions are recommended.
4. Review the potential solutions.
5. Review manufacturers' test data.
6. Review the contractors' qualifications and history of coating application.
7. Perform adhesion testing.
8. Determine the code requirements based on the owner's long-term goals.
9. Determine if photovoltaics are part of the owners' long-term goals.
10. Evaluate the life cycle cost of a 40- to 60-year life retrofit versus a short-term coating option.

Once a solution is determined, the design professional should prepare the appropriate construction documents that define the scope of work so that all bidders have a clear understanding as to what is required.