Technical Bulletin

Marine-Grade Lighting

Marine and coastal environments are particularly harsh on buildings due to high levels of airborne salt particles, winds and humidity. When ocean waves break, salt water becomes aerosolized and carried inland by the wind. This salt and moisture can cause premature decay and failure in metal building materials and fixtures. To ensure durability and normal service life for lighting fixtures in these environments, it is recommended to specify marine-grade trims and fixtures. Regardless of the material or finish process, lighting fixtures for coastal regions should comply with the American Architectural Manufacturers Association's (AAMA), AAMA 2605 performance standard and testing procedures for optimal wear and corrosion resistance.

Where are Marine-Grade Finishes Required?

While the highest levels of salt spray are closest to shore, accelerated corrosion can occur up to five to 10 miles inland, according to the NFIP Technical Bulletin 8 by FEMA[1]. For installations within 10 miles of the coast, marine grade, IP-rated fixtures should be used for proper protection and longevity.

In regions with extreme weather and environmental conditions, corrosion may occur even further inland than 10 miles. The strongest example would be isthmuses, surrounded by ocean, like the southernmost parts of Florida. Since there isn't a comprehensive source of corrosion data by geographic region, it's best to consult local building professionals and examine levels of corrosion in older buildings to identify high-corrosion areas.

Metal Corrosion

Lighting fixtures often use a combination of metals like aluminum, steel, and other alloys for housings, trims, and major components. Aluminum, commonly die-cast or extruded, is frequently used for trims and fixture bodies due to its fluidity, casting strength, light weight, and hardness. However, metal alloys present a challenge.

When exposed to air and water, raw aluminum alloys develop an aluminum oxide layer that protects against further corrosion. This natural protective layer is sufficient in most interior or mild climates but inadequate against salt water or acidic substances. Salt and moisture make aluminum alloys susceptible to galvanic corrosion.

An example of corrosion on aluminum.

Galvanic corrosion occurs when a more negatively charged metal (sacrificial anode) transfers electrons to a more positively charged metal (cathode) via an electrolyte. This corrosion can cause pitting, finish deterioration and loss of structural integrity for the metal. In marine environments, salt and moisture create an electrolytic solution that facilitates this process of galvanic corrosion. Many aluminum alloys contain elements like copper, which are problematic due to their position on the galvanic scale. Therefore, lighting manufacturers must take additional measures to protect metal parts from galvanic corrosion and ensure a proper fixture lifetime.

[1] Refer to Section 6, page 14 - https://www.fema.gov/sites/default/files/2020-07/tb8_corrosion_protection_metal_connectors_coastal_areas.pdf

Marine-Grade Lighting Finishes

For light fixtures that retain their day-one appearance for years, marine-grade lighting fixtures are an the best choice. There are two main processes to achieve marine-grade finishes with aluminum parts: marine anodizing (also known as hard anodizing) and epoxy-based powder coating. Alternatively, manufacturers may use other metals like brass or stainless steel, which are naturally more corrosion-resistant, though these are mostly used for landscape lighting fixtures.

Epoxy-Based Powder Coating

Powder coating provides a highly durable and corrosion-resistant finish for aluminum fixtures. This specialized painting process uses electrostatically charged paint particles that are magnetically attracted to a positively charged substrate, ensuring an even and thorough application. After coating, the substrate goes through a curing process in an oven, where the particles melt and fuse together, creating a robust finish.

Epoxy-based powder coating follows a similar process but offers even higher abrasion and corrosion resistance. Epoxies, a class of polymers used as adhesives and sealants, consist of two parts: a resin and a hardener. When mixed, they undergo a chemical reaction that forms a rigid cross-linked structure, providing excellent corrosion resistance and durability. Additionally, epoxies maintain flexibility, making them suitable for areas prone to extreme thermal changes, as they resist cracks in the finish due to underlying metal expansion or contraction.

The epoxy powder coating process begins with surface preparation, involving mechanical cleaning (such as sandblasting) and chemical treatments to ensure the substrate is free of contaminants for optimal adhesion. After preparation, an epoxy primer is applied, followed by a super-durable polyester powder coat finish. Once cured, this process results in an ultra-durable outdoor finish. The combination of epoxy and polyester polymers; heavy application thickness; and high adhesion creates a UV-resistant, corrosion-resistant, and flexible finish that can withstand extreme architectural environments.

Anodized Aluminum

Anodizing involves submerging a metal part in an acid-electrolyte solution and applying an electrical current, creating a controlled oxide layer that is durable and corrosion-resistant. Standard anodizing forms an oxide layer about 12 microns thick, which is inert and resistant to corrosive elements but can wear quickly. This process can create micro-pores in the aluminum surface, which require sealing. Standard anodized aluminum is suitable for typical indoor or non-marine exterior applications, but the thinner oxide layer, even with a sealant, is still susceptible to scratching and corrosion.

Anodized aluminum tends to have a more metallic appearance, often showing brush marks and texture.

Hard anodizing, on the other hand, creates a thicker oxide layer of 25 microns using a stronger acid bath, typically sulfuric acid with organic acids like oxalic or amino sulfonic acid. This process operates at a lower temperature but uses a higher electric current density, resulting in greater abrasion resistance and durability. Hard anodized aluminum is more suitable for marine-grade applications and industrial or commercial uses requiring high wear resistance.

Despite the high durability that comes from hard anodizing, there are some drawbacks, specifically for architectural lighting. Both standard and hard anodizing involve harsh chemicals, higher costs, and skilled labor. Annodizing is also an innately variable process, which can result in inconsistent color. Finally, anodized aluminum may also be susceptible to UV damage and color fading, and its metallic appearance,

compared to traditionally painted metal finishes, may not be ideal for architectural-grade lighting trims.

Non-Aluminum Marine-Grade Fixtures

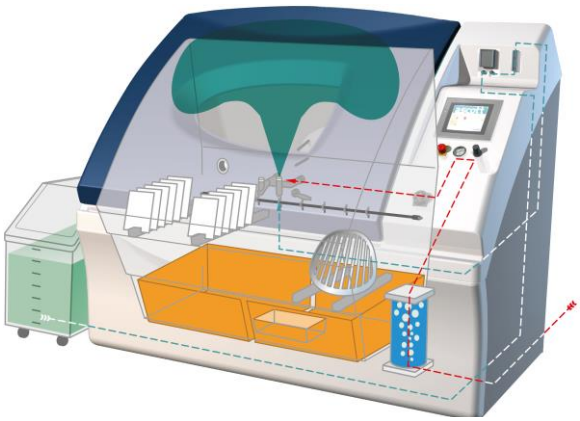
Some manufacturers use metals other than aluminum to achieve marine-grade durability, with brass being the most common. Brass, an alloy of copper and zinc, forms a durable protective layer known as a patina when oxidized. This patina prevents corrosion but changes the fixture's appearance over time. Raw brass initially has a high shine and yellowish color, but in marine environments, it typically develops a light green patina. While this change may be desirable for some installations, it can be bothersome for others due to its unpredictability.

Brass develops a bright green patina in marine / coastal environment.

AAMA 2605-05

As noted, AAMA 2605-05 is set by the American Architectural Manufacturers Association (AAMA), which outlines performance requirements and testing procedures for coated aluminum products. The full document title is “AAMA 2605-05 Voluntary Specification, Performance Requirements and Test Procedures for Superior Performing Organic Coatings on Aluminum Extrusions and Panels.” This ten-year weathering performance specification demands high abrasion, salt spray, and humidity resistance for coated aluminum materials.

Section 7.8.2, Salt Spray Resistance, is particularly relevant for marine-grade finishes. Test samples are scored with a knife deep enough to expose the underlying aluminum and then subjected to a 4,000-hour, 5% salt solution spray test in a highly specialized test chamber that atomizes and disperses salt water[2]. The parameters for this test are defined by the ASTM B 117 standard[3], ensuring consistent testing conditions. After 4,000 hours, the specimen is examined for finish failure and blistering around the scored area, according to ASTM D 1654[4]. To pass, the finish must not deteriorate more than 2.00mm beyond the scribe and must have less than 3% finish failure in the unscribed area.



A diagram of a salt spray chamber from Ascott Analytical, used to test marine grade products.

These stringent and rigorous testing standards simulate real-world stress from marine or coastal environments consistently exposed to salt fog and spray. When evaluating lighting fixtures, look for products and manufacturers that can substantiate marine grade claims with independently verifiable testing performed in accordance with these standards.

Marine-Grade Fixtures and IP Ratings

Aside from the finish of exposed metal trims and fixture components, marine-grade lighting fixtures should

[2] Example test chamber: https://www.ascott-analytical.com/how-chambers-work/cct-chambers-salt-spray-mode-how-it-works/
[3] ASTM B 117 can be purchase here: https://store.astm.org/b0117-64.html
[4] ASTM D 1654 can be purchased here: https://store.astm.org/d1654-24.html

also be IP rated to ensure that increased levels of humidity, moisture and salt cannot reach internal components and electronics in the fixture. Marine-grade fixtures should achieve a rating of at least IP65, which means it is fully dust tight and protected against water jets. For a comprehensive overview on IP Ratings, reference DMF's IP Ratings Technical Bulletin[5].

DMF's Marine-Grade Products

DMF Lighting has select products that can be configured with marine-grade trims or finishes, all of which comply with AAMA 2605-05, Section 7.8.2 and achieve a minimum rating of IP65.

- M Series Coastal IP/Marine Grade Trim – The 4-inch M Series recessed downlighting family features a wide range of specification options. Our newest 4" Coastal IP/Marine Grade Trim offers superior durability for corrosive, marine environments. Available for the round downlight in both black and white colors, the marine-grade finish utilizes a super durable epoxy-based power coat finish (as outlined on above) and additionally achieves an IP66 and IK10 rating with its fully sealed and impact resistant front lens. Look for the "IP" part code under the trim selection for the standard round downlight.

IP	Marine Grade/IP66 [17]

- Coastal IP65/Marine Grade Cylinders – DMF's 3" and 4" Cylinders offer a massive array of options for exterior lighting applications, from pendant, surface mount and wall mount in a variety of extrusion lengths, and are now available in Coastal IP65/Marine Grade configurations. Utilizing the same light engine modules from their counterpart downlight families, these marine-grade cylinders are finished in the same manner as the Marine Grade/IP trim and achieve an IP65 rating, appropriate for use in fully exposed, uncovered exterior applications. Complete information and spec sheets can be found on the respective web pages:
  - 3" Coastal Cylinders
  - 4" Coastal Cylinders

[5] https://dmflighting.s3.us-west-1.amazonaws.com/wp-content/uploads/IP-Ratings.pdf