



GECC-1

Proven corrosion prevention
for over 30 years

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GECC-1 is a coating used for corrosion prevention on steel and stainless steel turbine components. Composed of an aluminum base coat and a ceramic top coat, the coating provides a galvanically sacrificial layer to protect the substrate from corrosive environments.

GECC-1 has been in use for over 30 years and has a robust operating history. The chemistry and process control elements of the GECC-1 coating are discussed, as well as visual appearance and surface finish characteristics of this class of protective anti-corrosion coatings.





Figure 1. GE Gas Turbine Compressor Rotor with GECC-1 Class A Coated Blades

What is GECC-1?

GECC-1 is an inorganic phosphate aluminum-ceramic slurry coating used for sacrificial corrosion protection on steel and stainless steel turbine components. The sacrificial base coating is composed primarily of aluminum powder while the outer top coating contains ceramic particles that give the system a blue tint. These types of coatings have been used in industry for over 40 years dating back to the original Teleflex formulation by Charlotte Allen. Improvements to this original formulation by Roger Haskell at General Electric led to GECC-1.

Background on Chemistry and Application Method

There are two classes of GECC-1 coating, A and B. Class A denotes a base coating and top coating. This is typically used in compressor blade airfoil applications (see Figure 1). Class B denotes a base coat only, and is typically used on rotor wheel applications to prevent corrosion in the web portion of the disk. This paper is focused on class A coatings used in compressor airfoil applications.

Prior to the application of GECC-1 coating, parts should be cleaned thermally or chemically to remove any residual machine oils, followed by a dry grit blast—preferably with aluminum oxide to remove oxide scale allowing for good adhesion to the steel substrate. Once the surface is clean and free of oils and oxides, the base coat is applied. The base coat slurry is a water-based phosphate solution with aluminum powder in suspension with small amounts of hexavalent chromium ions.

The suspension is mixed to disperse the aluminum powder prior to spraying onto the parts. GECC-1 coating is applied using a commercial paint spray HVLP gun as is done with other commercial slurry coatings. After the aluminum-filled base coat has been applied, it is dried and cured at up to 650°F (343°C). At these temperatures, the phosphate solution vitrifies, turning into a glassy matrix that tightly bonds the aluminum particles to one another and to the metal substrate, resulting in an insoluble metal-ceramic composite coating.

The cured base coat is not electrically conductive. It is also somewhat porous, due to microscopic spaces that remain between the aluminum particles. In both classes of GECC-1, the cured base coat is burnished with a dry media blast, using either fine abrasive grit or glass beads, to reduce the porosity and to make the coating electrically conductive through the aluminum particles. The electrical resistance of a properly burnished base coat will typically be much less than 15 ohms when measured between

two probes placed 1" apart on the coated surface. When conductive, the aluminum-ceramic base coat of GECC-1 is galvanically sacrificial to steel and will protect components from corrosion.

Corrosion resistance of burnished sacrificial aluminum-ceramic is further enhanced in the GECC-1 Class A system by adding a sealing and chemically passivating top coat. This top coat slurry mixes fine blue metal oxide pigment with the same chromate/phosphate binder utilized in the aluminum-filled basecoat. It is sprayed over the burnished base coat and then dried and cured in the same manner to produce a semi-transparent glassy layer on the surface of the basecoat. Oxide pigments in the top coat give the translucent sealer a blue color.

The top coat substantially fills any porosity that remains on the surface of the burnished base coat. More importantly, the chromate/phosphate binder in the top coat chemically passivates aluminum on the surface of the base coat that has been exposed by burnishing. When the GECC-1 top coat has been properly applied and cured, the surface of the coated part is no longer electrically conductive. This passivating effect of the top coat provides a physical barrier that shields the aluminum-ceramic base coat from environmental effects and accounts for the durability of the GECC-1 Class A system in normal service. A cross-section of the Class A coating is shown in Figure 2.

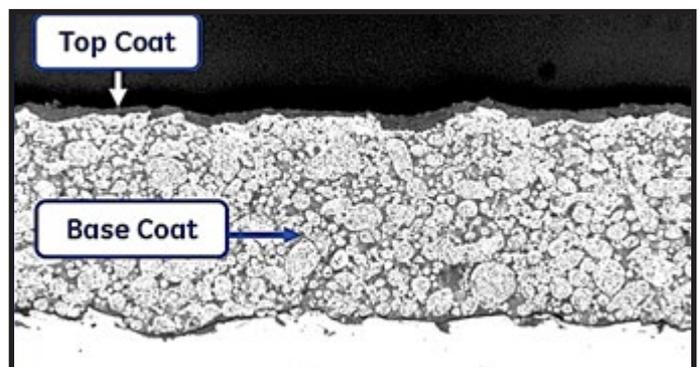


Figure 2. Cross Section of GECC-1 Class A Coating Field Run at FP&L Martin Site

Mechanism of Corrosion Prevention

Both classes of GECC-1 provide sacrificial (cathodic) protection of underlying ferrous base metal. Steel and aluminum have different electrode potentials. When in contact with one another in the presence of a corrosive electrolyte such as salt water, the aluminum will preferentially be attacked due to its higher potential, even when the steel is exposed directly to the corrosive environment. The aluminum base coat in GECC-1 is burnished and compacted to ensure it is electrically conductive and galvanically sacrificial. Burnishing is critical to assure there is an electrically conductive path between the aluminum coating and the steel substrate so preferential galvanic corrosion occurs in the protective coating, rather than the part.

GECC-1 can be applied to all GE compressor steel alloys. Earlier GE publications advised against coating the forward airfoil material, GTD-450, due to a potential fatigue life decrease. This is no longer a valid concern for GECC-1. Extensive laboratory testing and field experience has demonstrated that GECC-1 provides effective pitting resistance for GTD-450, with no detriment to part durability. This paper's cover page illustrates a GE compressor with GECC-1 coated GTD450 blades.

Process Control Elements

The GE process specification for GECC-1 has five main controlling CTQ (Critical to Quality) measurements that are taken during the coating application process to help ensure the performance and effectiveness of the coating for corrosion protection:

- Base coat burnishing for densification
- Base coat conductivity check to ensure effective burnishing
- Total coating thickness (base coat + top coat)
- Water swab test to confirm coating layers were properly cured
- ASTM B117 salt fog (during qualification phase at new vendors)

In addition, the specification outlines acceptable surface features and limits to that acceptance. Allowances in process specification are as follows:

- Fisheyes
- Pimples
- Dimples

The specific surface features above are acceptable provided they are below a size threshold and do not exceed an average occurrence per unit area defined in the specification. Touch-ups on GECC-1 coated blades are also permitted by GE to cover these imperfections and do not affect the performance of the coating.

Physical Characteristics

Color Variation

The GECC-1 coating has a distinct blue appearance which is imparted by the reflection in the outer microns of the top coating; it is recognized from years of GE experience with the top coat formulation used that there will be some color variation in the final product. Color in sealed sacrificial coating systems is driven by the types of oxide pigments or fillers in the top coating. Various colors can be seen across the industry from tan (khaki) to green or gold (no pigment) to the GECC-1 blue. Chromate/phosphate top coats are translucent; as such, some of the color and reflectance of the burnished base coat shines through, contributing to the overall color of the finished

system. Consequently, all sealed sacrificial coatings exhibit some variation of intensity, regardless of color. Though color variations may be more apparent in darker colored top coats, even unpigmented sealed sacrificial coating systems vary in color. For example, the color of one such competitive sealed sacrificial coating system, (SermeTel 5380DP¹), varies from gold to a green depending upon the thickness of the unpigmented top coat, the type of burnishing media used on the base coat and even the cure time and temperature used.

The GE process specification for GECC-1 allows for color variation in the GECC-1 coating system. This color variation does not affect the protective nature of the coating provided the CTQs of the GE specification are met.

Surface Condition and Surface Finish

The primary application for GECC-1 coating is corrosion protection of forward compressor blades. The coating process, like other spray-and-cure galvanic sacrificial coatings, entails a grit blast preparation step to remove surface oxides and to roughen the surface for mechanical adhesion of the coating to the blade surface. This step will increase the airfoil roughness to a certain extent. The base coating application is next and based on the loosely packed aluminum particles present also leads to some roughness. The top coat sealer which is used to passivate and make the overall coating system more protective does smooth the final coating slightly. In general, a coated blade finish is 20–30 Ra more rough than a GE super-finish airfoil.

The GECC-1 coating process will typically produce a surface finish in the 30–60 Ra range, depending on a host of factors from uncoated surface finish, to blade geometry, to local vs. spatially averaged measurements. Blades that are super-finished would see an increase in surface roughness due to the grit blast surface preparation and coating application. GECC-1 should be considered to have limited surface finish debit on blades that are not super-finished. Over its lifetime, GECC-1 coating tends to maintain its surface finish—compared to a surface that may over time become rough from surface corrosion and pitting.

Summary

Our GECC-1 coating has been in use for over 30 years, providing sacrificial corrosion prevention on compressor airfoils and rotor components. This two-part coating consists of an aluminum base coat and a ceramic top coat that work in tandem to provide robust corrosion protection. GECC-1 has a specification to ensure that the performance and corrosion protection of the coating are maintained. Allowances are made for certain characteristics and features—such as color and surface imperfections. As such, some variation in the finished product is expected, both with respect to color and surface finish. These variations do not affect the protective properties of the coating.

As a leader in materials science, GE seeks new and innovative ways to address the challenges our customers face—GECC-1 was created firmly in that spirit, and 30 years on, it continues to fill a niche in the protection of heavy duty gas turbine compressor components.



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