



3700 Mansell Road, Suite 220, Alpharetta, GA 30022
P. O. Box 920220, Norcross, GA 30010

Phone: 770-281-8980
Fax: 770-281-8981

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PROPERTIES OF PORCELAIN ENAMEL Resistance To Corrosion

DATA BULLETIN PEI 503

Porcelain enamel is defined as a substantially vitreous or glassy inorganic coating bonded to metal by fusion at a temperature above 800°f.

INTRODUCTION

Porcelain enamels possess excellent corrosion resistance in a variety of corrosive environments. Long-term weathering tests conducted by the National Bureau of Standards (NBS) and the Porcelain Enamel Institute (PEI) confirm the resistance of porcelain enamel coated metals to various atmospheric conditions including corrosive industrial atmospheres, gases, smoke, salt spray and sea coast exposure. Porcelain enamel surfaces can be readily cleaned after such exposure and changes in appearance are almost imperceptible, especially among those coatings formulated to have a high degree of acid resistance.

WEATHER RESISTANCE

The weatherability of porcelain enamel is usually measured by the degree to which the coating retains its original gloss and color. In general, acid resistance porcelain enamels have better weather resistance than those that are non-acid resistant. Thus, those porcelain enamels to be exposed to weathering should be specified to have no less than a Class A acid resistance rating.

Porcelain enameled signs have been known to be still in good condition after 50 years exposure. The NBS-PEI exposure tests show that porcelain enamels of even the poorest weather resistance can protect metal from outdoor atmospheric corrosion for 15 years. To achieve this performance, the metal substrate must receive good initial coverage and there must be no pinholes or mechanical damage.

Glossy, acid resistant porcelain enamels have shown no appreciable change in appearance after 15 years exposure. However, similar exposure may substantially change the appearance of some matte and non-acid resistant porcelain enamels. Some types of highly pigmented red and yellow porcelain enamels may show some fading after several years of weathering. Details on NBS-PEI weathering tests are available from PEI.

Test references: ASTM C346 Gloss of Ceramic Materials 45 degree Specular; ASTM D2244 Instrumental Evaluation of Color Differences of Opaque Materials; ASTM C703 Spalling Resistance of Porcelain Enameled Aluminum; ASTM C538 Color Retention of Red, Orange, and Yellow Porcelain Enamels.

ACID RESISTANCE

The acid resistance of porcelain enamels can vary widely depending on composition and, to some extent, the processing used. Special formulations can provide porcelain enamels with excellent corrosion protection against aqueous solutions of alkalis, salts and most acids except hydrofluoric. Even such corrosive media as molten metals and vapor phases present in hot gases have been confined within porcelain enameled structures. The degree of attack by acid solution on porcelain enamels appears to depend less on the type of solution than on its pH.

The highest degree of acid resistance is obtained by sacrificing other desirable properties such as alkali resistance. To achieve maximum service conditions, a proper balance of acid resistance, alkali resistance and other properties is necessary. Such a balance is achieved for the porcelain enamel coatings used on such applications as home laundry equipment, dishwashers pyrolytic (or self-cleaning) oven liners and architectural panels.

Test references: ASTM C282 Citric Acid Spot Test and ASTM C283 Boiling Acid Test.

ALKALI RESISTANCE

Nearly all porcelain enamels are unaffected by alkali at room temperature. Specially formulated porcelain enamels resist hot solutions of the wide variety of alkali detergents in general use for laundry and dishwashers. These ordinarily have a pH between 9.5 and 11.5. Special chemical resistant coatings provide alkali resistance to solutions with a maximum pH of 12 at temperatures to 212 degree F (100 degree C).

Alkali resistant porcelain enamels are not necessarily acid resistant and vice versa. For porcelain enamels that resist both acids and alkalis, a balance between maximum acid resistance and maximum alkali resistance needs to be achieved in the formulation.

The standard test for alkali resistance is ASTM C614, which indicates the resistance of a porcelain enamel to a hot solution of tetrasodium pyrophosphate. Alkali resistance is expressed as mg/cm² (mg/in.²) in terms of weight loss for the area exposed to the test solution. In addition, many appliance manufacturers use one or more commercial detergents under controlled conditions to evaluate alkali resistance.

WATER RESISTANCE

All porcelain enamels are completely resistant to water at room temperature; resistance decreases at higher temperatures. Although most porcelain enamels will withstand boiling water for a short period of time without damage, they will be slowly attacked when subjected to continuously changing hot water over a period of years. However, special porcelain enamels have been developed for water heater storage tanks that withstand continuous exposure to hot water for many years.

The natural water available in different areas of the country will attack porcelain enamels differently. For example, aerated water with a low dissolved solids content has been found to be more corrosive than hard water.

Freezing and thawing in the presence of moisture will cause some porcelain enamels (and many other coatings) to spall or disintegrate. However, properly formulated and processed porcelain enamels will withstand thousands of cycles of freezing in the presence of moisture without failing.

SALT SPRAYING RESISTANCE

Many evaluations have shown that porcelain enamels with complete coverage will withstand the standard ASTM B117-571 salt spray test for days and even weeks without evidence of corrosion. In addition, experience has shown that porcelain enamels provide excellent service in applications involving salt air exposure or intermittent or continuous exposure to sea water.

SOIL CORROSION RESISTANCE

Specially formulated porcelain enamels with good continuity provide excellent soil corrosion resistance. The formulations used are those that are resistant to both acid and alkaline ground waters. The most common method of testing is to bury specimens in different types of soil for periods of ten years or more. It has been found that corrosiveness of a particular soil depends primarily on chemical composition and pH of the ground water.

RESISTANCE TO ORGANIC SOLVENTS

Porcelain enamels are completely resistant to attack by common organic solvents, dyes, greases and oils. Porcelain enamels are not dissolved by these materials and do not absorb them. For those organic materials that

hydrolyze on contact with moisture to form acid solutions, an acid resistant porcelain enamel is necessary.

GENERAL CHEMICAL RESISTANCE

Porcelain enamels are formulated with relatively inert inorganic oxides, thus providing an impervious surface that is highly resistant to most chemicals. Resistance to the following may be provided:

Strong Acids (HCl;H ₂ SO ₄)	Any concentration at temperatures to 375 degree F (191 degree C).
Hydrofluoric Acid	Not resistant.
Alkali	Maximum pH of 12 at 212 degree F (100 degree C).
Water	140 degree F (60 degree C) continuous service.
Organic acids and solvents, oils, ultraviolet light, salt spray and soil corrosion	Not affected.

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