LEAD INDUSTRIES ASSOCIATION
292 MADISON AVENUE
NEW YORK 17, N. Y.

November 17, 1960

SUBJECT: SUPPLEMENT TO
"LEAD IN THE CERAMIC INDUSTRIES"

To Members of the Lead Industries Association:

The attached supplement to our technical data book, "Lead in the Ceramic Industries," has just been published by the Lead Industries Association. It is being mailed to all persons who now have this looseleaf data book, and press releases describing it are going to appropriate trade papers.

It deals with leaded porcelain enamels for aluminum, a rapidly growing market for lead in ceramics.

It was prepared by Mr. S. W. Turner of the Association staff with the assistance of the Ceramics Technical Committee.

Very truly yours,

Secretary

RLZ:JRH

Att.

PORCELAIN ENAMELS FOR ALUMINUM

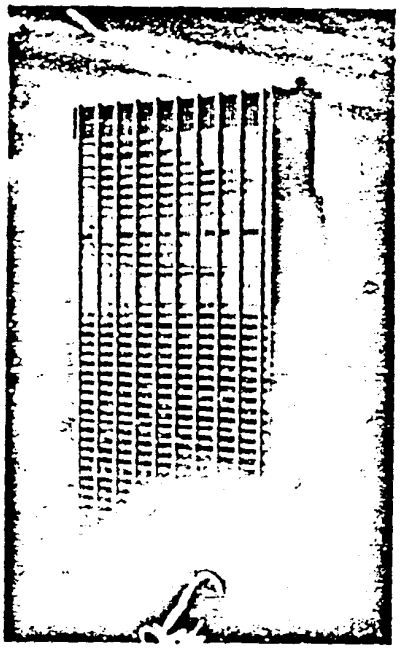
"After more than 15 years in research, development, and commercial evaluation, porcelain enameled aluminum is finding ever increasing uses in architecture, signs and a host of newer applications." With these words, Mr. B. Bracker of DuPont recently summarized the rapidly growing markets for porcelain enameled aluminum. The common denominator in this growth equation is the unique combination of properties offered by porcelain enameled aluminum – the durable color of porcelain enamel and the lightness of aluminum – a combination which is hard to beat.

WHAT ARE THE ENAMELS?

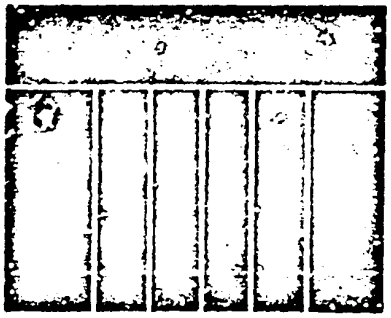
Aluminum porcelain enamels distinctly differ in two ways from conventional porcelain enamels for steel – differences which make it possible to successfully coat aluminum:

1. Firing temperatures are 580° to 600° less (1920° to 1020° F.), and,
2. Coefficient of thermal expansion is considerably higher (14 to 18 x 10⁻⁶ in. in. °C.)

Early attempts to apply porcelain enamel to aluminum used the well-known ability of lead to form low melting glasses. Successful coatings were obtained, but their poor chemical resistance offered little commercial utility.



Lower Manhattan's towering new landmark, the Chase Manhattan Building, is sheathed in 100,000 sq. ft. of porcelain enameled aluminum sheet. The facade – all black with 35 to 50% glass – was specified by the architects Skidmore, Owings & Merrill.



ENAMELS

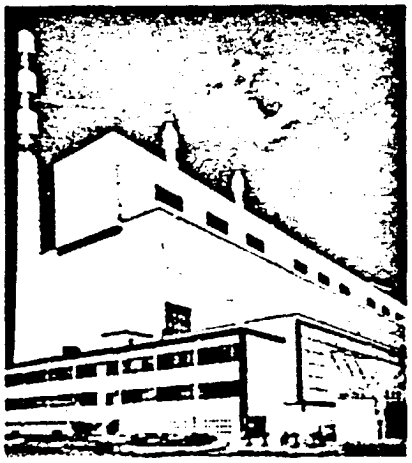
The first compositions of real commercial value were developed and introduced by DuPont over 10 years ago. Since this first introduction, the use of porcelain enameled aluminum has grown so that today suitable lead bearing frits are supplied by all of the major frit producers. The essential components of these enamels are lead oxide, silica, and the alkali group (K_2O, Na_2O, Li_2O), particularly lithium oxide. Within this system, an increase of the ratio of lead to silica and alkali will increase the gloss and flow of the enamel, but at some loss of acid resistance. The alkali group accounts for the needed high coefficient of expansion. As in all ceramic systems though, it is the proper "balance" of lead, silica, and alkali which achieves low firing temperature, high gloss, high thermal expansion, with excellent chemical stability. Usually, some of the silica will be replaced by titania. Smelted in the frit, titania does not increase acid resistance as might be expected, but is added to increase aging stability in water suspensions. Titania mill additions, however, will increase acid resistance (refer to figure 3). Some other modifications of the basic frit that have become necessary are:

1. Antimony pentoxide is added in small percentages to reduce the tendency of the enamels to darken where there are traces of organic matter, not, as is the usual practice, for opacification.
2. Boric Oxide is added in small percentages to reduce tearing and crawling.
3. In practice, opacity is obtained by titania mill additions. Titania in the frit will produce some opacity but high opacity cannot be obtained in this way.
4. These enamels are stable with all coloring oxides except the cadmium sulphoselenide red and orange pigments. Eight percent cadmium oxide (CdO) in the frit will stabilize these pigments, however.

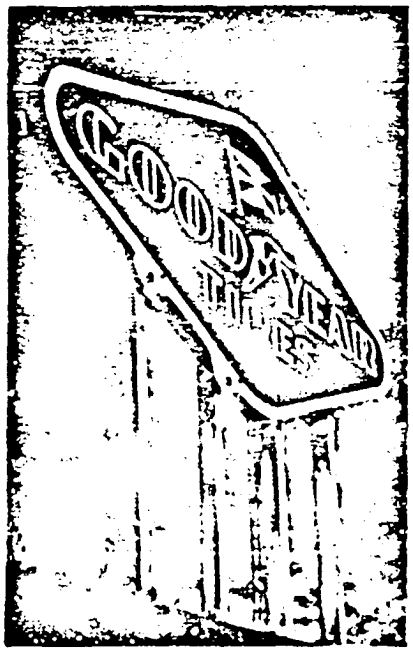
on *industrial buildings*

The mammoth Thos. H. Allen Electric Generating Station supplying power to the city of Memphis, Tenn. is enclosed in over 300,000 lbs. of porcelain enameled aluminum in green and yellow.

Courtesy H. H. Robertson Co.



Probably the world's largest free standing illuminated sign – some 52 feet high – has a background of blue porcelain enameled aluminum expanded metal. If it looks opaque in the picture, it's supposed to. Using expanded metal reduces wind loads but it was installed so that the background appears nearly opaque from the ground.



WHERE ARE THEY BEING USED?

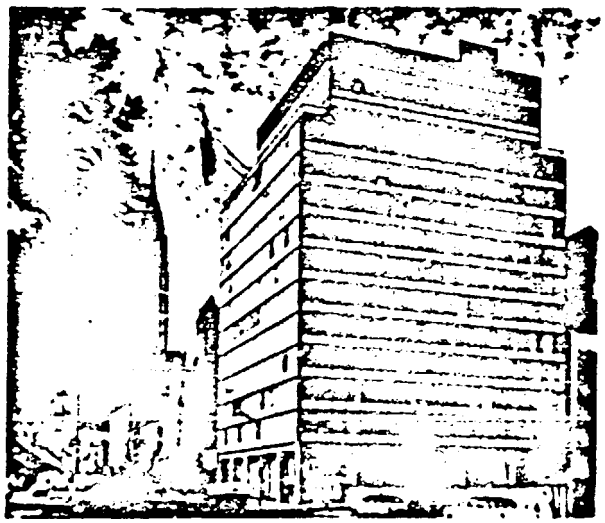
Participating in the enormous growth of the curtain wall concept in architecture, porcelain enameled aluminum is expecting its major market to be architectural siding. Numerous examples of office buildings, manufacturing plants, and schools, to name but a few, can be cited – a few are shown on these pages. But many other shapes besides flat panels are available. Fabricated forms such as extruded trim, expanded metal and louvred shapes are adding colorful highlights to many new buildings. Even pressed wall tile that can be applied right over old ceramic tile is available.

A so far untapped potential is the do-it-yourself market. Because porcelain enameled aluminum can be sawed, sheared and drilled with simple tools, any home owner can do his own wall panelling. The hard, durable, colors of porcelain enameled aluminum are ideal for playrooms, trafficked halls, patio walls and a host of other uses around the home. Porcelain enameled aluminum laminated on hardboard suitable for the do-it-yourself market is already available from at least one producer.

Castings Since 1951, cast aluminum parts with a porcelain enameled finish have been in production. Already available is a line of cookware, porcelainized on the external surfaces, and colorful ashtrays. These uses presage a great new area for porcelain enamel – finishes for parts and housings in industrial and consumer machinery and appliances. Porcelain enamel, of course, is ideal for such applications. Unlike organic finishes, porcelain enamel is colorfast and will give years of service, being highly resistant to heat, abrasive wear, detergents, mild alkalies and acids.

So far, porcelain enamel has been applied only to permanent mold castings. But the process is applicable to any casting with a consistently dense physical structure that will withstand firing temperatures without deforming or surface blistering. Bosses, recesses and special shapes can be coated uniformly without difficulty. No design limitations are involved here. However, cross sections should be fairly uniform so that they will heat uniformly when the frit is fired. The thin porcelain enamel coating has a habit of recreating the underlying surface texture. So if a high gloss finish is desired, the cast surfaces must be given a rough prefinish.

Shipboard Use Being highly resistant to salt spray and salt water corrosion, aluminum porcelain enamels have a great future market on the seas. Thousands of square feet have already been installed in the Carriers U.S.S. Saratoga and Forrestal as partitions in wet spaces. On the other side of the tonnage displacement scale, many small pleasure craft owners have installed porcelain enameled hardware on their boats.



on extruded sections

The Girl Scouts National Headquarters building on 3rd Ave in New York City is sheathed in glass framed in porcelain enameled extruded aluminum sections. The vertical strips – called mullions by architects – and the spandrel strips porcelainized in gray black are the extruded frames.

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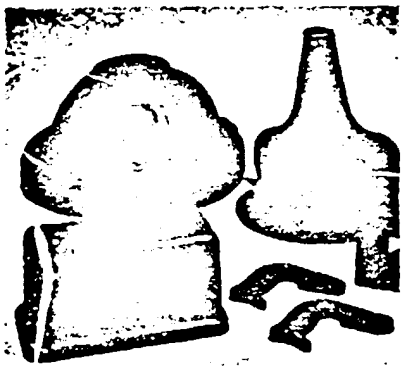
ENAMELS

WHY USE PORCELAIN ENAMELED ALUMINUM?



Experimental parts, porcelain enameled for beauty and protection from both the weather and strong detergents. An illustration of the great potential of porcelain enamel finish on cast aluminum parts and housings on machinery.

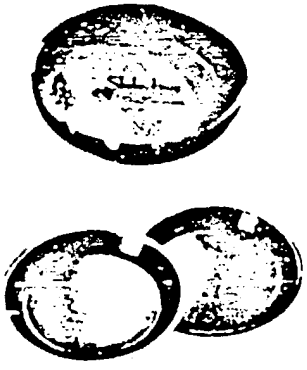
The advantages of porcelain enamel finishes over other types of finishes are well known. In fact, a more durable, scratch resistant, colorfast finish cannot be found anywhere. Other finishes have great value in many places but, when a finish that looks new and colorful after years of service is wanted, porcelain enamel is specified. Finishing aluminum with porcelain enamel gives a hard-to-beat product. For aluminum itself is lightweight, has high corrosion resistance, and can be fabricated into sheet, formed shapes, extruded sections and castings, all of which can be porcelain enameled.

This porcelain enameled coating is extremely adherent preventing progressive spalling from any accidentally damaged areas. In fact, certain fabrication operations like cutting, sawing, shearing, and drilling, can be performed after enameling without damage to the coating; even a slight amount of deformation can be accomplished. This means that standard sheets can be cut and fitted on the job. Because of the corrosion resistance of aluminum, there is no danger of rusting or streaking on damaged or cut areas.

Since only one coat is required for porcelain enameled aluminum, and it can be applied thinner (2 to 4 mils), costs will be comparable to 2 and 3 coat processes using less expensive frits.

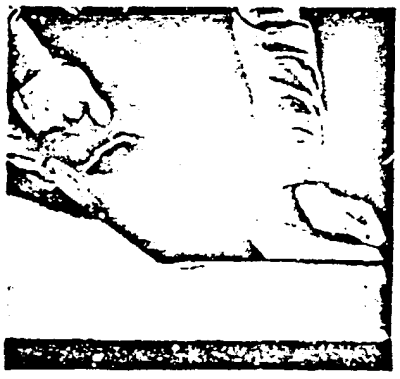
on cast parts and ashtrays

Colorful ashtrays and coasters. Cast aluminum, available on the market with a beautiful, durable porcelain enamel finish.



on the horizon for the do-it-yourselfer

Laminated panels of porcelain enameled aluminum on magnetic board can be sawed to size by the home handyman and erected in playrooms, kitchens, trafficked halls and a host of other places in and around the home.



ENAMELS

PROPERTIES OF PORCELAIN ENAMELED ALUMINUM

Formability: Porcelain enameled aluminum has the ability to endure cutting or drilling, or even a little forming after enameling. This important property is due to two factors. First, the porcelain enameled coating is tightly adherent, so that progressive spalling from a damaged or cut location does not occur. Second, due to the high opacity of lead-bearing porcelain enamels, a single coat with a thickness only one-half to one-fifth of that required for steel is sufficient for aluminum. A considerably more flexible coating is the result.

Torsion Resistance: Illustrating the formability of porcelain enameled aluminum, a torsion resistance rating of 200 plus for 3 mil thickness of porcelain enamel is given according to the test described by the Porcelain Enamel Institute. This test employs right angle shaped specimens, 12" long, and having a 3/16" radius at the right angle bend. The specimen is twisted until coating failure occurs at the radius of the bend.

Abrasion Resistance: Abrasion resistance is high – about 10 times that of organic finishes. Abrasion resistance will vary from 30 to 85% residual specular gloss, according to the standard test specified by the Porcelain Enamel Institute. The Taber abrasion resistance test gives a value of 0.0178g. for the best types, using 10,000 cycles with a 1,000 gram load and a CS17 wheel.

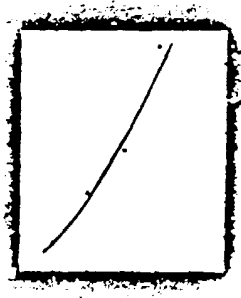
Chemical Resistance: Chemical resistance will vary, of course, with frit formulation and can vary with firing conditions. The best types have high chemical durability – being colorfast and showing no loss of gloss after years of exposure to the weather. High resistance to weathering is normally associated with high acid resistance. The better formulations with PEI citric acid spot test rating from B to A and AA can be expected to have excellent weather resistance. Figures 1 and 2 give citric acid and sodium pyrophosphate solubility curves for a commercial frit of class A rating. High alkali resistance is not considered as important a measure of weather durability as high acid resistance, but it indicates that the porcelain enamel will not stain, streak, or lose color when cleaned with strong detergents – an important point for appliances and machinery parts.

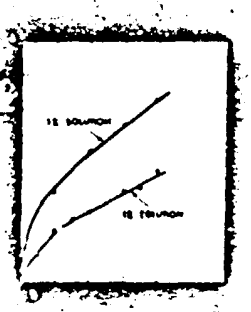
Reflectance: Reflectance for white light ranges up to 88% with total reflectance as high as 90%.

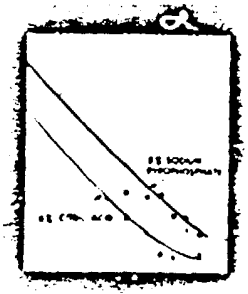
Thermal Stability: Porcelain enameled aluminum can be heated to within 500° F of the firing temperature without damage to the coating. Dry cold and freezing temperatures do not affect it, nor does alternate freezing and thawing in the presence of moisture.

Thermal Shock Resistance: Porcelain enameled aluminum panels heated to 1,000° F have been plunged into cold water without cracking or flaking of the enamel coating.

Dielectric Strength: The porcelain enamel is suitable for insulating and shielding purposes, has a voltage breakdown rating of 500 volts per mil thickness at room temperature.







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ENAMELS

PORCELAIN ENAMELED ALUMINUM

thermal stability	withstand 600 F without damage
chemical resistance	class B to AA — P.E.I. citric acid spot test
torsion resistance	200 plus — 3 mil coating, P.E.I. torsion test
abrasion resistance	65% residual specular gloss — P.E.I. abrasion test
thermal shock resistance	1000 F into cold water — no damage
dielectric strength	500 volts/mil
reflectance	88% for white light

"Pebble finish" green porcelain enameled panels lend color and texture to the new New Kensington, Pa., high school. The panels are mounted below and above windows on aluminum framing. Panels 1/8" thick insulated with 1" fiberglas are used. A 1/2" air space between the porcelainized aluminum sheet and the fiberglas is maintained by stainless steel clips.