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

August 28, 1961

SUBJECT: PORCELAIN-ENAMELED ALUMINUM EXTRUSIONS

To Members of the Lead Industries Association:

Attached is a reprint of an article on the above subject, which appeared in the May 1961 issue of "Precision Metal Molding." It was written by Mr. Sid W. Turner of the L.I.A. staff.

Additional copies up to twenty-five may be had free of charge on request, larger quantities at 3¢ per copy.

We are also circulating this reprint to our list of 5,000 design engineers.

Very truly yours,

Robert L. Zeller

Secretary

RLZ:mk
Enc.

a Precision Metal Molding

reprint

Design tips for using

PORCELAIN-ENAMELED ALUMINUM EXTRUSIONS

Distributed by:

Lead Industries Association
292 Madison Ave.
New York 17, N.Y.

Reprinted from PRECISION METAL MOLDING, May, 1961

Where can porcelain enameled aluminum extrusions be used? Almost anywhere that color, wear-resistance, corrosion resistance, and almost indefinite life are wanted in addition to the light weight, ease of extrusion, and other advantages of aluminum. For example:

- *Trim on most home appliances*
- *Furniture hardware*
- *Business machines*
- *Architectural products*
- *Sporting goods*
- *Optical goods*
- *Scientific instruments*
- *Special machinery exposed corrosive atmospheres*
- *Special machinery requiring superior wear resistance*

PORCELAIN ENAMELED ALUMINUM now offers the engineering designer the greatest flexibility he's ever had with this type of finish. For the first time, extruded aluminum shapes can be porcelain-enameled. Although there are some limitations on complicated cross-sections or long hollow forms, most shapes can be coated with no trouble.

Extruded shapes, coated with porcelain enamel give a product with all of the advantages of aluminum, plus durable, trouble free color, added corrosion resistance, flexural strength, fire resistance, and high dielectric strength. They can be sawed, drilled, welded or fastened with screws.

Porcelain enamel has been decorating metals for over 3000 years. But some of the biggest advances have taken place in the last ten, such as production of enameled aluminum permanent mold castings (since 1951),[1] and now aluminum extrusions.[2]

Architects have been the first to make extensive use of porcelain-enameled aluminum extrusions. Ideal for trim and for narrow mullions (vertical strips between windows), colorful shapes have been used as decorative structural members on large and small buildings.

Door frames, sash and window frames, and metal furniture are other examples of good design use of porcelain enameled aluminum extrusions. Bright and colorfast after many years of service (it washes clean like glass, because it is glass), porcelain enamel is a choice worth considering for any product that's meant to last for years.

In a breakthrough for a new area, one manufacturer of office machinery has specified small enameled aluminum extrusions for their chemical and heat resistance.

Fabrication

Unique among porcelain-enamel products, aluminum can be cut, sawed, or drilled, without fear of damaging the coating. The lead-bearing porcelain enamels are so adherent to the aluminum, that spalling from a cut or damaged edge just doesn't occur.

Aluminum itself is also highly corrosion-resistant, so there is no danger of rust or unsightly corrosion products forming at the exposed areas.

This means that, unlike other porcelain-enameled products, when using aluminum you can cut parts and drill and tap all fastening holes directly in the porcelain-enameled extruded stock. In building construction, panels can be fabricated right on the job.

Welding and joining

There are few design limitations to joining methods. Enameled aluminum extrusions can be welded, brazed, soldered, or fastened with screws.

An uncoated flange or underside of an enameled extrusion can be welded without discoloring or damaging the coating. The same welding techniques used for plain aluminum extrusions may be used for enameled stock. In fact, even the reverse side of a thin enameled sheet can be welded without damage if the operator is careful.

Enamel can be applied right over a welded area that has had the proper surface treatment. If enameling is contemplated, a type 4043 welding rod and inert gas should be used. The weld should then be sandblasted, and this followed by a long and strong cleaning treatment in a caustic etchant.

Applying enameling after soldering or brazing usually won't work, as the melting points of most solders and brazing materials are below the maturing temperature of the enamels.

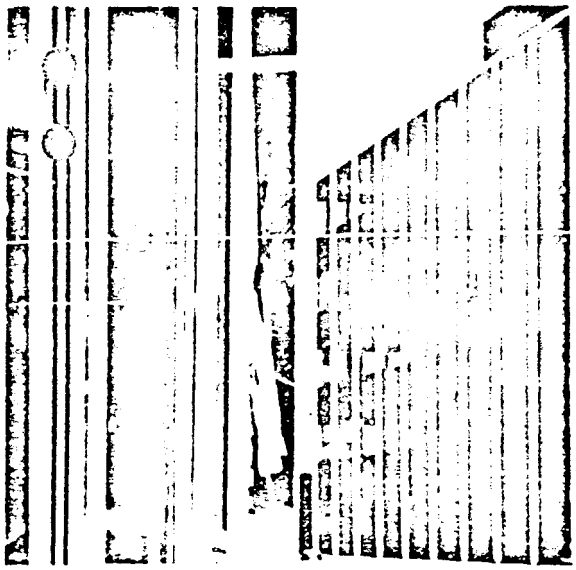
Design factors

The Porcelain Enamel Institute recommends type 6061 alloy for porcelain enameled extrusions. Very few limitations are imposed on the cross section shape by the porcelain enameling process. Limitations that do exist are due to the low mechanical strength of aluminum at the enameling temperature.

Thin-walled extrusions requiring large overhanging tongues will present a problem to the enameler. These shapes often will distort during firing, particularly if the thin section is adjacent to a much thicker section. Differences in heating and cooling rates cause the trouble here. However, enameling of both sides tends to lessen warpage.

Flanges and angles are advantageous to the design, acting as stiffeners which strengthen the metal at firing temperatures.

When mated extruded sections—dovetail, contact, contour, snap or sliding fits are designed, allowance for enamel thickness must be made in the die itself. Nominal thickness is usually 4 mils if the extrusions can be sprayed with automatic equipment; allow a tolerance of ±.5 mil, so final



ARCHITECTURAL DESIGNERS use aluminum extrusions to add strength and light weight. When parts are porcelain enameled, color is added as well as long life.

thickness is 3.5 to 4.5 mils. With manual spraying, the tolerance is ±1 mil, and final thickness is from 3 to 5 mils.

Carbon and other foreign matter must be removed from the surface before enameling. All corners and fillets should have a minimum radius of 1/16 inch, to prevent enamel burns and build-up of the coating.

Check with enamelers, such as Du Pont's electrochemicals group (Wilmington) or Ferro Corp. (Cleveland) for specific information.

Surface finish

Aluminum porcelain enamels are applied in very thin coats and don't have the flow characteristics of conventional steel enamels. As a result, all surface marks will show through the enamel.

Therefore, extruded shapes should be as free of die lines as possible. Also, careful handling of the raw aluminum stock is very important.

Scratches will appear usually as a series of bubbles or thin depressions in high gloss coatings. Rough surfaces such as a sandblasted surface are impossible to cover with a smooth coating.

Light scratches can be removed in a caustic cleaner. Deeper scratches must be ground out first with 80-grit disks, then finished with 150-grit disks; then the grinding marks are etched out in the cleaning tank.

Brake press lines can be removed the same way.

Properties of Porcelain Enamel

- **Appearance.** There is practically no limit to the variations in light-fast enamel colors, from brilliant hues to delicate tints. Textures such as stippled, mottled, and rippled finishes can be had. Almost any degree of surface reflectivity is possible, from dull matte to high gloss.

- **Durability.** The properties of glass provide long life at low maintenance cost. Some field installations of porcelain-enameled aluminum have been in service more than ten years, with no deterioration of any kind discernable.

- **Chemical Resistance.** Enameled aluminum is highly resistant to acids, alkalis and sulfides. The Porcelain Enamel Institute's acid durability rating is Class A for whites and pastels, Class B for colors. The enamel doesn't stain, streak or fade on exposure to strong detergents. Surfaces have shown no sign of deterioration after 450 hours in a 20% salt spray.

- **Impact Resistance.** In standard tests, samples averaged five impacts before loss of coating. No sharp edges, progressive spalling or flaking occurred.

- **Thermal Shock Resistance.** In tests, panels heated to 1000 deg F and plunged into cold water showed no cracking or flaking.

- **Thermal Stability.** Porcelain-enameled aluminum can be heated to within 300 F of the firing temperature without damage to the coating. (Firing temperatures are 920 to 1020 F.) Dry cold and freezing temperatures do not affect it, nor does alternate freezing and thawing in the presence of moisture.

- **Abrasion Resistance.** The present lead-bearing enamels for aluminum are not resistant to abrasion as conventional steel enamels, but they are ten times more resistant than normal alkyd-amine paint, according to PEI.

SOME REPRESENTATIVE FRIT COMPOSITIONS FOR ALUMINUM

(Composition given in weight percent)

PbO	38.1	34.7	35.4	36.4	42.6
SiO_2	25.3	31.5	23.4	34.9	28.2
CaO	2.2	2.6	2.0	2.2	2.4
Na_2O	10.2	11.1	9.5	13.4	9.8
K_2O	6.3	8.1	7.7	2.2	7.4
TiO_2	8.7	10.7	8.1	9.3	9.7
Sb_2O_3	2.9	—	1.8	1.6	—
B_2O_3	4.3	—	4.0	—	—
ZrO_2	—	1.3	—	—	—
CeO	—	—	8.1	—	—

Porcelain enamels for aluminum differ from conventional porcelain enamels for steel in two significant ways:
1. Firing temperatures are 500° to 600°F lower (920° to 1020°F).
2. Coefficient of thermal expansion are considerably higher (14 to 18 × 10⁻⁶ in./in./deg C.)

(1) *Vitreous Enamel for Aluminum Permanent Mold Castings*, PMM, April, 1955, pg. 60.

(2) *Porcelain Enameling on Aluminum*, PMM, April, 1960, pg. 55.