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

March 7, 1961

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 low-firing porcelain enamels for steel, a new market which we believe offers great growth potential for lead.

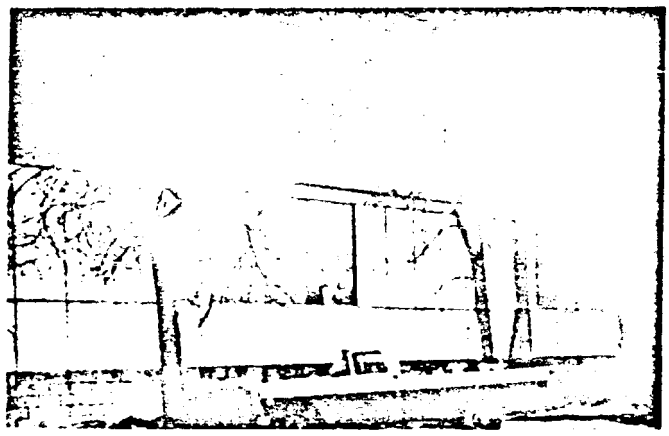
It was prepared by Mr. S. W. Turner of the Association staff with the assistance of the Ceramics Technical Committee.

Very truly yours,

Secretary

RLZ:JRH

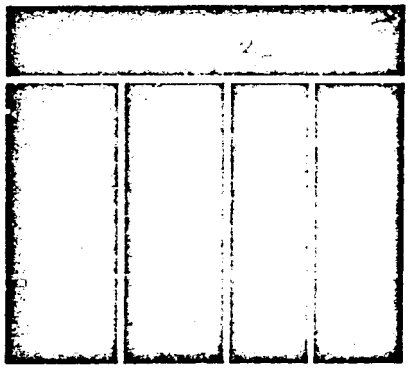
Att.



1000 F. lead bearing porcelain enamels cover a wall at Erie's Erie, Pa. porcelain enameling plant. Constructed in 1956 to check the weather durability of these enamels, no sign of rust or fading or deterioration has yet been observed.

LOW FIRING PORCELAIN ENAMELS FOR STEEL

Low firing porcelain enamels offer twin promises to the porcelain enameling industry — greater profit margin and an expanded product line. Lower production costs with low temperature frits will yield higher profit margins to the porcelain enameller. Partly darly important benefits from using these frits are lower furnace, fuel, maintenance and tooling costs.

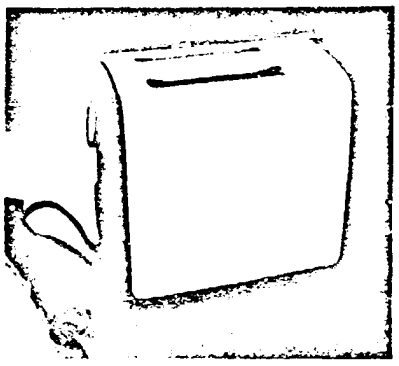


An expanded product line will be the result of an invasion by these low temperature frits of territory formerly occupied exclusively by organic finishes. Many products can now be covered with beautiful, durable, low temperature porcelain enamel products that were formerly not suitable because conventional frits don't cover corners and sharp angles and because of the inevitable distortion of the high temperature process. Distortion problems are practically nonexistent with the low temperature frits and corners and sharp angles get excellent coverage as well.

1000 to 1100 F. PORCELAIN ENAMELS

"Low temperature porcelain enamels," is a catch-all phrase. It means anything that fires lower than the conventional porcelain enamels. Actually, there are two major classes of low temperature frits for steel in use today — those maturing from 1250° to 1350° F. and those that fire at 1000° to 1100° F. These latter frits are called the extra low temperature enamels and are the subject of this supplement. Some representative formulations of these porcelain enamels are given above. Thermal coefficients of expansion for these enamels are within 1 x 10^{-6} of steel.

No special design features need be considered when using the 1000 frits. Toasters and other products formerly using organic finishes can now be coated with beautiful, color-fast porcelain enamel

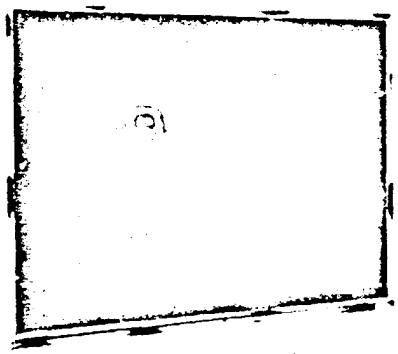


HOW 1000 FRITS CUT PRODUCTION COSTS

Low cost furnace construction and maintenance will undoubtedly yield the greatest savings from the use of these extra low temperature frits. Low temperature firing requires forced convection heating for highest production rates. Although more complicated than conventional furnaces, the enormous difference in firing temperatures — 400 to 500 F. — so reduce the design criteria that the initial cost of a furnace can be several times lower than a conventional furnace. Furnace wear at 1000 to 1100 F. will also obviously be much lower, so maintenance costs are reduced. At 1000 to 1100 F. lower cost furnace hardware can be used — and it will stand up longer too. Of course, fuel costs at the lower temperatures will be lower. It is possible in some cases to save by using lighter gauge steel, where high strength or rigidity is not essential, because the extra low temperature frits can be fired on extremely thin stock without danger of warping. In fact, sheets which are too thin to be satisfactorily coated with conventional enamels can be porcelain enameled with the low temperature frits.

These extra low temperature frits have no preference for enameling grade steels. Cold rolled steel will do just as well. So a savings is obtained here as well. An additional advantage is that if other kinds of finishing are being carried on in the same plant, only one kind of steel need be purchased, cutting down inventory problems.

Colorful blackboards in 1000 F porcelain enameled steel are now a mainstay in schools, laboratories and institutions



HOW 1000 FRITS EXPAND PRODUCT LINES

Appliance cabinets (stoves, washing machines, etc.) and the burgeoning new use of metal curtain wall in architecture are today's big markets for porcelain enamel. But a host of other finishing applications — applications formerly in the realm of organic and plating finishes — could well use the beautiful, durable finishes possible only with porcelain enamel. These are products which, because of complicated design, or light gauge metal, would hopelessly distort at the high temperatures required for the conventional process. But with the low temperature process, this is no longer true.

With the new low temperature frits almost no limitations exist on the shapes, forms and gauges that can be porcelain enameled. There are three reasons for this:

- Firing temperatures are well below the transformation temperature of steel — the point at which the steel transforms from ferrite to austenite accompanied by a large dimension change.
- At 1000 to 1100 F. steel has a much higher tensile strength than at the higher temperatures required for conventional porcelain enameling. This means that there is very little tendency for the steel to sag during firing.
- Thinner coats of the low temperature frits are possible — 2 to 5 mils compared to 5 to 12 mils. Thinner coats result in lower stresses during firing.

These three factors combine to reduce distortion so that only one side of a product need be coated. Many articles which can be coated only on one side, such

EXTRA LOW TEMPERATURE PORCELAIN ENAMELS

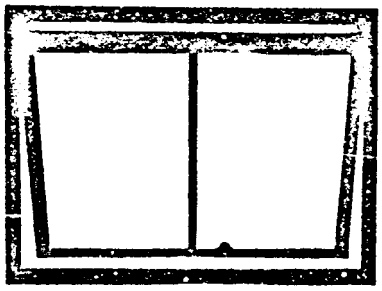
firing temperature	1000° to 1100° F.
no warpage	almost no limitations on complicated shapes that can be coated
coverage	excellent coverage on sharp edges and radii
adherence	because of thin coatings and high adherence, enameled sheets may be bent without chipping
surface finish	similar to organic finishes
gloss	better control of gloss than with conventional porcelain enamels
reflectance	76% in white
acid resistance	A to AA rating — P.E.I. citric acid test
abrasion resistance	harder than aluminum porcelain enamels, not so hard as conventional porcelain enamels

as hollow items like sash and window frames, can now have the benefits of porcelain enamel. In addition, these 1000° F. frits, unlike conventional frits, give excellent coverage on sharp corners and radii. In short, no special enameling design features need be considered in the design of the product.

WHAT ARE 1000° FINISHES LIKE?

Extra low temperature finishes are porcelain enamel and share the well-known properties of this type finish with the conventional frits, i.e., high chemical resistance, hardness, abrasion and scratch resistance and the like. Yet, there are differences in degree. Because the low temperature enamels do not "lay down" as well as the conventional enamels, the surface texture will not be as smooth. To the eye, in fact, the low temperature finishes look a lot like organic finishes. A full range of gloss values, from matte to high gloss, are obtainable by changes in the milling formula. Opacity is obtained primarily from mill additions. While a good white with about 76% reflectance can be achieved, the high opacity levels of the conventional porcelain enamels cannot be matched at present. Future research, it is hoped, will change this.

Chemical Resistance Chemical resistance of the extra low temperature coatings is excellent. Surprisingly, these 1000° finishes rate much higher on the average than the 1300° F. enamels. A P.E.I. (Porcelain Enamel Institute) citric acid spot test rating of "A" to "AA" is obtained in white and most colors. Certain strong colors, particularly the cadmium-selenium reds and oranges, will have lower resistance ratings, however. Weather resistance can be expected to be satisfactory because of the high acid resistance. Data is limited because of the newness of the frits but, in installations so far, no deterioration has been observed after several years exposure to the weather.



sash and window frames

Being hollow, sash and window frames can be coated on only one side. 1000° F. porcelain enamels do this without any distortion. Extra low temperature frits give excellent coverage on sharp corners and radii, as well.

HOW ARE 1000° PORCELAIN ENAMELS PROCESSED?

Extra low temperature enamels are processed just like conventional enamels except that greater care must be taken in the cleanliness of the steel and more careful control of firing temperatures must be maintained. Shortcuts, particularly in the cleaning operations, are to be avoided. Even greater care must be applied when non-premium steels are used. The recommended metal preparation is:

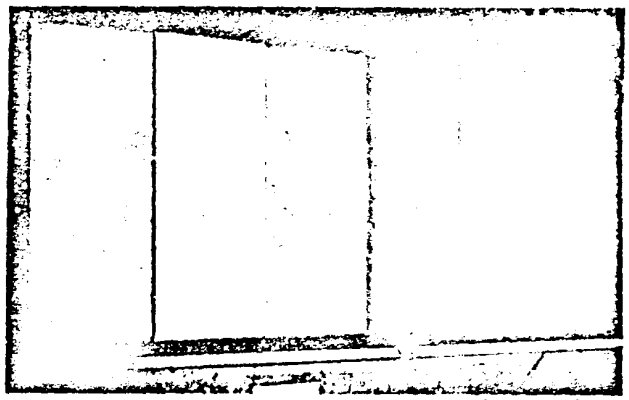
1. Cleaner bath – boiling for 20 minutes in proprietary bath (Oakite or Wyandotte or equivalent)
2. Water rinse – room temperature
3. Acid bath – 6-8% sulfuric acid 150 F. 10 minutes
4. Nickel dip – 0.06 to 0.08 gm. sq. ft.
5. Water rinse – room temperature
6. Neutralize – ½ to ¼ normal strength is recommended (dilute neutralizer should be used to minimize blisters and similar defects caused by residual salt on the steel surface.)
7. Dry

Application Spraying is the recommended method of application. Due to the extremely low firing temperatures of these frits, the use of clay and electrolyte formulations in the slip are detrimental. The result is that the base-coat and finish-coat slips have good suspension, but poor set. They work well for spray gun applications, but only to a limited extent for dip applications. Because the low temperature finishes do not smooth out or "lay down" well during firing, the desired surface texture must be obtained by proper spraying of a slip of the proper consistency.

Firing Firing of the 1000° F. porcelain enamels must be conducted in furnaces with a uniform heat distribution and accurate temperature control. A somewhat shorter firing range of the low temperature porcelain enamels is the reason. Conventional furnaces designed to operate at 1400° – 1500° F. rely on radiation for their major heating power. Radiation heating at 1000° – 1100° F. is very inefficient so firing time in a conventional furnace is unnecessarily long. Furthermore, temperature control is very difficult for conventional furnaces at low temperatures although, with care, successful firing can be accomplished. Properly, however, a furnace designed for 1000° – 1100° use – a forced convection furnace – should be used with these frits. With a forced convection furnace, heat transfer is efficient and high production rates can be maintained.

Shelf Life These frits must be ground very fine to mature evenly at the low firing temperatures. This is, no doubt, the reason for the comparatively short shelf life of these frits. The base coats work well after as much as three weeks of aging at room temperature, but cover coats should be used within one week. Over-grinding must be avoided as the shelf life can be considerably shortened. Troubles from aging are tearing, crawling, and rough, gassy texture.

1. U. S. Patent 2,842,458 to Feeney and Hommel, 1958
2. GILES, "Some Characteristics of Low Temperature Porcelain Enamels," *Proceedings of the Porcelain Enamel Institute Forum*, Vol. 18, 1956.
3. XLT OHCONAMEL Specification Sheet, O. Hommel Co., Pittsburgh, Pa.



colorful kitchen cabinets

Completely washable and immune to color fading, extra low temperature porcelain enamels put permanent color on kitchen cabinets