CLUB PRODUCTS A.S

MEMORANDUM

DATE: 21 January, 1974

SUBJECT: New Process for enameling Stainless Steel and Aluminum

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The attached report represents the experimental trials, and the results obtained from the writers research to produce and discover a new and inexpensive method for the production of transparent stainless steel. In addition, a potential new product line - transparent enamels for aluminum. Both goals were in my opinion reached successfully.

As the report indicates, additional time and experimentation will be required to find all of the possible combinations of color and enamels to give the wide range of product possible. At present, I feel the system and method is an acceptable one from both the technical and production standpoint. I believe we now have a viable process, and most important a new and proprietary one. We could be the first producer in the world with transparent aluminum enamel.

Club Products A.s

Halden, Norway

20, January, 1974

PRELIMINARY REPORT

Experimental proceedure to determine the possibility and advantage of the use of low firing aluminum enamels for both stainless steel and pressed aluminum ware.

PURPOSE:

To find a lower cost system of application of enamel to our present stainless steel gift ware production. To find, and produce an enameled coating as good ar better than the present "Crystal" and at a lower cost for both materials and application. The new enamel coating to be used for both stainless steel and for aluminum.

1) It has been known, from experiments made in Cleveland in 1972, that the conventional aluminum enamels would adhere to stainless steel. It was now desired to formulate the aluminum enamel into a transparent coating rather than opaque to duplicate the presently used transparent stainless steel enamel used at Club Halden. The aluminum enamels were not available in transparent types as the conventional way for production of transparent frit was to smelt in color oxides. Commercial suppliers of frit would not produce smelted in color frits due to the expense involved. Smelting in a color requires the manufacturer to reline his smelter for each color change. He thus requires the purchase of very large quantity of material by the customer, and at a very high price to cover his production costs.

2) It was thought, that a transparent color could be produced by the use of the regular aluminum enamel frits - (Clear transparent types), with only a very slight color oxide addition. The idea being that the small quantity of color oxide would tint the milled enamel, but not give opacity. Tests were made to determine the possibility of this and the results did give a color hue without opacity. The color results however, were not a dark in tone as with smelted in frits. Blue, blue-green, and green gave interesting results. Addition of black also provided an interesting color shade. Reds, yellow, and violet were not satisfactory, as the colors were too light and the addition of more oxide only tended to produce an opacity. The maximum percentage of color oxide was limited to about 0.5 to 0.7 %. The actual percentage will vary according to the particular color oxide used.

3) After establishing that such transparent color enamels could be produced, it was then investigated if we could silk screen a design onto a flat aluminum sheet. This was a very important factor, since if we could indeed screen a design onto the flat sheet prior to the drawing or forming operation in the press, we could have a great variety of design, and most important a design that would cover the entire surface of a dish or bowl. It is difficult or impossible to silk screen a design onto a concave or convex surface - (Screen the design onto the inside surface of a plate for example) - after the item has been formed. Several screens were made up with a rather complex design that covered the entire surface of the ware (A dish in this case), while the ware was still in the flat state. The decoration was made with aluminum silk screen enamel, dried, and then pressed into shape. A thin sheet of paper was used between the decorated surface and the die surface during drawing. The results were excellent. The plate with decoration was drawn into the proper shape with no deterioration of the design.

4) After the drawing operation was completed, the silk screen design was fired at 580 deg. Cent. for from 7 to 10 minutes. The results were again excellent. No problem was encountered in the firing operation. The resulting enamel on the decoration was hard and bright.

5) After cooling; a coating of the colored transparent enamel AL-8 type was sprayed onto the plate. The plate was again fired at the same conditions as with the decoration. The results were again very good. Several different designs were used as also different colrs of transparent enamel. In all cases the results were quite unusual and different from the transparent stainless steel enamels.

6) Scratch tests and drop tests were made to the finished aluminum plates. The enamel did not chip, shatter or break as it does with the stainless steel enamel. The aluminum enamel is slightly less hard than the stainless enamel, but will withstand hard scratching with a sharp knife blade. One can cut food placed in the enameled dish without destroying the enamel. The acid resistance is also slightly lower with the aluminum enamels (Class A/B), but the alkaline resist is better than with stainless steel enamels. It should be pointed out, that there are other aluminum enamel frits with better A-R properties than the Ferro AL-8 I used, but the AL-8 was available for these tests since it is the same frit used for making and coating our frypans in opaque. Investigations will be made with other better A-R frits in the future.

7) A thick aluminum sheet was selected - (3 mm. 2S alloy) for these tests. The thicker sheet gives the feeling of weight and quality, and matched the weight of the stainless steel. Several different surface treatments were given to the aluminum sheet to see if any particular surface condition would influence the enamel or the final visual condition. Samples were decorated and transparent enameled coated in the "As formed" condition, several were first sand blasted then decorated and coated, and some were immersed in sodium hydroxide prior to decoration and enameling. In all cases, the enamel was adherent, the only difference being in the cosmetic surface condition. Each different type surface giving a different specular reflection of color hue. The sand blasted and alkaline treated surfaces gave the best visual results.

8) One enamel cover coat was sufficient for good coverage, with the surface very glossy and even in texture. Additional cover coats did not give any improved surface, so that a one coat system is quite acceptable. Various combinations of colors and shades can be produced including a "Hi-lite" around the edge of the plates.

9) The major advantage of the use of this special mixed oxide formulation is the ability for us to use a clear non smelted in frit making color changes very simple and at a very low cost. However, trials will be made with smelted in frits to see if we can obtain deeper colors than is possible with the present system. In particular tests will be made to develop a red and yellow color which at the moment is not possible with the mixed oxide formulations.

10) There is no reason why this type of colored transparent enamel covering a silk screen decoration could not be used for other aluminum cookware products are well. No one in the world at present has or manuafactures such items. We can compete with the inexpensive aluminum ware, (Gift line items), that have transparent anodized

colored surfaces. Our primary advantage is that we could offer enameled surfaces which are harder and much more durable than any of the anaodized surfaces. Also we have the advantage of being able to produce these cheaper than if we contemplated anodization.

11) We now have many dies for the production of stainless steel ware. The same dies with slight modification to allow the use of heavier aluminum stock could also produce the items in aluminum.

ADVANTAGES:

1) Aluminum sheet in 2S alloy is common and available from many sorces. No special surface condition is required for the application of the silk screen or transparent enamels.

2) With stainless steel, the surface condition is very important to the final results obtainable. Acceptable stainless steel is often difficult to find.

3) Aluminum being more malleable can be drawn into more complex shapes without the use of special dies. In addition, there is no waste of metal as clippings and scrap after the blanks have been cut-can be either remelted or sold as high priced scrap.

4) Scrap from the present stainless steel can not be re-claimed, since the designs are cut directly into the stainless surface. Any manufacturing reject can only be re used as opaque coated items. Scrap can not be re melted and must be sold as scrap at a lower price than aluminum scrap on a weight for weight basis.

5) The aluminum items are fired at 550 to 570 degrees C. lower than is required for stainless by about 200 degrees. Thus a savings in furnace energy.

6) The aluminum coated ware will not chip or shatter as will the stainless ware after being subjected to both thermal or mechanical shock.

7) Since surface designs can be silk screened rather than cut as is now being done with the stainless steel, a faster, cheaper surface perperation is available. The possibility of design changes with screening is infinite. Special designs could be produced for any occasion with ease.

8) This combination of silk screen over the entire surface, then coated with transparent enamel is an absolute first for aluminum ware.

STAINLESS STEEL:

Investigations into the possible use of aluminum transparent enamels for Stainless steel:

As mentioned in paragraph (1), page 1, aluminum enamels were investigated for use on stainless steel in 1972 by the writer. The aluminum enamel formulations described under use for aluminum ware were now tried as a substitute for the stainless steel enamels.

1) The available aluminum enamels were investigated (AL-8, and AL-28 from the Ferro Corp.) The AL-28 frit is not satisfactory, in that it is not 100% transparent when milled. The AL-8 however was good and also had the advantage that it was a cadmium stabalized frit allowing the use of cadmium bearing color oxides for reds and yellows.

2) The AL-8 was milled in a very simple formulation to give a transparent enamel, with the same small quantity of color oxides added as with the aluminum experiments. In addition to the transparents an opaque black was tried to give a deep gloss black color with a semi-transparent cover coat.

3) Stainless samples were fired at the same temperature as the aluminum and the results indicated very good coverage and gloss with one coat. The adherence was much better than was available with conventional stainless steel enamels. Color however, was again not as deep as with the smelted in frits. The colors that were produced were quite different than any now available with our present stainless enamels.

4) It was also found, that the edge of the stainless steel ware did not have to be sand blasted for the enamel to obtain good adherence. (The sand blasted edge was one primary patent requirement for application and adherence of our present stainless steel enamels). Thermal shock and mechanical shock tests indicate the aluminum transparent enamels were better than the stainless enamels, but not as good as when the same formulations were applied onto aluminum metal surfaces. The aluminum frit enameled stainless ware could be struck hard enough to dent the steel without a complete loss of coating as is obtained with the stainless steel enamels. The fired ware would take repeated heating and quenching without shattering of the enamel.

5) Aluminum slik screening decoration could be applied directly to the clean stainless steel, (Even a polished surface), fired, and was excellent in adherence. The silk screen decoration could then be coated and fired with transparent aluminum enamel either in color or clear to produce a one coat gloss surface.

6) Since the aluminum enamels are fired on stainless steel at the lower temperature of 570 degrees C. much less oxidation is present on the back of the stainless steel ware and this requires much less effort to polish. (Approx. 1/3 the time and effort as when fired with stainless steel enamels). - This is one particular advantage with aluminum ware, in that the aluminum does not produce a stain or dark oxide when fired. Aluminum can be polished prior to enameleing and will retain its shine even after the firing operation.

7) Rather interesting effects are produced with the use of aluminum transparent enamels in place of the regular stainless steel enamels, in that the color hue and optical refraction effects are quite different due to the specular reflection properties of stainless vs. aluminum. Clear transparent aluminum enamel gives a pearl luster to the cut or ground design used in the steel. Additions of 0.5% black oxide gives a smoke effect, while 0.6% blue/green oxide has the property of change of color when observed in daylight or under tugsten incandescent light. In daylight the color is a distinct blue, while under tungsten light is is a decided green.

8) Again with smelted in color frits the final colors would be very much deeper and darker. The aluminum frits seem to adhere, fire and look as good or better than the persent stainless steel enamels. Further, the aluminum enamels can be produced either as transparents, or as opaques with little problem.

9) When an opaque enamel is desired, no surface preperation is required to the stainless other than a simple cleaning operation with organic solvents. No sand blasting is required for the opaque aluminum enamels as is now required when stainless enamels are used. The ware is produced on the press, cleaned,enameled, fired, back polished and complete. Some considerable savings are obtained in labor and handling costs.

10) A very importamt trial was made to determine if we could silk screen a decoration over the entire surface of the stainless steel as we did in the aluminum experiments. The silk screening to be made prior to pressing the blank into its final shape and form. The same test was done as in the aluminum and the results were excellent. We can screen a full decoration with aluminum screen enamel onto stainless steel, form the ware with paper interleaved between the decoration and the die surface. Coat this formed ware with cover coat in transparent enamel and fire the entire item. This could never be done in the past with stainless steel, and because of it, now screened designs were available. It should be remembered, that many color combinations can be produced in this manner with different colored silk screen enamels and cover transparent enamels.

11) Since a total silk screen enamel can be put onto the surface of stainless steel before it has been formed, it could also be possible to apply a multi-colored decal to the flat blank, press the blank to form without destruction to the decal and fire the design to the stainless. We would require the decal to be produced in aluminum type enamels similar to the type we use in our silk screen designs. (This same technique would also apply to aluminum ware).

12) Experiments were made to obtain different effects on the stainless steel. Because we can fire the enamel at a lower temperature, it is possible to first oxidize the stainless at about 700 degrees C for a few minutes. This gives the stainless surface a deep gold or bronze color. This surface is then coated with a clear transparent aluminum enamel and fired at 580 dgrees C. No change is produced on the bronze color oxide and it is covered with the clear enamel. If the blank is first oxidized to this color, and then the feather pattern is ground into it, the ground areas become silvery with the high contrast bronze color background. Clear transparent enamel over this combination is a most unusual effect.

13) Because of lack of time additional experiments were not made, in that the original purpose of the trials was to determine the possibility and results of the use of aluminum transparent enamels. It is very possible with additional experiments to find very unusual combinations all of which would be very new and unique.

ADVANTAGES:

1) Aluminum transparent enamels are easier to produce and use. Color changes by changes of oxide in the mills are easy and inexpensive.

2) Only one coat and one firing is required to produce a satisfactory finished product.

3) Temperatures are lower, less cost for production.

4) Aluminum enamels are available from several sources, and do not require "Special" formulations or are only available from limited supply sources. The enamels can be produced as either transparent, semi-transparent, or opaque only by changes in the milling composition.

5) No special surface treatments are required for the stainless steel prior to enamel application.

6) No special alloy is required.

7) We now have the possibility of silk screening a design over the entire surface of the stainless and then covering the design with a clear transparent enamel.

8) Edge configurations on the stainless do not have to be sand blasted prior to enameling.

9) Adherence to mechanical and thermal shock better than with the present stainless enamels.

10) Surface quality and gloss same or better than the present stainless steel enamel, even when several coats of stainless enamel is used.

11) Over all operations are less, costs are less, and this is a new process not used by any other manufacturer in the world to the writers knowledge.

DISADVANTAGES:

1) Aluminum enamels are slightly softer than the present stainless steel enamel.

2) The acid resistance is lower, but other aluminum enamels with better A/R are available.

3) Deep colors can not be produced except by smelted in technique.

4) Because of the lower A/R some colors in opaque should not be used - reds or yellows - because of the possibility of cadmium release into food. (This could be overcome if the red or yellow colors were smelted into the frit).

5) Limited possibility of commercial suppliers producing a smelted in color except on a large volume basis.

6) Any information pertaining to transparent enamels is not available from any suppliers as no one has used or manufactured such materials on a commercial basis. All information we now have has been obtained on an R & D basis.

A. A. Panzer