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Plate stability in screenless printing

Stephen E. Martin

PLATE STABILITY IN SCREENLESS PRINTING

by

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A thesis submitted in partial fulfillment of the
requirement for the degree of Master of Science in the
School of Printing in the College of Graphic Arts and Photography
of the Rochester Institute of Technology

May, 1980

Thesis adviser: Dr. Julius L. Silver

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An Abstract

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ABSTRACT

Lithography in the minds of most people is a method of reproducing a photograph or artwork by means of a halftone screen. The screen, usually no finer than 400 lines per inch reproduces the image by varying degrees of density through control of the dot size. With screenless printing the image is reproduced without the screen, resulting in much better detail.

The purpose of this thesis is to determine what type of plate material will work best with the "Association Product Coating", since the ST Sumner Williams plate that worked well with this coating is no longer produced. The criterion for a good plate is that it produce a full range of densities and run cleanly. This study is to determine whether a finely grained plate such as the brush grain, is the plate to use with the coating. Testing was done at different coating concentrations, different exposure times with different plate materials, and with different concentrations of prime coats.

It was also theorized that perhaps the sensitizer had something to do with how the coating performed. The concentration of the sensitizer was varied in each test to see how much of a change there was.

The test did prove that the coating worked with the

finer grained plates, and that prime coats would reduce the amount of scrumming on the plate. It was also found that a one percent concentration of sensitizer worked the best.

Abstract approved: ______________________ , thesis adviser

______________________ , title and department

______________________ , date

PLATE STABILITY IN SCREENLESS PRINTING

Introduction

Screenless printing is a method of printing a continuous-tone picture without halftone dots. With conventional halftone printing a screened image is produced, which is then exposed onto a planographic printing plate.

For screenless printing an image is produced on panchromatic film so that a longer tonal range can be obtained. From this the image is exposed onto a planographic plate.

Before one can produce a good screenless plate a continuous-tone negative or positive must be made which has a great amount of detail in both shadow and highlights. This is because in making a continuous-tone plate there is a tendency to lose highlights and shadow contrast as well as a tendency for middle tones to increase in contrast.

Continuous-tone printing was widely used before the invention of the halftone screen which came into use at the end of the 1800's. The reason continuous-tone, or screenless printing, never became a serious competitor with other printing processes is because most of the plates at that time had a very unstable printing layer which was only good for short runs and could only be run at slow speeds.

If done properly the resolution of screenless printing is about ten times as great as that of conventional half-tone printing[1]. There also is no possibility of moire patterns, which can occur if contact screens are used as in half-tone printing. Another advantage of screenless printing is that sudden changes in density do not occur as they do with dot loss in half-tone printing, since a softer gradation of tones is achieved. A better saturation of pastel colors can also be achieved by screenless printing. Since no screen is needed, continuous-tone is less costly to produce and can produce a quality which is greater then that of gravure.

In theory it is possible to produce a four color job with three colors through the use of purer and stronger process inks. With this comes the savings of an extra flat and plate besides the trouble of printing a fourth color. This may be possible with screenless printing, due to stronger saturation of colors.

Ruderman[2], claims that screenless plates will appear to lose density in the highlights, leading the pressman to think the plate is beginning to sharpen. Because continuous-tone has no dot pattern which can build up ink and spill over, the plate itself cannot be overinked or plugged. Ruderman notes:

> "pressman can increase their ink to the point that densities exceed 2.00 as compared to the maximum 1.4 density permissible by conventional lithographic techniques."[3]

Screenless lithography has a market in producing high

quality art objects, paintings, photographs, scientific literature, and textiles.

In making a plate, a close tolerance must be maintained in the manufacturing of the screenless plate since the grain must be fine and carefully shaped in most cases. Also in making the plate a uniform coating must be maintained so that closer control can be kept over the exposure and processing of the plate.

For screenless printing there are basically three types of plates used. These are collotype, random dot, and an association product plate. The collotype plate is presumed to be a combination of lithography and intaglio (relief of non-printing layer). The originator of this process was Talbot. On October 29, 1852 he applied for a patent using bichromate and gelatin as a coating for photo-gravure.[4] The Frenchman, Alphonse Poitevin, found further use of this coating by applying it to a lithographic stone, usually absorbent limestone, and printed a crude negative with it. This caused the exposed area of the emulsion to harden, and the unexposed areas to swell when in contact with water. The hardened areas accept ink while the exposed areas of the gelatin swell because of water and thus repelling the ink. Due to the soft gelatin the process at that time could only make 1000 impressions before the plate wore out.

Joseph Albert further developed Poitevin's invention by using a glass plate for a substrate. He first coated the

glass plate with a binder and then a bichromated gelatin. By applying a binder he hoped to gain better adhesion between the gelatin and the glass plate. He hoped to further improve the adhesion by exposing the front as well as the back side of the glass plate. He called this process "lichtdruck".[5] This term was later changed to "collotype" which it is called today.

In 1865, Tessie' du Motay and Marechal applied a chromated gelatin coating to a copperplate substrate.[6] This was only good for short runs because the gelatin on top of the copper base did not adhere long enough and peeled off quickly. This process of using copperplate became known as "phototype".[7]

Joseph Albert was the first to introduce a rotary collotype press. In 1873 he had the press built so that a greater press speed could be obtained.[8] About 1896, August Albert substituted for the glass collotype plate, a thin aluminum sheet. Three years later he employed the aluminum plate on a rotary press.[9]

The old style of collotype as mentioned earlier was done on a glass plate. In making the plate, the matt side is scrubbed and evenly coated with a solution of gelatin and sodium silicate. This makes way for a better adhesion of the emulsion which is to follow. The emulsion consists of gelatin which can vary in ratios of added chrome alum and potassium bichromate. As the emulsion is applied, air is

trapped beneath the gelatin. The coating is then heated until dry. During the drying process these vapor bubbles escape through the skin of the emulsion. The rising of these bubbles is thought to be caused by stresses within the gelatin layer in the process of drying. When heated sufficiently these bubbles will break the surface and cause what is known as reticulated grain on the surface.[10] The reticulated grain has been measured and the results assume that it can produce approximately a 1250 line screen.[11] During the drying process the gelatin becomes harder and more sensitive at the center of each of the granulations than at the edges. The plate is then exposed to light from both the front and back side of the plate. The plate is now put in a bath of glycerine and distilled water. This will wash away the bichromate sensitizer and cause the unexposed areas to swell. The degree of swelling will depend on the various amounts of hardening that the coating receives. In earlier years only alcohol was used to harden the gelatin, but the grain was so reduced that a screen had to be used to form any kind of pattern. Early terms for this process were called "Aquatone" or "Optak".[12]

It has been found that as the bichromate concentration of the coating is increased the quantity of moisture soaked up by the surface is reduced. However, the amount of water closer to the substrate will always be greater.[13]

Work has also been done on getting a double layered collotype printing plate to work.[14] The results have been

favorable in that the properties of the upper layer vary widely from that of the lower layer nearer to the substrate. The favorable results were due to better adhesion in the lower layer. This was accomplished by reducing the swelling in the lower layer.

The swelled areas of the plate will accept water from the atmosphere in accordance to the amount the gelatin swells. The lowest part of the hardened area being the shadow and highest levels reaching a point of higher highlights.

As expressed by Pavlenko and Nechiporenko in their paper to the IARIGAI Conference in 1975:

> "Main cause of short durability and instability of printing is gradual flattening out of the specific for collotype printing plate structure which results from recurrent moistening of the printing plate to replenish the wasted moisture."[15]

By "flattening of the specific", they are referring to the gelatin coating which must undergo constant remoistening.

Most collotype printing is done direct, so that each time a sheet passes through the press it takes moisture from the plate. For this reason most pressrooms are kept at a constant 65 relative humidity.[16] This factor also makes some types of paper unsuitable for collotype printing. Collotype inks must also be very viscous and tacky so that they can repel the water taken up.

RANDOM DOT

The second type of screenless printing mentioned was random dot. The plate for this method must have a fine grain without any directional pattern or regularity. The grain that produces the longest tonal range seems to be five or six microns. These refinements are necessary if the grain is not to appear on the print and if high quality is wanted.

Another reason grain must be carefully controlled is that the sensitizers and emulsion depends on the grain for adhesiveness and physical strength. Irving Pobboravsky and Milton Pearson said in their paper to TAGA:

> "the ability of a plate to produce ink-receptive spots varying in area is due to the point-by-point sensitivity distribution across the surface of the printing plate. The sensitivity distribution is, in turn, due to the coating thickness distribution formed by the peak and valley topography of the grained plate."[17]

With the greater sensitivity as stated above it is possible to achieve better resolution.

The random dot plate consists of a thin coating of a positive working light-sensitive resin, usually a diazo oxide plus filler resin. Close tolerance of the coating thickness must be adhered to as well as to the exposure times. Exposure times are more critical with screenless plates because there are no sharp breaks in contrast, as there are in a screened plate.

A test was conducted at the Graphic Arts Research Center,

at R.I.T., to determine whether there was any correlation between exposure times and coating thickness.[18] A diazonium resin (negative working) plate was made up using several coating thicknesses. Several exposures were then made for each coating thickness. After careful development the results showed that the thinnest coating produced the greatest amount of ink receptive areas on the plate. From this information it was concluded that coating thickness did determine how sensitive the coating might be. Furthermore, it was concluded that the coating adheres to the high point of the grain but does not adhere to the valley of the grain on negative working plates. When processed only the insoluble coating adhered to the high point of the grain.

With a positive working plate the change from insoluble to soluble must take place from the top and proceed downward. The only part of the coating that will remain, is the area that was left insoluble in the valley of the grain. A short exposure will leave the greatest amount of coating and thus produce the largest ink receptive area. Unlike the negative plate, the positive plate prints from the valley rather than the top of the grain.

From past experience it has been found that if a plate is smoothed leaving no grain and then coated, exposed, and developed, that the prints from the plate will produce sharp breaks between the highlights and shadow areas. This would produce the same kind of effect as using high contrast films.

Since the coating either adheres to the top of the grain or in the valley, the tonal range must be determined by where this coating adheres. The sensitivity due to exposure of this coating seems to be more critical on shallow slopes than if a grain has steep slopes.[19]

Because coating adhesion depends upon exposure, it is necessary that correct exposures be determined. This may have several trials as plates may tend to be exposed by extraneous light. Tests at GATF found that the:

> "same screenless litho plate did not always print the same type of image on different press runs. However, these tests did show that consistant results depend on keeping every element in the process as consistant as possible."[20]

More graduation in densities can also be obtained by applying an additional layer on the plate. A less active sensitizer is preferred over a highly active sensitizer. This is because better tonal range can be achieved through development with the less active sensitizer. An even greater density range can be achieved if the plate is given a flash exposure before the main exposure.

A positive working diazo oxide plate called the "Compulith" plate, by its inventor Milton Ruderman, has an added protection by being positive, in that the image area is protected. Ruderman says this about his plate:

> "the image is guarded against over development because it is the non-image area that is exposed to light and consequently removed. Furthermore, unlike negative plates where the heaviness of the image depends on the strength

> of the platemaker who rubs it up, development of substractive plates does not permit the platemaker to affect the image area."[21]

Images of continuous-tone plates should have a density range of approximately 0.40 to 1.40.[22]

ASSOCIATION PLATE

The third type of screenless plate is the "Association Product Plate", which is a negative-working plate. A negative-working plate refers to a plate which produces positive images on the plate from film negatives, whereas positive-working plates can only produce positive images from film positives. The coating that makes up this association plate consist of several polymers (which are thermoset with heat), along with a light sensitizer. This coating can be applied to substrates such as metal, plastic, or paper. Applied in one layer the polymer surface is sensitive to ultraviolet light after sensitizing. The coating is resistant to most types of solvents and high temperatures.

An advantage the plate has is that there is no need to worry about oxidation or gum blinding, because the grain plays no part in the non-image areas of the plate, except for acting as a carrier, and because dampening is by absorption, negating the need for gum. Gum is eliminated because the aluminum is coated and has no contact with outside elements. The reason the grain plays no part in the printing is because the image and non-image areas are on the same planar

surface. This type of plate has a true planographic surface in contrast to conventional offset, wherein the non-image area is recessed to the grain.

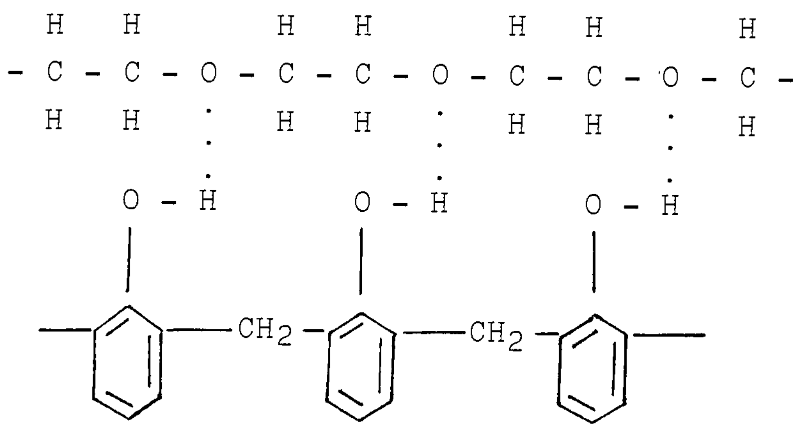
The two polymers that make up the coating have in combination, properties which differ from their individual ones. The polymers used are a combination of poly (ethylene oxide) and a phenolic resin. The plate is hydrophilic, since the ethylene oxide polymer $(-CH_2-CH_2O-)_x$ is water soluble until combined with phenolic resin. The best molecular weight for this material is about 50,000 to 10,000,000.[23]

There are two basic types of phenolic resins, novolac and resole. Novolac resins require a catalyst or crosslinking agent before they become thermosetting. Resole resins, the type used are one-step resins which need no catalyst for cross-linking. This heat sensitive phenolic resin is a result of condensation of a phenol with formaldehyde. The resole resin is a result of condensation between one mole of phenol with 1.5 mole of formaldehyde.[24] Resole resins are used because they give a longer life to the printing plate.

Poly (ethylene oxide) has been given the name "Polyox" by the Union Carbine Corporation. In a TAGA paper, Julius Silver said:

> "Polyox and phenolic resins interact extensively as a result of hydrogen bonding between the relatively electronegative ether oxygen and the relatively acidic hydrogen of the phenolic resin."[25]

The interaction can be better shown by the formula:



The ideal ratio is 0.6 to 1.8 parts of ethylene oxide polymer to one part of phenolic resin.[26] As the poly (ethylene oxide) content becomes smaller this same coating will become harder. The coating can be applied in one layer or multiple layers with the best drying temperature for each layer being about 80°C- 160°C.[27] It has been found that one layer works as well as several layers.

Before the exposure is made to a sensitized coating the coating is hydrophilic. When the plate is exposed to ultra-violet light this coating will change to an oleophilic state, meaning it will readily accept ink. The amount of change from hydrophilic to oleophilic will depend on whether a halftone or continuous-tone negative is used, and this change will be in direct proportion to the amount of exposure that the coating received. By washing the plate with water some of the poly (ethylene oxide) along with all the photointiator will be washed away increasing the phenolic resin content which is oleophilic in the exposed areas. The amount of reaction can be varied by the amount and type of photo-initiator that is

used. Basically the only requirements for a photo-initiator is that it be water soluble, and this is only so that the plate can be developed by water. The United States Patent for this type of coating states:

> "The organic photosensitive component of the composition is selected from the organic, non-oxidizing sensitizer agents which when acted upon by light energy at ambient temperatures yield free radicals capable of reactions with the phenolic resin component thereby "hardening" and increasing the molecular weight of the phenolic resin."[28]

In his TAGA paper, Silver mentioned that one type of water soluble photo-initiator would be:

> "aliphatics with a multiplicity of halogens on a single carbon atom such as iodoform acetone-bromoform, and carbon tetrabromide."[29]

The preferred amount of photosensitive material is about 0.1 to 0.13 parts of sensitizer to one part of phenolic resin.[30] Very fast photosensitizers can be used with these photopolymers to lower the exposure times. However, longer exposure times seem to give better graduation in tone. After the plate has been developed, the exposed areas will take on water in an indirect proportion to the amount of light that area received.

The plate has held up very vell with speeds of 5000 impressions per hour.[31] The plate runs with less fountain solution then does the conventional lithographic plate. Another advantage of this plate is that when printing is finished, all that needs to be done is to clean the ink off

of the plate.

HYPOTHESIS

The objective of this thesis is to test plate grains to determine what type works the best with the Association Product coating. As stated earlier, this type of coating produces a planographic surface and does not depend on the grain for tonal reproduction.

Part two of the hypothesis deals with coating concentration and what effect does it have on print quality and tonal values. There is a question as to whether thinner top coats will produce a wider tonal scale.

Third part of the hypothesis pertains to prime coats. It is thought that with thinner top coats, it would be necessary to have an intermediate coat for adhesion and also to eliminate any part that the grain may play in tonal reproduction of the printed matter. For a prime coat to work, it will be necessary that the coating have an adhesion to the grain structure of the plate as well as to the top coat.

FOOTNOTES FOR CHAPTER I

[1]Dr. F. Uhlig, "Screenless Offset Printing Process Using Presensitized Printing Plates", Journal of Photo-Graphic Science, (Vol.18, 1970), p. 4.

[2]Author anonymous, "How to do Continuous-Tone Lithography", Printing Production, (Dec. 1968), p. 74.

[3]I. Gregg Van Wert, "An Approach to Continuous-Tone Lithography for Web & Sheetfed", Printing Magazine, (May 1973), p. 25.

[4]Josef Maria Eder, History of Photography, trans. Edward Epstean (New York: Columbia University Press, 1945), p. 609.

[5]Robert J. Lefebvre, "Continuous-Tone Lithography", Penrose Annual, (Vol. 60, 1967), p. 246.

[6]Josef Maria Eder, History of Photography, trans. Edward Epstean (New York: Columbia University Press, 1945), p. 617.

[7]Ibid., p. 617.

[8]Ibid., p. 619.

[9]Ibid., p. 621.

[10]Author anonymous, "Collotype", Reprorama, (No.41,1974), pp. 10-11.

[11]Ibid., p. 11.

[12]Robert J. Lefebvre, "Continuous-Tone Lithography", Penrose Annual, (Vol. 60, 1967), p. 246.

[13]R.Kotik, L. Pavlenko, P. Sokolov, "Developments in Rotary Offset Collotype", Thirteenth IARIGAI Conference, (1975), p. 5.

[14]Ibid., p. 11.

[15]Ibid., p. 4.

[16]Author anonymous, "Cotswold Show Their Collotype", Printing World, (August 15, 1975), p. 117.

[17]Dr. Albert R. Materazzi, "Screenless Printing", Graphic Arts Monthly, (January 1975), p. 72.

[18]Author anonymous, "Screenless Lithography", Roland News, (No. 28, 1970), p. 19.

[19]Author anonymous, "Continuous-Tone Printing", Book Production Industry, (June 1967), p. 45.

[20]Ibid., p. 47.

[21]I. Gregg Van Wert, "An Approach to Continuous-Tone Lithography for Web & Sheetfed", Printing Magazine, (May 1973), p. 26.

[22]Robert J. Lefebvre, "Continuous-Tone Lithography", Penrose Annual, (Vol. 60, 1967), p. 249.

[23]Julius L. Silver, Barry L. Dickinson, "Photosensitive Compositions Containing Polyethylene Oxide, a Phenolic Resin, a Photosensitive Compound and an Oxidizing Agent", U. S. Patent 3,231,381 (Jan. 25, 1966), part 2.

[24]Ibid., part 3.

[25]Julius L. Silver, "Photosensitive Association Product", TAGA, (1969), p. 142.

[26]Julius L. Silver, Barry L. Dickinson, U. S. Patent 3,231,381 (Jan. 25, 1966), part 5.

[27]Ibid., part 6.

[28]Ibid., part 4.

[29]Julius L. Silver, "Photosensitive Association Product", TAGA, (1969), p. 144.

[30]Julius L. Silver, Barry L. Dickinson, U. S. Patent 3,231,381 (Jan. 25, 1966), part 5.

[31]Julius L. Silver, "Photosensitive Association Product", TAGA, (1969), p. 147.

CHAPTER II

Related Literature

The ST plate, made by the Sumner Williams Corporation Boston, Massachusetts, worked well with the Association Product but production of the ST plate was later discontinued. To obtain good printability with this coating another type of plate had to be found. For the plate to be successful the coating has to have some adhesion to the metal substrate.

Wear of the plate is due primarily to loss of adhesion, but abrasion of the coating plays a part as well. Some of the causes for abrasion are:

1. Overloading of ink
2. Flat areas in rollers
3. Rollers swelling
4. Imperfect ductor rollers
5. Incorrect roller pressure
6. Glazed rollers

Causes for lack of adhesion are due to forces acting between the coating and the substrate. This lack of adhesion can also lead to abrasion.

In November 1968, J. F. Padday presented a paper to the Institute of Printing describing the type of adhesion and cohesion which act across the printing surface. In his description Padday considers surfaces involved in lithography

in terms of their surface energy values:

> "those less than that of pure water being defined as of low energy and tending to be hydrophobic. The low energy image is adhesive to a low energy liquid (ink) phase, and the high energy areas of the plate adheres to high energy liquid (water). Good lithographic printing results when the forces of adhesive between phrases is weaker than the cohesive forces within them."[32]

If a plate should be smoothed, this area will have a lower surface energy because of the reduction in area due to loss of grain. This area will also become more receptive to grease. Aluminum has been the most common substrate, because of its tendency to be harder, less brittle, and less stretchable then most other types.

Ball graining of the substrate can also cause a greater loss in adhesion because a greater amount of silica residue is left behind then if brush grained. Before plates are grained it is important to know what the plate properties are to be. In both ball graining and brush graining the degree of roughness can be varied. If better adhesion is wanted the coarser grain is used, because it provides a greater surface area. Under 10X to 100X magnification an observer can achieve a fair evaluation of grain uniformity, direction, and the presence of any contaminants. Under magnification the area of defects can also be seen to start at the uncoated areas of the grain.

In the case of litho plates which have a raised surface for the image area, it is sometimes wise to use an anodized

surface. An advantage with this type of surface is that it produces the qualities of a very fine grain plus an extra hard surface. Disadvantage is that the internal stresses can be transferred to the surface affecting the surface conditions. The degree of anodizing can be varied by changing the voltage which affects the micro-structure of the cell, causing it to become larger. For a very high coating hardness a voltage of 30 volts might be used.

The most common wear of the image itself is due to the pick-up of paper dust from the blanket, which had previously come from the paper. This type of wear is due to abrasion. Another cause of frictional wear of the image is related to ink flow thickness, pressure between blanket, form rollers, and the plate, as mentioned earlier as the causes for abrasion.

In packing the blanket the pressure behind the blanket should be adjusted according to the thickness of paper being run, with compressible blankets not exceeding .003 inches (over bearers) pressure between the plate and the blanket.

When torsional stresses in the plate rolls through the nip, that area of the plate will flex causing a weakening in the physical bonding and also a polishing of the plate surface. With most litho plates, the coating thickness can influence press life of the plate. Too thick a coating will cause problems as well as the filling in of the contours of the grain. A plate which has considerable wear will show an unusual gloss or sheen in the worn areas.

Another type of plate wear is due to lack of adhesion of the coating to the substrate. Factors which affect the adhesion are roughness of the surface, and the affinity of the coating for the surface.

The roughness of the surface pertains to "mechanical adhesion", while the affinity of the surface for the coating refers to "specific adhesion".[33] The force of specific adhesion operates at the interface of coating and substrate. It is thought that this force does not extend into the coating for more than a few microns. Therefore, if one measures the force of adhesion one must add the specific adhesion force to the measurement.[34]

As to mechanical adhesion; if the surface is rough enough practically all coating materials will adhere to it. But if the surface is smooth, coatings may be peeled off easily.

Coatings made up of a high molecular weight polymer tend to have a great cohesive strength, but lack the adhesion which is needed for smooth metals. In order to develop a coating which can be useful it is necessary to balance the adhesion and cohesion forces. J.J. Bikermans, the author of "The Science of Adhesive Joints", views adhesive breaks as:

> "adhesive breaks are really cohesive breaks within a thin interfacial layer between adhesive and adherend suggests that polymerization at this interface is sufficient to explain the increase in apparent adhesion, but conclusive proof is lacking."[35]

Breaks at low exposure will occur more toward the surface,

while breaks occurring after high exposure tend to be nearer to the base/polymer interface.

The break or wear of the plate coating is also dependent upon the mechanical strength that the coating has with respect to grain. By applying different concentrations of coating to the grain it should be possible to find different levels of adhesiveness between the coating and the substrate.

By applying a gray scale and exposing it to the plate, one has a means of measuring any wear that might occur during press runs. In trying to get longer runs from the coating it may be necessary to apply some sort of prime coat between the coating and the metal substrate. The reason for a prime coat is that the coating may have a greater attraction for the prime coat then for the substrate. In selecting a prime coat, it must have high attraction for the substrate, as well as be thin enough to follow the contours of the grain without filling in the valleys. The reason the valleys must not be filled in is because the top coat must still have the mechanical strength of the contours of the grain. If the valleys are filled in the mechanical strength will be lost.

FOOTNOTES FOR CHAPTER II

[32] R.E. Whitworth, "Spotlight", British Printer, (Aug. 1972), p. 21.

[33] Henry Fleming Payne, "Performance Test", Organic Coating Technology, (Vol. 1, 1954), p. 649.

[34] Ibid., p. 651.

[35] R.W. Woodruff, W. Jeffers, and R.A. Snedeker, "Image Formation by Photoadhesion", Photographic Science and Engineering, (Mar.-April, 1967), p. 95.

CHAPTER III

Methodology

The question, as previously stated, is whether the stability of a continuous-tone gray scale can be maintained on different types of grained plates. The term stability refers to repeatability of gray scale when variables are kept constant for one particular type of plate.

It is also necessary to consider whether the coating concentration has anything to do with this stability. A third question to be asked about stability, is whether it can be improved by applying a prime coat between the substrate and top coat.

To accomplish this a continuous-tone coating, such as the "Association Product Coating" was used. The ingredients that were used to make up this coating were: phenolic resin, N,N-dimethylformamide, poly(ethylene oxide) known as Polyox, ammonium dichromate, p-toluene sulfonic acid, and phloroglucinol Amounts of each ingredients are listed in table I.

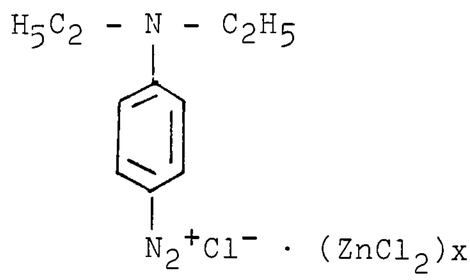
TABLE I

N,N-dimethylformamide	1200.00 grams
Polyethylene oxide (Polyox)	49.00 grams
Phenolic resin (as 60% solution)	54.00 grams
Ammonium dichromate	3.60 grams
Phloroglucinol	1.20 grams
P-toluene sulfonic acid	.69 grams
	1308.49 grams

These ingredients were blended until a viscosity was reached of 65-70 cps, at which time 1200 ml of N,N-dimethylformamide was added and 1.2 grams of phloroglucinol put in the mixture and blended to a viscosity of 40 cps.

Once the coating was made, it was applied to different types of grained material such as ball grain, brush grain, wire brush, and anodized brush grain. The coating was applied to the plate as the plate was being whirled. As soon as the plate was coated and dried it was then baked in an oven at 160° C for 20 minutes.

Each type of plate was tried at varying amounts of coating concentration. Ball grain plates were tried at full concentration, with one-half percent DE-40 and one and one-half percent DE-40. DE-40 is a diazo salt sensitizer expressed as:



The next step was to try a 50% reduction in coating with one-half percent and one and one-half percent solution of DE-40. The exposure times for the ball grain plates were 30 to 100 seconds, in five second increments. Since the sensitizers were water soluble, the plate can be developed by water. The need for gum arabic after development is also eliminated, because the metal substrate is not exposed to outside elements.

Ball Grain Plates

The results from the ball grain plates did not produce much detail in step graduation and the plate had a tendency to catch up very rapidly when the dampening rollers were taken off. The two problems are thought to be due to the coarse grain structure of the plate. This would lead to coating of only the valleys of the grain and not the peaks, leaving bare aluminium exposed to the inking system.

Brush Grain Plates

The second type of plate that was tried was a brush grain plate. The plate was coated with different coating concentrations and different percentages of sensitizer.

The first brush grain plate was coated with a full coating

concentration. Percentage of sensitizing solution tried was one-half, one, and one and one-half percent, as shown in figures 1 and 2. Best percentage of sensitizing solution for this concentration was one percent DE-40. The one-half percent and one and one-half percent sensitizer had only a three step graduation, on the stouffer gray scale, which made it poor for this type of printing.

The second brush grain plate was coated with one part coating to one part N,N-dimethylformamide. When sensitized with one-half percent, one percent, and one and one-half percent sensitizers, these plates produced about the same number of step graduations, but the shadow area of the scale seemed to be lower in density as shown by figure 3.

The third type of brush grain was coated with a mixture of one part coating to two parts N,N-dimethylformamide. This plate produced a longer graduation scale of five steps, that resulted in better tonal reproduction for one-half percent, one percent, and one and one-half percent sensitized plates (figure 4).

To ensure that the grain did not play any part in the printability of the plate, several plates were made with a prime coat. This prime coat was applied between the metal substrate and the top coat. Composition of the first mixture of prime coat was one part Polyox to eight parts phenolic resin. This was then diluted with different percentages of N,N-dimethylformamide. After blending, the prime coat

FIGURE 1

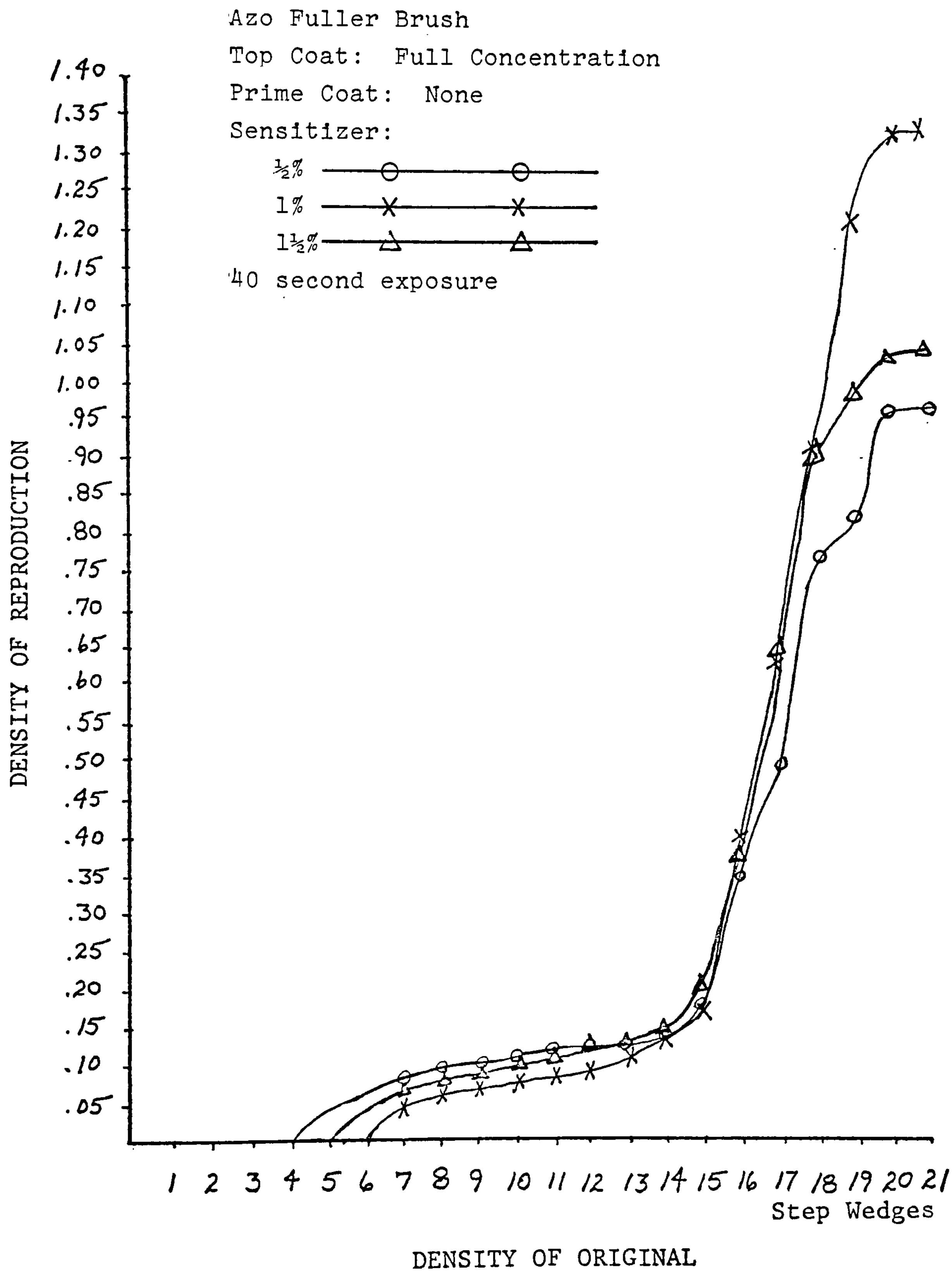

Azo Fuller Brush
Top Coat: Full Concentration
Prime Coat: None
Sensitizer:
½%
1%
1½%
40 second exposure
DENSITY OF REPRODUCTION
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
1.00
.95
.90
.85
.80
.75
.70
.65
.60
.55
.50
.45
.40
.35
.30
.25
.20
.15
.10
.05
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
Step Wedges
DENSITY OF ORIGINAL

FIGURE 2

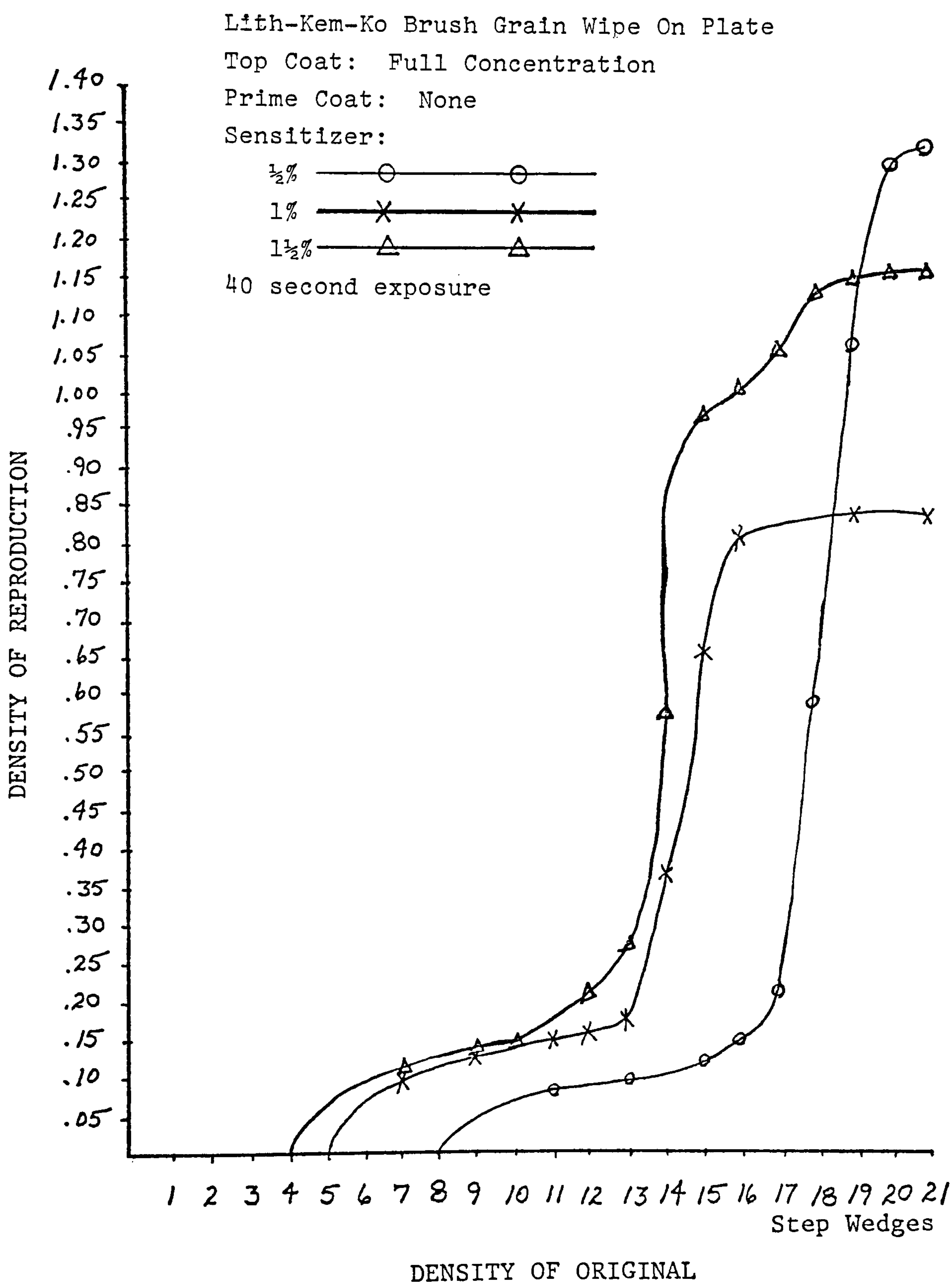

Lith-Kem-Ko Brush Grain Wipe On Plate
Top Coat: Full Concentration
Prime Coat: None
Sensitizer:
½%
1%
1½%
40 second exposure
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
1.00
.95
.90
.85
.80
.75
.70
.65
.60
.55
.50
.45
.40
.35
.30
.25
.20
.15
.10
.05
DENSITY OF REPRODUCTION
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
Step Wedges
DENSITY OF ORIGINAL

FIGURE 3

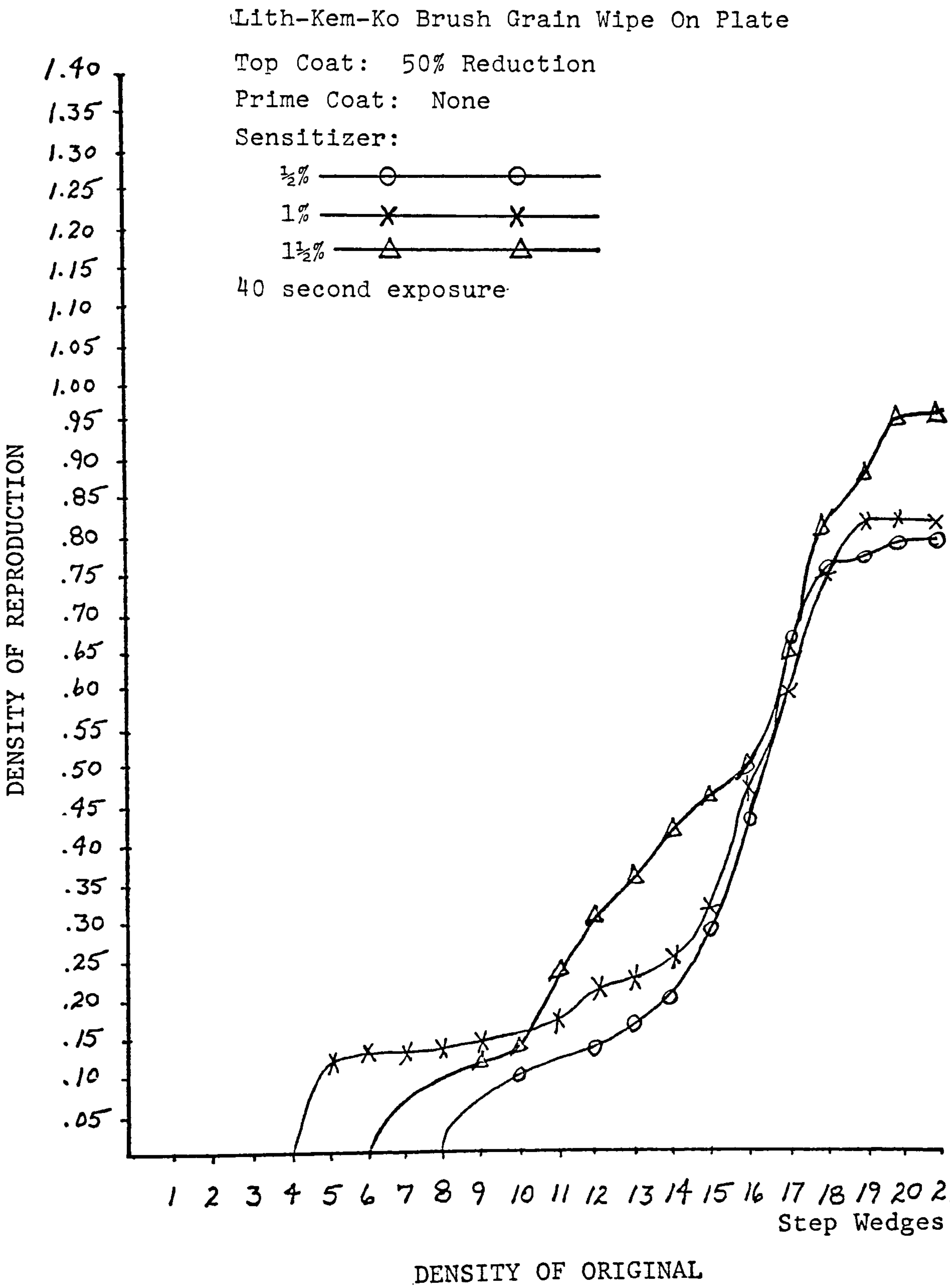
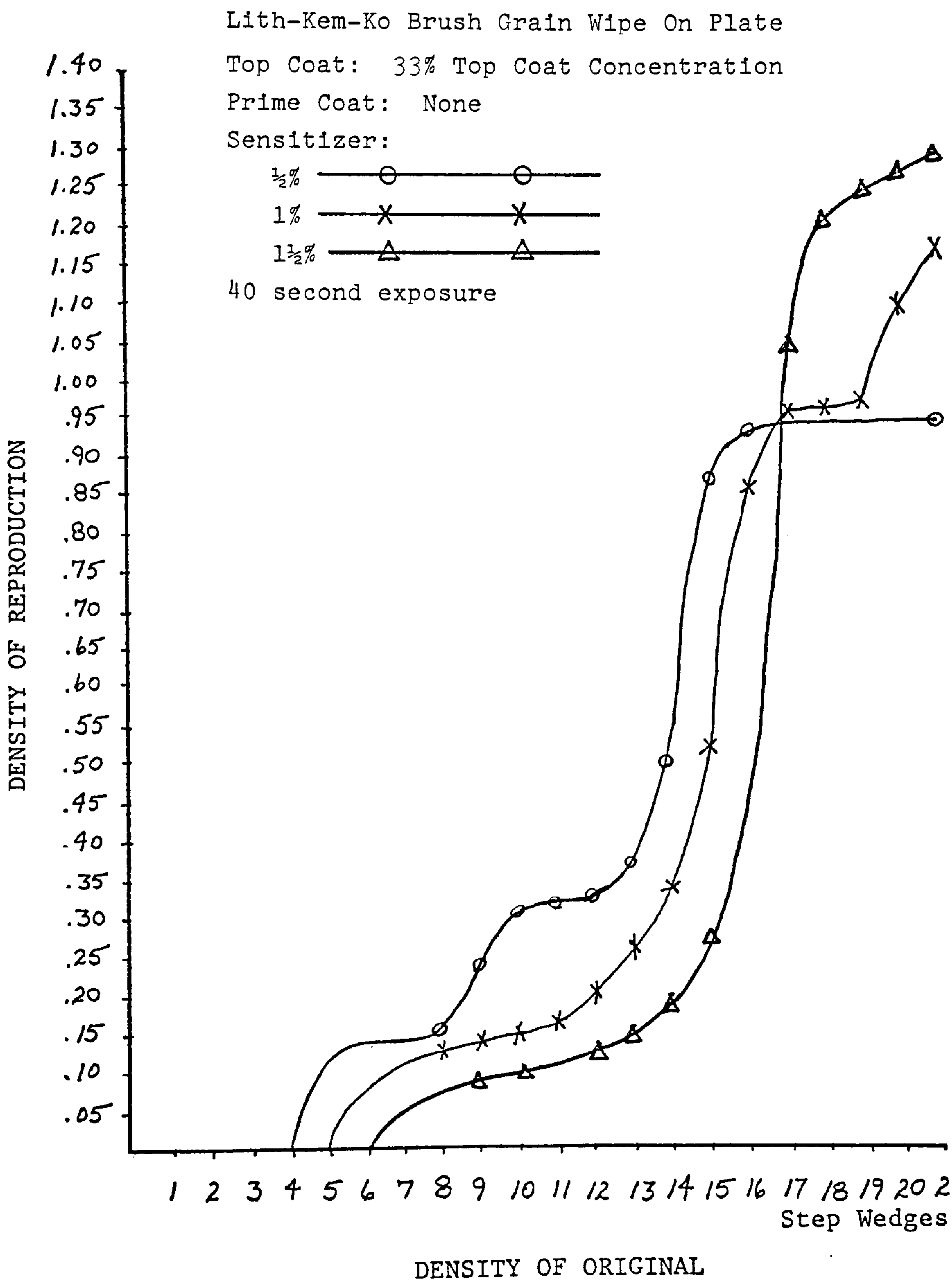

Lith-Kem-Ko Brush Grain Wipe On Plate
Top Coat: 50% Reduction
Prime Coat: None
Sensitizer:
½%
1%
1½%
40 second exposure
DENSITY OF REPRODUCTION
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
1.00
.95
.90
.85
.80
.75
.70
.65
.60
.55
.50
.45
.40
.35
.30
.25
.20
.15
.10
.05
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
Step Wedges
DENSITY OF ORIGINAL

FIGURE 4



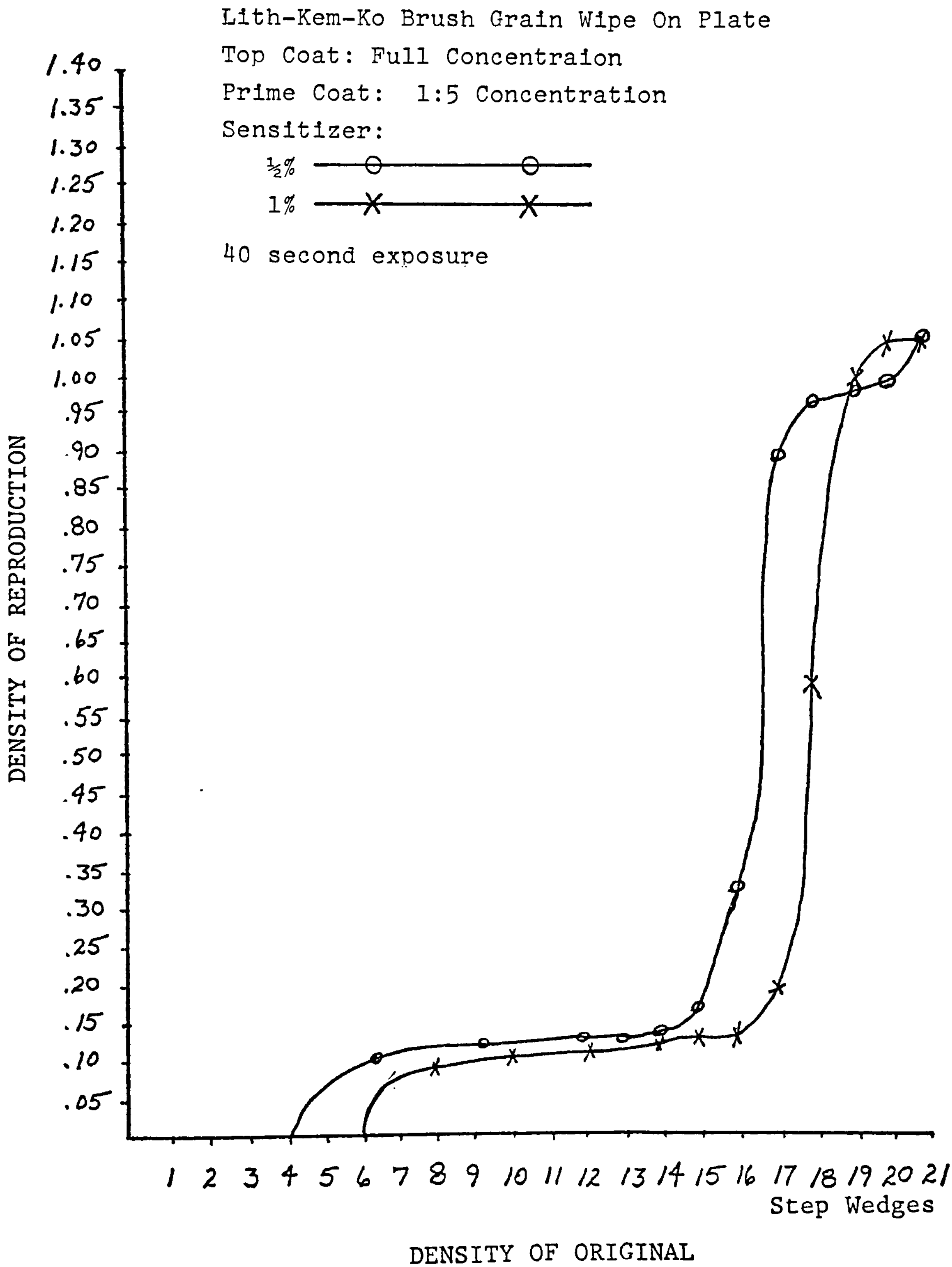
Lith-Kem-Ko Brush Grain Wipe On Plate
Top Coat: 33% Top Coat Concentration
Prime Coat: None
Sensitizer:
½%
1%
1½%
40 second exposure
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
1.00
.95
.90
.85
.80
.75
.70
.65
.60
.55
.50
.45
.40
.35
.30
.25
.20
.15
.10
.05
DENSITY OF REPRODUCTION
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
Step Wedges
DENSITY OF ORIGINAL

was whirled and baked on a brush grain plate. The procedure of how the prime coat was applied is explained later. At this time the top coat was ready to be whirled on and baked. However, after being baked the top coat had no adhesion to the prime coat, and rubbed off. The problem was thought to be due to a loss of mechanical strength, as a result of the prime coat filling in the valleys of the grain. There could also have been a problem with too much Polyox.

A second mixture of prime coat was then made with only phenolic resin mixed with N,N-dimethylformamide. This prime coat gave much better adhesion then the first prime coat. The first trial with this second prime coat produced a rather thick prime coat and resulted in little graduation of middle tones (figure 5). With a reduction in phenolic resin of one part to 15 parts N,N-dimethylformamide, the gray scale gave a greater graduation in steps, even with a full top coat concentration (figure 5). The best percentage of sensitizer for this plate was the one percent solution of DE-40. This one-half percent DE-40 was not sensitive enough and required and extended exposure time. The one and one-half percent DE-40 was too sensitive and lacked the ability to reproduce good middle tones.

With better adhesion, trials were begun on testing whether the grain had anything to do with this printability of the plate. To begin, a prime coat of one part phenolic resin to 15 parts N,N-dimethylformamide was blended. Of this, five

FIGURE 5


Lith-Kem-Ko Brush Grain Wipe On Plate
Top Coat: Full Concentraion
Prime Coat: 1:5 Concentration
Sensitizer:
½%
1%
40 second exposure
DENSITY OF REPRODUCTION
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
1.00
.95
.90
.85
.80
.75
.70
.65
.60
.55
.50
.45
.40
.35
.30
.25
.20
.15
.10
.05
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
Step Wedges
DENSITY OF ORIGINAL

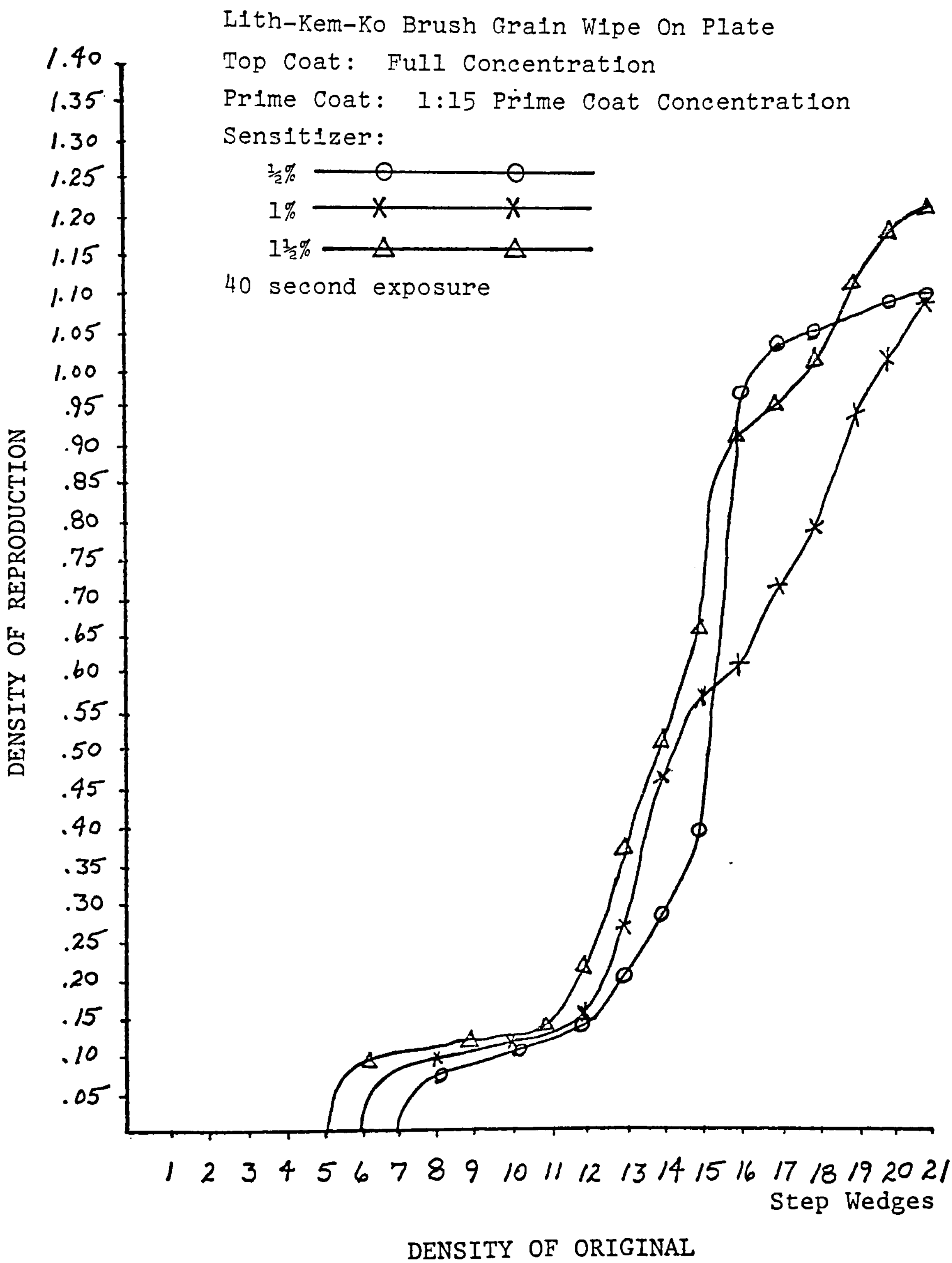
milliliters was whirled on a Fuller brushed grain plate. After the prime coat was dry it was then baked at 160° C for 20 minutes. A thin top coat consisting of 20 ml of full top coat concentration and 40 ml of N,N-dimethylformamide was then blended. 40 ml of this mixture was then whirled on top of the prime coat and allowed to dry. The top coat was then baked at 160° C for 20 minutes. A one percent solution of sensitizer was then poured onto the plate and allowed to air dry.

With the plate now ready for exposure a gray scale was put in place and exposures were made in five second increments from 30 seconds to 60 seconds. The plate was then water developed and put on a ATF Chief 15 press for running. To answer the question about grain, the dampening roller was lifted and the plate allowed to run. The plate ran cleaner for a longer period of time then did the same plate without a prime coat, suggesting that the prime coat did make a difference especially when the top coat is diluted in concentration (figure 6).

Brush Grain Anodized Plates

Because of the harder surface that the anodized plates have, several of these were run to determine whether they have better printability qualities. Using the same coating techniques as mentioned earlier, the first brush grain anodized plate was coated with a prime coat and then a full top coat concentration. Again, a one percent sensitizer with 40 second

FIGURE 6



Lith-Kem-Ko Brush Grain Wipe On Plate
Top Coat: Full Concentration
Prime Coat: 1:15 Prime Coat Concentration
Sensitizer:
½%
1%
1½%
40 second exposure
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
1.00
.95
.90
.85
.80
.75
.70
.65
.60
.55
.50
.45
.40
.35
.30
.25
.20
.15
.10
.05
DENSITY OF REPRODUCTION
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
Step Wedges
DENSITY OF ORIGINAL

exposure gave the best results (figure 7,8).

The next step was to apply a prime coat of one part phenolic to 15 parts N,N-dimethylformamide on a brush grain anodized plate. With a full top coat concentration the plate produced higher shadow then did the anodized plate without a prime coat (figure 9,10).

A dilution of the top coat of one part coating to two parts N,N-dimethylformamide was then applied over a plate with prime coat of one part phenolic to 15 parts N,N-dimethylformamide. Using a one percent sensitizer with 40 second exposure, the plate produced a good S shape curve with a density of 1.22 for shadow (figure 11).

Wire Brush Plates

A wire brush plate was prepared in the same way as the brush grain plates, with a full top coat concentration. The plate was sensitized with a DE-40 sensitizer and exposed. The plate did not produce densities as well as the anodized plates (figure 12).

A prime coat of one part phenolic resin to 15 parts N,N-dimethylformamide was then applied to a wire brush plate and then a full top coat applied over this. The press sheets produced from this plate, showed a greater density in the shadows as shown in figure 13.

Unconditioned Plates

An unconditioned plate was also tried with a full top coat concentration, and produced a good S shape curve, much

FIGURE 7

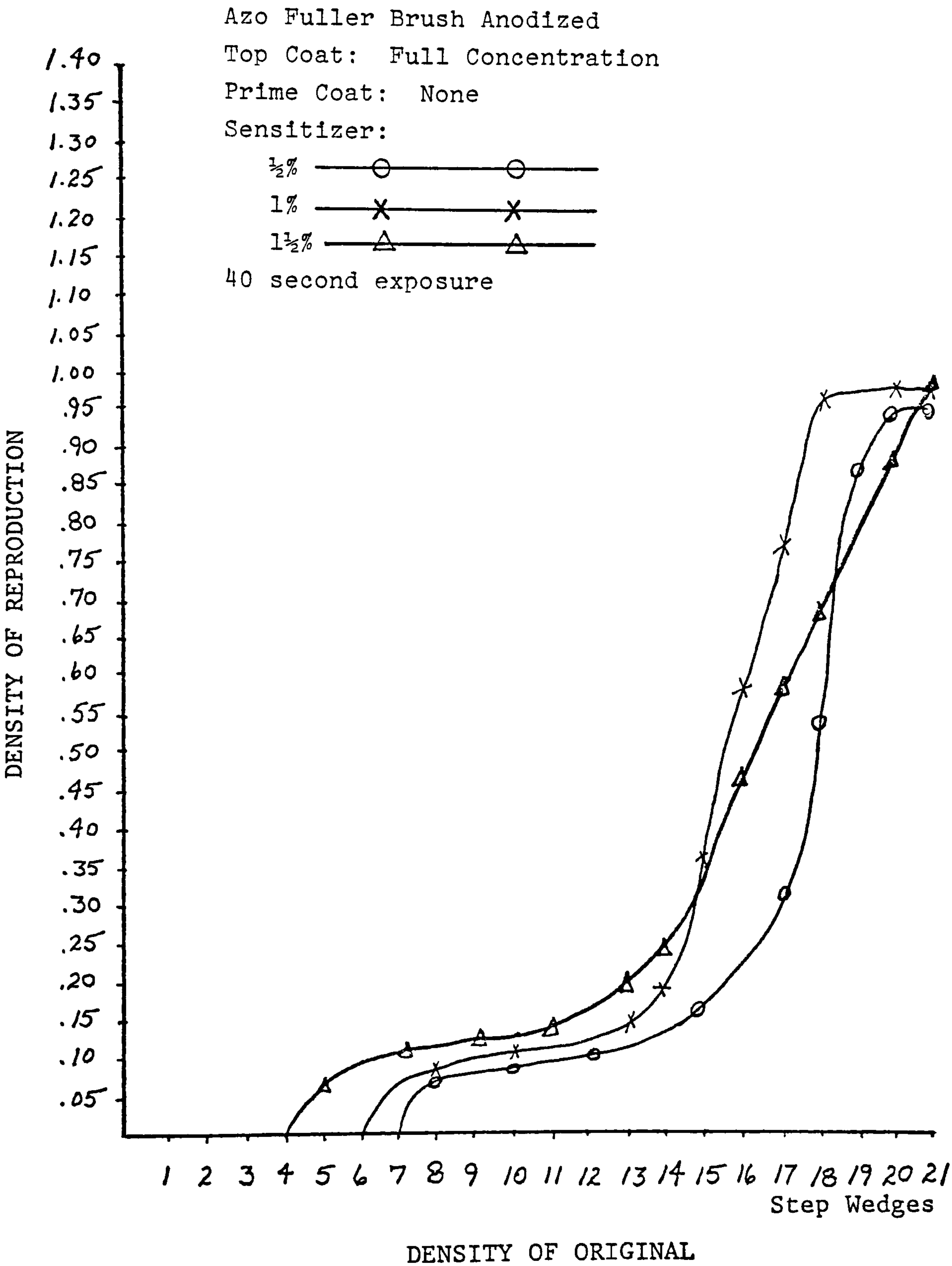

Azo Fuller Brush Anodized
Top Coat: Full Concentration
Prime Coat: None
Sensitizer:
½%
1%
1½%
40 second exposure
DENSITY OF REPRODUCTION
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
1.00
.95
.90
.85
.80
.75
.70
.65
.60
.55
.50
.45
.40
.35
.30
.25
.20
.15
.10
.05
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
Step Wedges
DENSITY OF ORIGINAL

FIGURE 8

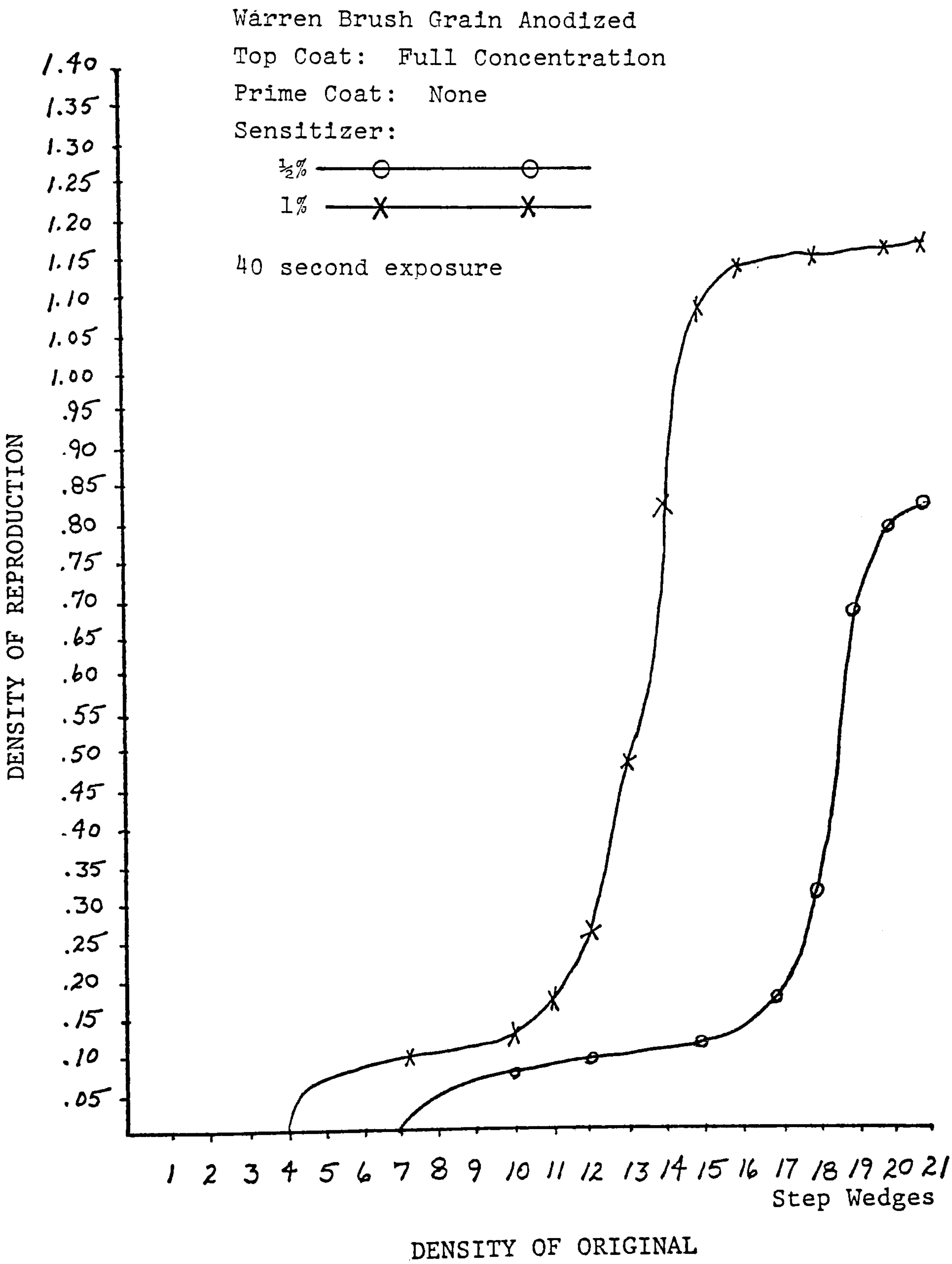

Warren Brush Grain Anodized
Top Coat: Full Concentration
Prime Coat: None
Sensitizer:
½%
1%
40 second exposure
DENSITY OF REPRODUCTION
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
1.00
.95
.90
.85
.80
.75
.70
.65
.60
.55
.50
.45
.40
.35
.30
.25
.20
.15
.10
.05
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
Step Wedges
DENSITY OF ORIGINAL

FIGURE 9

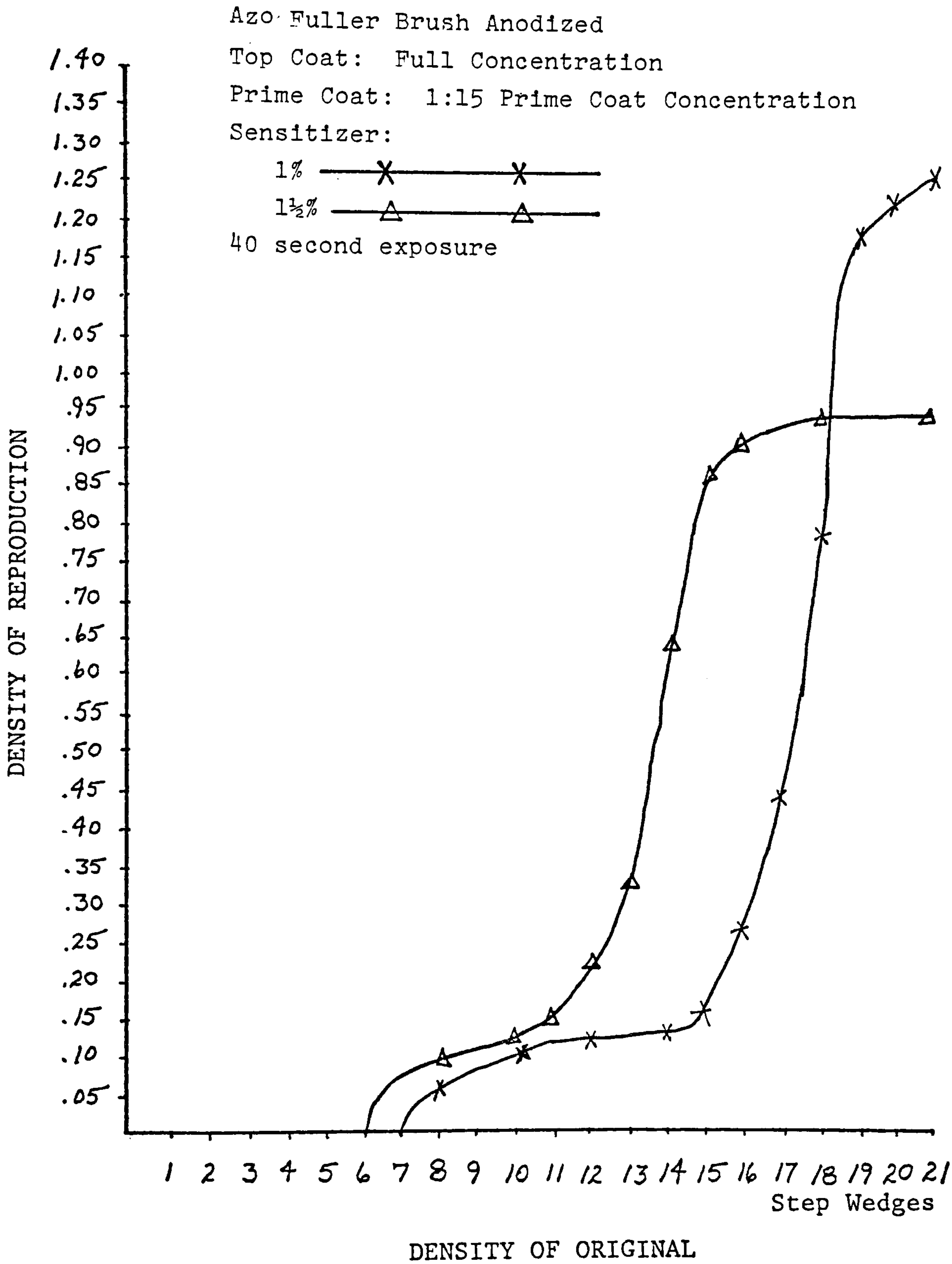

Azo Fuller Brush Anodized
Top Coat: Full Concentration
Prime Coat: 1:15 Prime Coat Concentration
Sensitizer:
1%
1½%
40 second exposure
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
1.00
.95
.90
.85
.80
.75
.70
.65
.60
.55
.50
.45
.40
.35
.30
.25
.20
.15
.10
.05
DENSITY OF REPRODUCTION
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
Step Wedges
DENSITY OF ORIGINAL

FIGURE 10

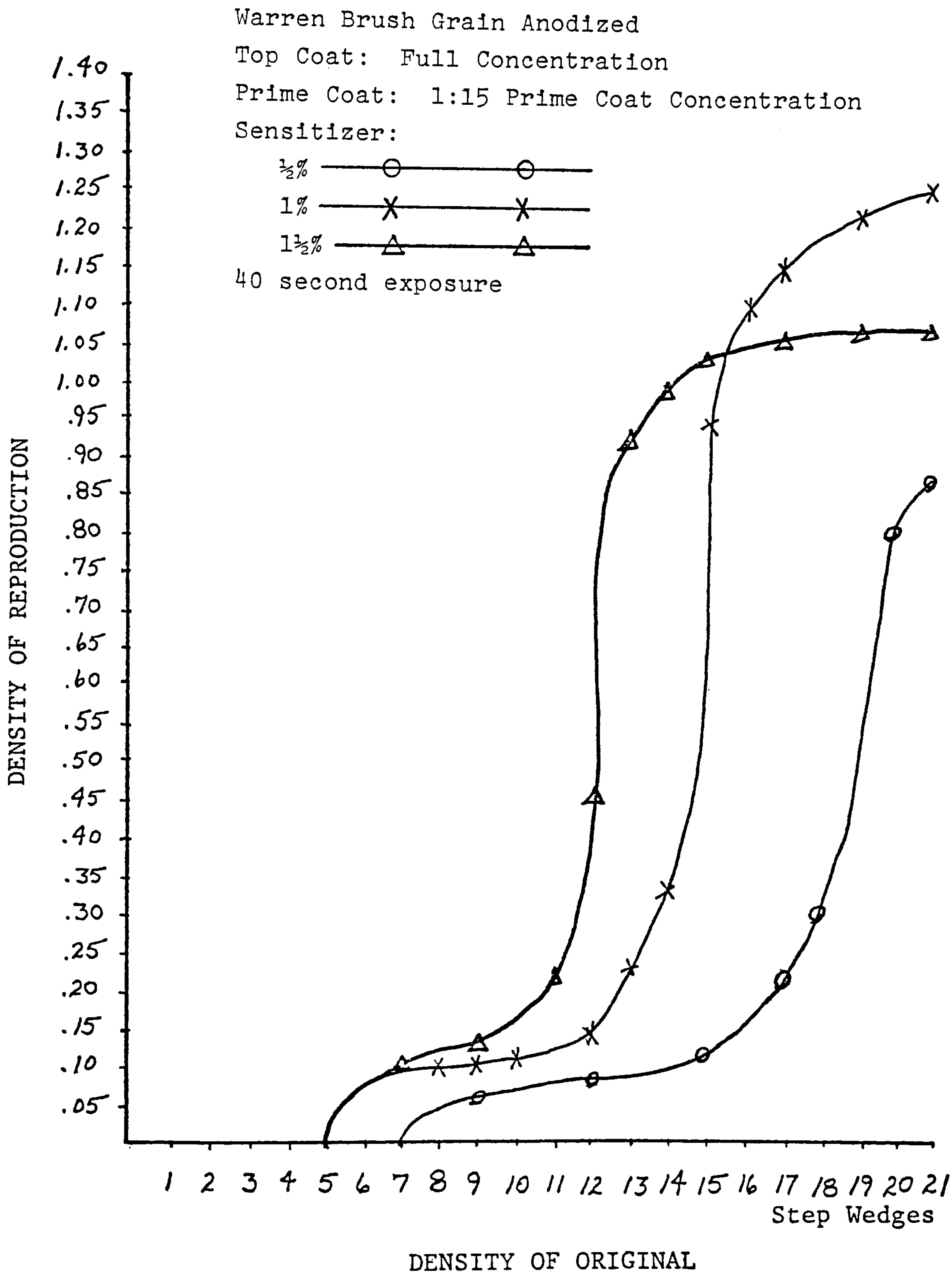

Warren Brush Grain Anodized
Top Coat: Full Concentration
Prime Coat: 1:15 Prime Coat Concentration
Sensitizer:
½%
1%
1½%
40 second exposure
DENSITY OF REPRODUCTION
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
1.00
.95
.90
.85
.80
.75
.70
.65
.60
.55
.50
.45
.40
.35
.30
.25
.20
.15
.10
.05
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
Step Wedges
DENSITY OF ORIGINAL

FIGURE 11

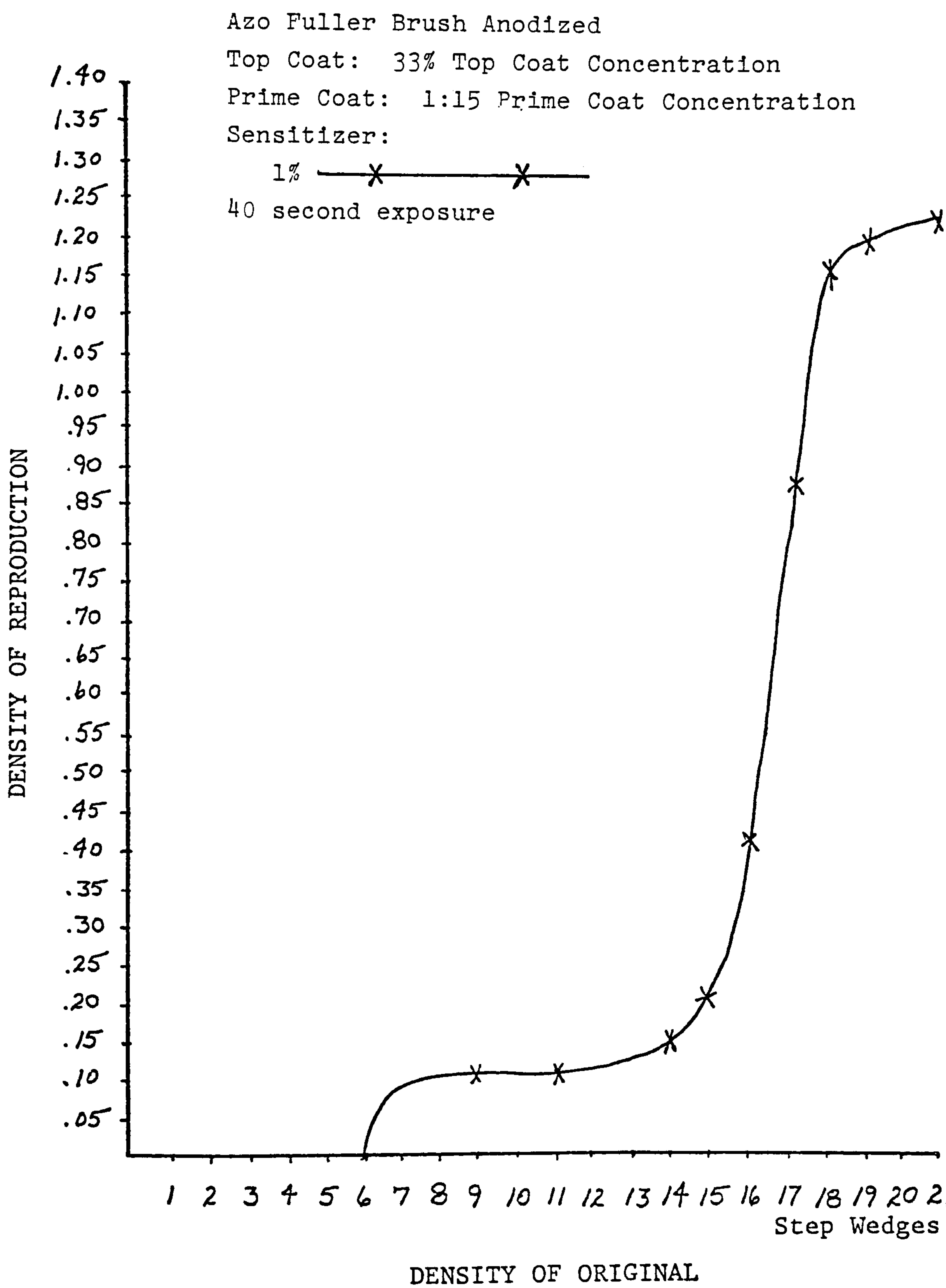

Azo Fuller Brush Anodized
Top Coat: 33% Top Coat Concentration
Prime Coat: 1:15 Prime Coat Concentration
Sensitizer:
1%
40 second exposure
DENSITY OF REPRODUCTION
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
1.00
.95
.90
.85
.80
.75
.70
.65
.60
.55
.50
.45
.40
.35
.30
.25
.20
.15
.10
.05
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
Step Wedges
DENSITY OF ORIGINAL

FIGURE 12

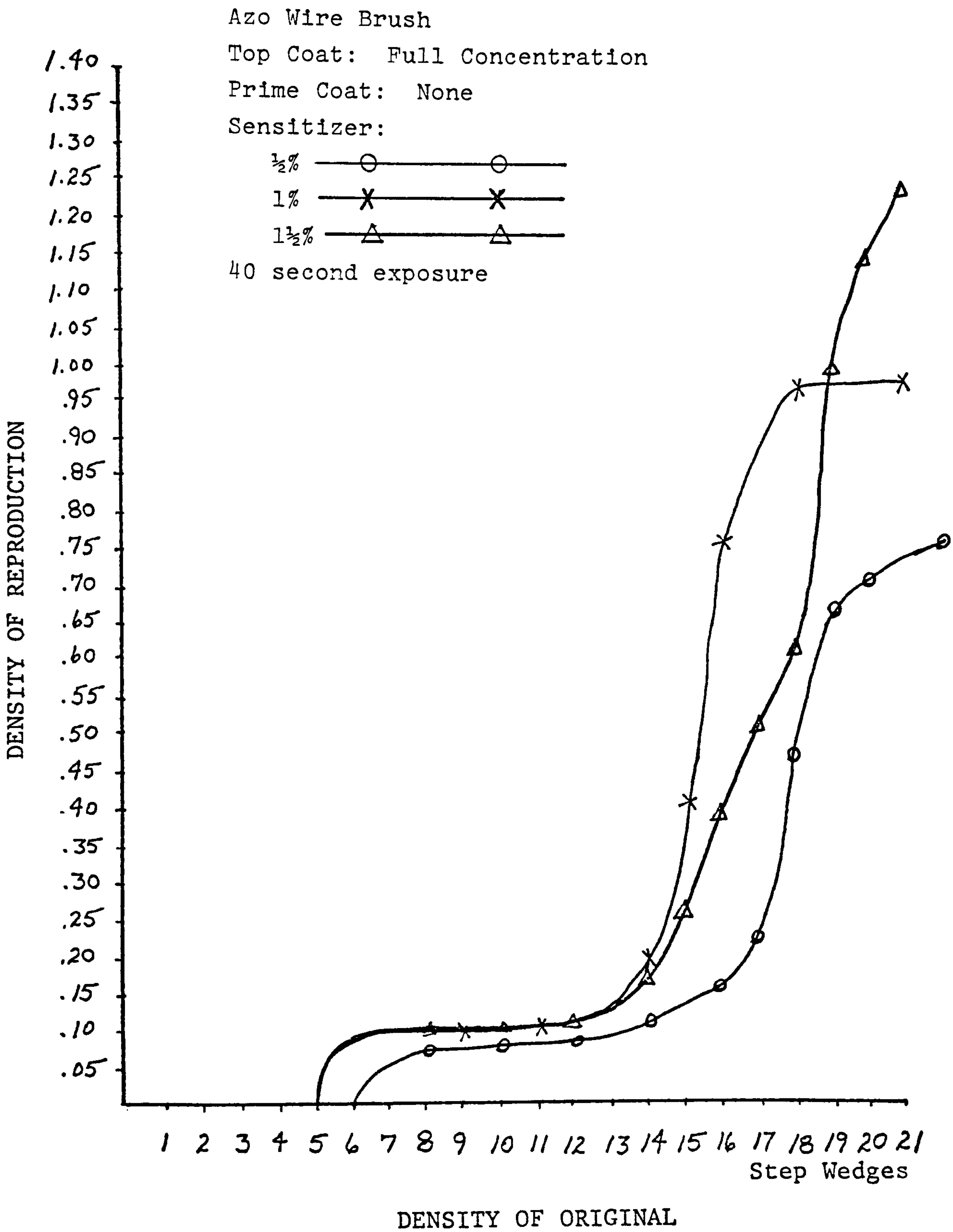
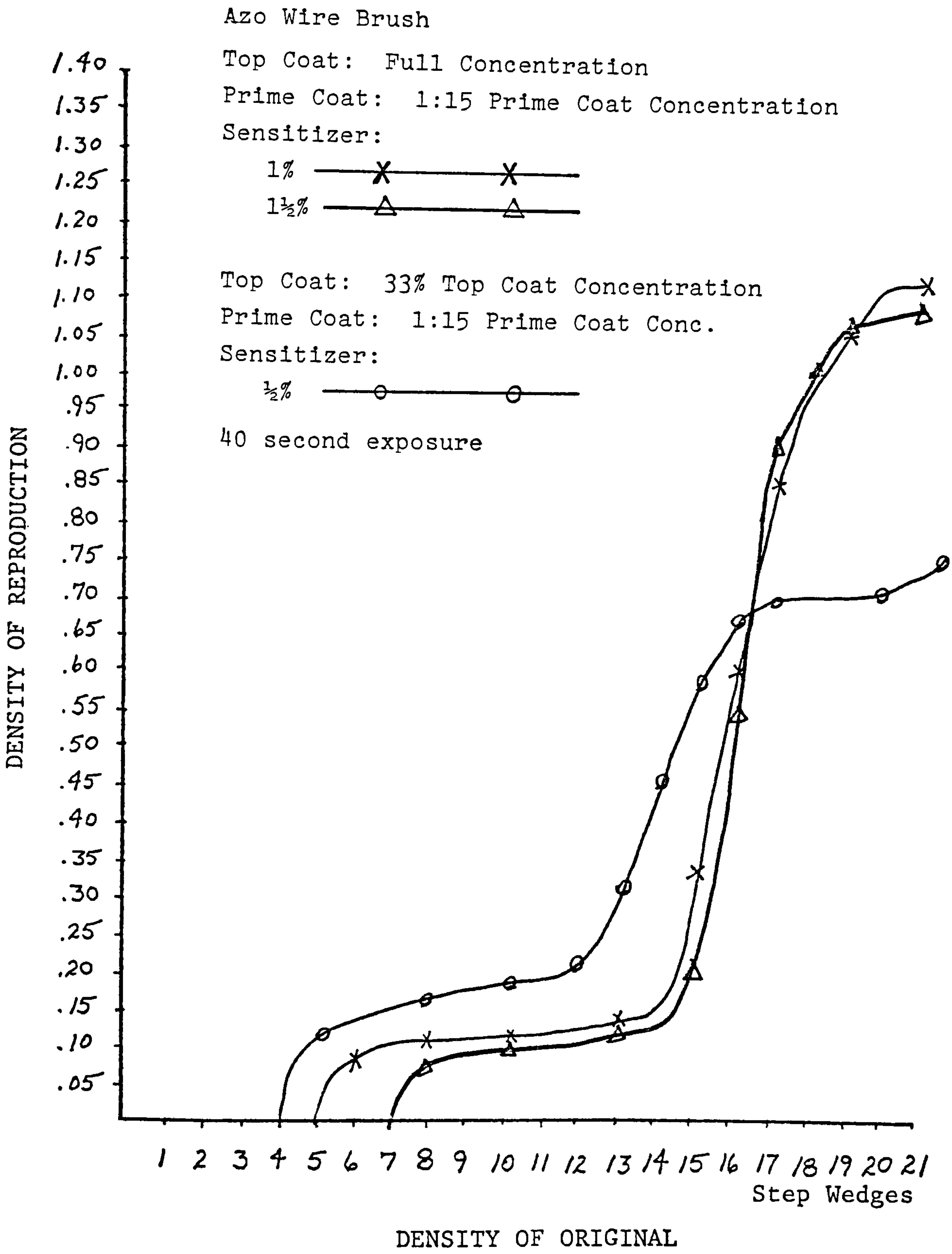

Azo Wire Brush
Top Coat: Full Concentration
Prime Coat: None
Sensitizer:
½%
1%
1½%
40 second exposure
DENSITY OF REPRODUCTION
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
1.00
.95
.90
.85
.80
.75
.70
.65
.60
.55
.50
.45
.40
.35
.30
.25
.20
.15
.10
.05
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
Step Wedges
DENSITY OF ORIGINAL

FIGURE 13


Azo Wire Brush
Top Coat: Full Concentration
Prime Coat: 1:15 Prime Coat Concentration
Sensitizer:
1%
1½%
Top Coat: 33% Top Coat Concentration
Prime Coat: 1:15 Prime Coat Conc.
Sensitizer:
½%
40 second exposure
DENSITY OF REPRODUCTION
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
1.00
.95
.90
.85
.80
.75
.70
.65
.60
.55
.50
.45
.40
.35
.30
.25
.20
.15
.10
.05
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
Step Wedges
DENSITY OF ORIGINAL

like a brush grain anodized plate (figure 14).

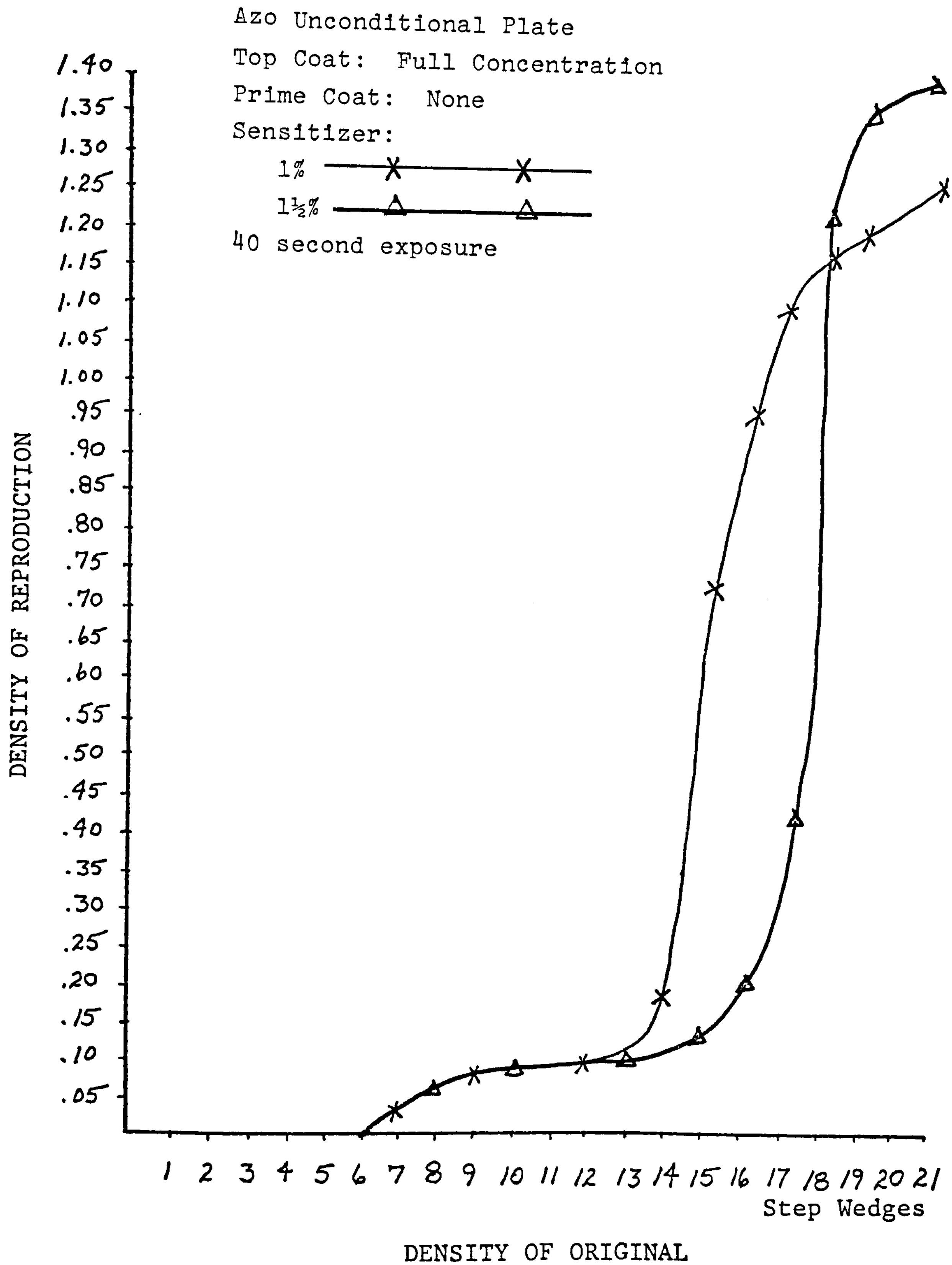
Plate Comparison

To obtain a better comparison between the different plates, a graph was made of each plate with a one percent sensitizer and 40 second exposure (figure 15).

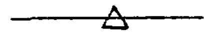
Ink Viscosity Chart

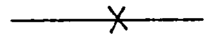
To determine whether the ink being used is non-Newtonian, a test was made on the viscosity. Readings were taken every minute on the Brookfield viscometer. As shown by table II, there was a rapid drop in viscosity during the first six minutes. After this time the viscosity sloped off gradually as shown in table II.

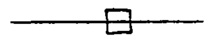
FIGURE 14

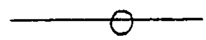

Azo Unconditional Plate
Top Coat: Full Concentration
Prime Coat: None
Sensitizer:
1%
1½%
40 second exposure
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
1.00
.95
.90
.85
.80
.75
.70
.65
.60
.55
.50
.45
.40
.35
.30
.25
.20
.15
.10
.05
DENSITY OF REPRODUCTION
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
Step Wedges
DENSITY OF ORIGINAL

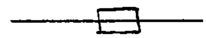
LIST AND DISCRIPTION OF PLATES USED IN FIGURE 15

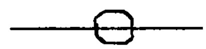
1. Azo Fuller Brush (Full top coat concentration, no prime coat) 

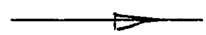
2. Lith-Kem-Ko Brush (Full top coat concentration, no prime coat) 

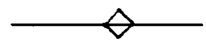
3. Lith-Kem-Ko Brush (50% top coat concentration, no prime coat) 

4. Lith-Kem-Ko Brush (33% top coat concentration, no prime coat) 

5. Lith-Kem-Ko Brush (Full top coat concentration, 1:5 prime coat concentration) 

6. Lith-Kem-Ko Brush (Full top coat concentration, 1:15 prime coat concentration) 

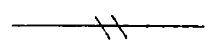
7. Azo Fuller Brush Anodized (Full top coat concentration, no prime coat) 

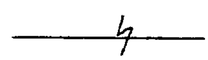
8. Warren Brush (Full top coat concentration, no prime coat) 

9. Azo Fuller Brush Anodized (Full top coat concentration, 1:15 prime coat conc.) 

10. Warren Brush Anodized (Full top coat concentration, 1:15 prime coat concentration) 

11. Azo Fuller Brush Anodized (33% top coat concentration, 1:15 prime coat concentration) 

12. Azo Wire Brush (Full top coat concentration, no prime coat concentration) 

13. Azo Wire Brush (Full top coat concentration, 1:15 prime coat concentration) 

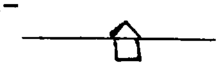
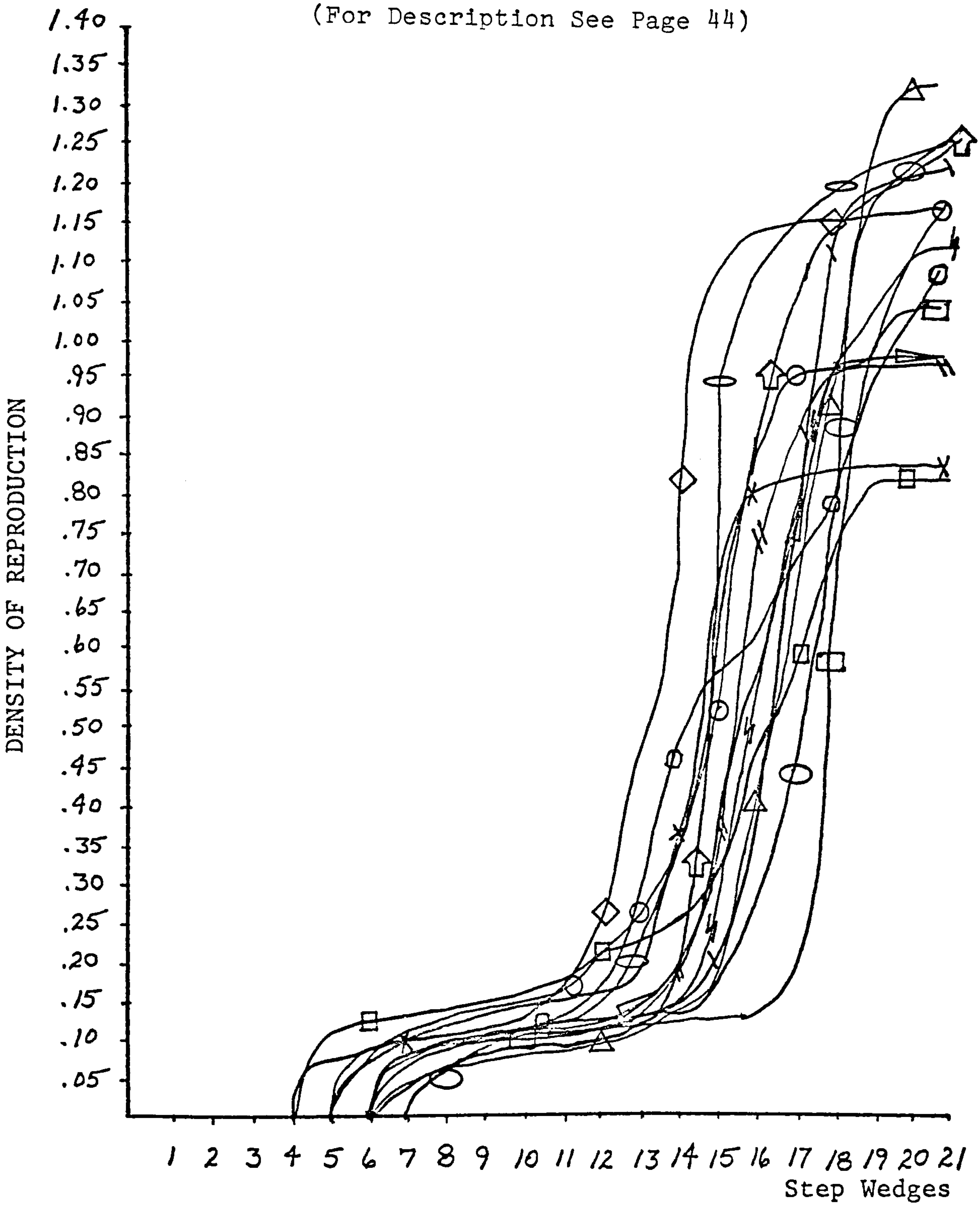
14. Azo Unconditioned plate (Full top coat concentration, no prime coat) 

FIGURE 15

EVALUATION OF PLATES WITH 1% SENSITIZER

(For Description See Page 44)



DENSITY OF ORIGINAL

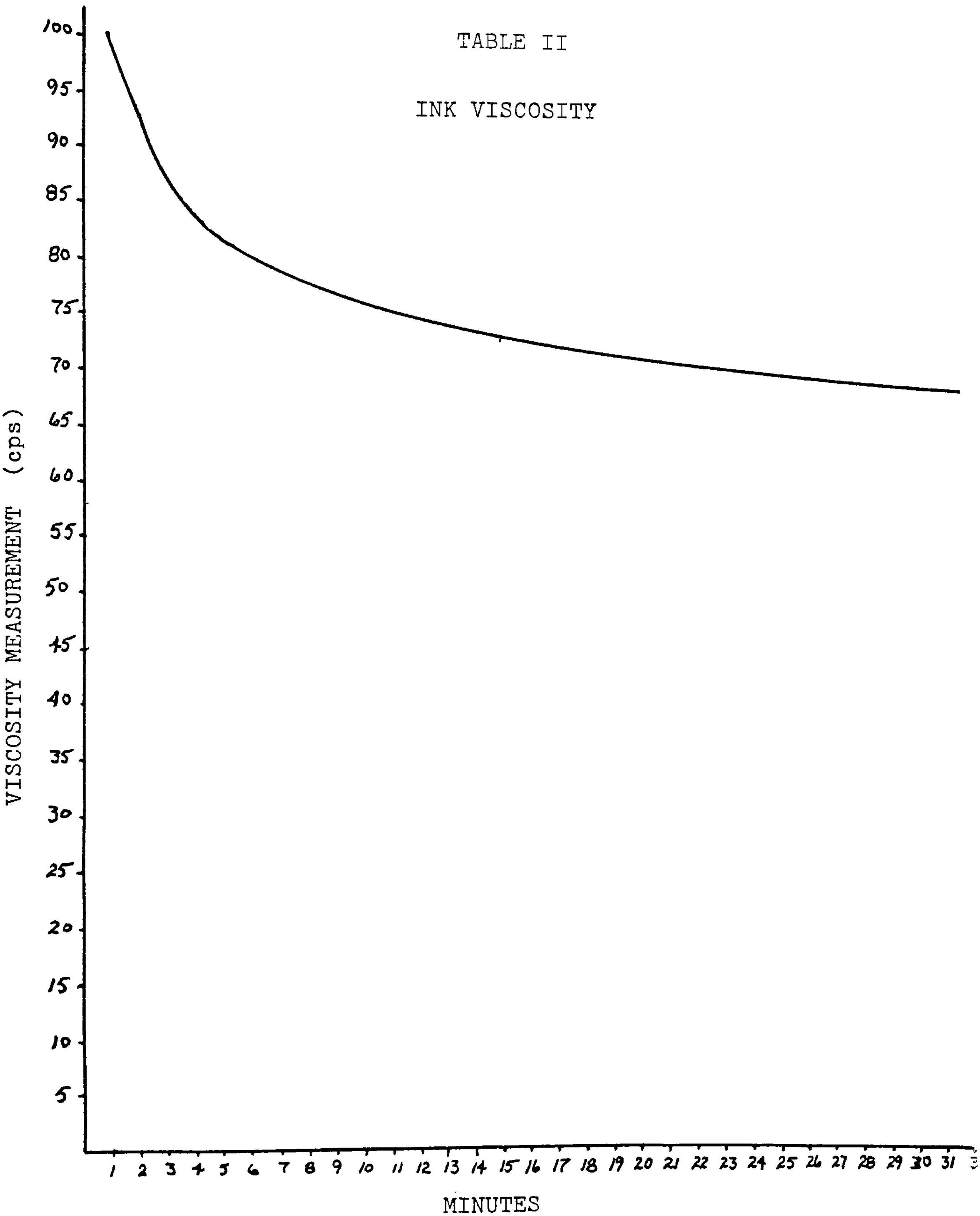


TABLE II
INK VISCOSITY
VISCOSITY MEASUREMENT (cps)
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
MINUTES

MATERIALS USED IN TEST

Gray Scale

Gray scale used in test was a 21 step continuous-tone stouffer scale. The density range for the scale was .04 to 2.94, with each step being a .15 increase in density.

Ink

Ink used in the test was an IPI Speed King Litho ink, neutral black PMS. As indicated earlier, the viscosity of this ink declined quite rapidly in the first few minutes of running.

Paper

Paper used for this test was Hammermill 20 pound uncoated stock.

Plate Material

Plate material used for the test was received from Azoplate, and were 10 inch X 15 inch plates with a thickness of .008 inches.

Ink Rollers

Ink rollers were cleaned before beginning each day to remove any contaminates that might have been left the day before.

Dampening Rollers

Rollers were cleaned and checked for water absorbency.

CHAPTER IV

SUMMARY AND CONCLUSIONS

As stated in the hypothesis, the Association plate does not depend on the grain directly for tonal reproduction as does collotype or random dot types of screenless printing. Dr. F. Uhlig in his paper, referred to in chapter I, showed that both of the latter two types of plates depend on grain structure for tonal reproduction.

In testing the hypothesis for plate material it was revealed that the anodized brush grain and wire brush plates were the best for the "Association coating". It was also concluded that thin top coats in combination with a prime coat do produce better tonal reproduction curves. When using a thin prime coat, good adhesion can be achieved between the top coat and the metal plate. This prime coat also acts as a coating for the grain and allows for thinner top coats.

Future work needs to be done on determining the degree of adhesion that the prime coat has for the metal substrate. This degree of adhesion would determine if this type of prime coat concentration can be used for long press runs.

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