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A study of the effects of clear extender varnish modification of gravure inks to produce an allowable color tolerance between a halftone gravure print and a SWOP standard offset press proof in hue, saturation, and brightness

Michael Thomas Green

A STUDY OF THE EFFECTS OF CLEAR EXTENDER VARNISH MODIFICATION OF GRAVURE INKS TO PRODUCE AN ALLOWABLE COLOR TOLERANCE BETWEEN A HALFTONE GRAVURE PRINT AND A SWOP STANDARD OFFSET PRESS PROOF IN HUE, SATURATION, AND BRIGHTNESS.

by

Michael Thomas Green

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Thesis Advisor: Professor Walter Horne

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Certificate of Approval -- Master's Thesis

School of Printing
Rochester Institute of Technology
Rochester, New York

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MASTER'S THESIS

This is to certify that the Master's Thesis of

Michael Thomas Green

With a major in PRINTING TECHNOLOGY
has been approved by the Thesis Committee as satisfactory for the thesis requirement for the Master of Science degree at the convocation of

May 1987

Date

Thesis Committee: Walter Horne
Thesis Advisor

Joseph Noga
Graduate Program Coordinator

Miles Southworth
Director or Designate

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ABSTRACT

Halftone gravure has become the accepted front end imaging procedure for the publication gravure industry. Halftone gravure refers to using screened or halftone film when imaging a gravure cylinder. This procedure has allowed the publication gravure industry to benefit from the pre-press advantages of offset printing. Therefore, the possibilities of an allowable color tolerance between a halftone gravure print and a SWOP standard offset press proof in hue, saturation, and brightness needed to be studied.

The purpose of this study was to determine whether an allowable color tolerance could be achieved between the gravure production print and the SWOP standard offset press proof. The experimental design involved the research of the effects of clear extender varnish modifications of gravure inks used to produce an allowable color tolerance between a gravure print and a SWOP standard offset press proof. It was important to compare the gravure print to the SWOP standard offset press proof because the publication gravure industry recognized the SWOP standard offset press proof as the standard or control parameter.

The methodology was based upon the modification of gravure inks by the addition of 10% intervals of clear extender varnish. Five intervals of 10% clear extender varnish were added to each of the gravure inks. After the gravure prints (10% to 50% clear extender varnish added to the inks) were printed, each was compared to an offset press proof which was printed in accordance with the Recommended Specifications for Web Offset Publications (SWOP). A Minolta Chroma Meter CR-121 was used to measure the "ΔE" values of each print which determined whether an allowable color tolerance had been established.

In conclusion, the study rejected the stated hypothesis of; there is no significant difference, defined as a "ΔE" value of less than six (allowable color tolerance), between an offset press proof produced in accordance with SWOP recommendations, and a halftone gravure print from cylinders produced with the same set of universal films, when using properly extended Group VI gravure inks. Of the ten image areas selected, only two had a "ΔE" value of less than six. The rejected hypothesis was supported by the suspicion that further addition of clear extender varnish to the gravure inks may not improve the situation.

The continuance of this study would be further enhanced by the investigation of the difference, if any, between Group VI gravure inks and the SWOP offset inks in relation to hue, saturation, and brightness.

Chapter One

INTRODUCTION

A. Statement of the Problem

Halftone gravure is the accepted preparatory imaging procedure for the publication gravure industry. The halftone gravure procedure is associated with offset film material. Screened negatives and positives are used for both offset plates and for the preparation of bromides for the gravure cylinder electronic engraving machine. This conversion has allowed publishers and advertisers to pick up existing offset advertisements and use halftone gravure to insert these advertisements into gravure publications.

A problem associated with this conversion procedure is that there is a difference in hue, saturation, and brightness between the gravure production print and the SWOP standard offset press proof. Some contributing factors to this problem are; dot gain in offset printing, and 100% trapping in gravure printing versus lower trap values in offset four color wet printing. Another contributing factor is the difference in ink film thickness between the halftone gravure print and the SWOP standard offset press proof.

The halftone gravure print has nearly 100% trapping on all four colors. The term 100% trapping refers to the fact that the ink has been equally transferred to the paper and to the previously applied ink film or films. Less than 100% trapping in offset printing occurs because of the wet-on-wet printing process.

> "The four-color offset press proof usually traps less efficiently on the third and fourth colors down. Depending on the laydown sequence, this will have some slight effect on the secondary color hues created by these trap sequences."[1]

Gravure printing achieves nearly 100% trapping because the ink film dries between each printing unit. Another contributing factor is that publication gravure printing inks are generally solvent based inks.

The difference in ink film thickness between a halftone gravure print and a SWOP standard offset press proof will affect the densities of each print. The halftone gravure print has a higher ink film thickness in the shadows which causes a higher saturation of a color.

B. Hypothesis

There is no significant difference, defined as a "△E" value of less than six (allowable color tolerance), between an offset press proof produced in accordance with SWOP recommendations, and a halftone gravure print from cylinders produced with the same set of universal films, when using properly extended Group VI gravure inks.

See APPENDIX A for a detailed explanation of the measurement of "△E".

In Stamm's thesis of 1980, "A Colorimetric Investigation of Color Tolerances." he states,

> "The study suggests the average allowable tolerance for light and dark limits and spot and process color was approximately six C.I.E. L*,a*,b* delta "E" units. Statistically the results indicate the light allowable tolerance is greater than the dark tolerance and the process color tolerances are greater than the spot, but for all practical purposes the differences are not significant.
>
> The delta "E" values were also subdivided into their component parts to determine which attribute of color (i.e. hue, chroma, and lightness) made up the largest portion of the delta "E". These results indicate, for the most part, the delta "E" values are equally represented by hue, chroma, and lightness."[2]

FOOTNOTES FOR CHAPTER ONE

1 Charles Rinehart. "Off-press Proofing." Gravure Bulletin, Summer 1985, V.36, No.2, p. 94.

2 Scott Stamm. "A Colorimetric Investigation of Color Tolerances." Rochester Institute of Technology, a thesis written in fulfillment of the Master of Science degree, August 1980.

Chapter Two

THEORETICAL BASIS FOR STUDY

A. Explanation of a Proof

In printing, a proof serves two purposes. "First it serves as a record of agreement and accountability used in the approval process. Secondly, it becomes a benchmark providing production aim points used in the process."[1]

To be acceptable to a customer, a proof must be a reasonable facsimile of the printed job. For customer approval, a proof must demonstrate the quality of the job to the customer before it goes on the production press. A proof is the primary communication link between the customer, who has a vision of what the job should look like, the separator, or service house who prepares the separations from which the proof will be produced, and the printer, who must deal with the problems of matching the supplied or accepted proof.

For example, magazine advertisements are usually created by advertising agencies or advertising departments of

manufacturers. These advertisements can contain subjects prepared by many different photographers and commercial artists. The advertisements could consist of color transparencies of different sizes and types, color photo prints, and sometimes artwork done on board, paper or canvas. These materials are then converted into color separations by the service house or color separator, which are proofed using a four color sheet fed offset press. For image quality and color matching, the accepted proof for magazine advertisements in the publication gravure industry is an offset press proof which has been produced in accordance with the Group VI/SWOP recommendations. For this reason, it is important to compare the modified gravure print to the SWOP standard offset press proof in order to demonstrate the procedure that occurs in the publication gravure industry.

Another type of proof is an off-press or "optical" proof which refers to a proof made without a printing press. Off-press proofs are usually made by a photochemical, photomechanical, or electrophotographic process. The purpose of an off-press proof is to display an accurate image of the printed job prior to a press run. Off-press proofs are very important because they can simulate certain printing

characteristics such as dot gain and trapping, and are controllable from proof to proof. For example, "off-press proofs trap all four colors close to 100 percent regardless of sequence. Therefore, we would expect to see small differences in color saturation and hue shifts in some colors when compared to an offset press proof."[2]

B. Explanation of Halftone Gravure

In recent years, the publication gravure industry has gone through many transitions. One of these transitions has been the emergence of halftone gravure. Halftone gravure refers to using screened or halftone films when imaging a gravure cylinder on an electronic engraving machine.

> "The market share of products being produced in the United States using the gravure process is changing because the gravure industry is adopting cylinder preparation methods that use offset lithography preparation and color proofing techniques. These techniques, which are called Offset/Gravure (O/G) conversions, or halftone gravure are more efficient and less expensive than existing cylinder preparation methods, and they compliment the gravure process's existing advantages."[3]

There are two aspects of gravure printing which have distinguished it from offset printing and have allowed halftone gravure to become prevalent. First, continuous tone gravure works from continuous tone (analog) film

separations, as opposed to high density variable area halftone separations used in offset. In continuous tone gravure, the continuous tone image carries the image detail to the cylinder by variable cell depth. The lateral dot halftone film carries the image to the cylinder by variable cell area. In gravure, screening is not done until films are etched or engraved into copper cylinders. While there are some advantages in working with continuous tone films as input to cylinder engraving, it is recognized that detail, sharpness, and color correction is more easily obtained by halftone films prepared for the offset process.

Secondly, there is a difference between gravure continuous tone proofs and offset proofs in terms of their relationship between the supplied separation films and the press proof. In the gravure publication industry, advertisement copy is photographed and scanned producing continuous tone separations. These continuous tone positive or negative films are used to etch or engrave the image into a copper plate or cylinder (variable area, variable cell depth) and proofed by the engravers using a gravure proofing press. Revisions and corrections are made to the engraved cylinder or plate and then reproofed. After final approval by the advertising agency, the service house will

use the GTA standard color book to obtain aim densities in the important color areas of the proof. The continuous tone separation films are then altered until the correct aim densities are achieved by using color correction techniques. This method is difficult to control. Also, the turnaround time is lengthy and costs are high. These "corrected" separation films are not proofed again before delivery to the printer.

In offset printing, if corrections are to be made, they are made directly from the original set of halftone separation films and then reproofed. From copy to film, the time and costs associated with offset are significantly less than continuous tone gravure. For these reasons, halftone gravure uses the pre-press advantages of offset and combines it with the press quality and long run advantages of gravure.

C. Publication Gravure Inks

Gravure inks differ from some types of printing inks in that the ink dries by evaporation of solvents. Solvent refers to a liquid which dissolves solids such as resins and dry ink. Gravure inks are formulated to meet the special needs of the printing process and the desired character-

istics of a printed product. When formulating gravure inks, one must consider press design, printing conditions, paper characteristics, ink film thickness, and use of the final printed product.

There are two methods of formulating gravure production inks. The first method is formulating ink for special conditions. One of these conditions would be by customer request. Special inks are made for customers by ink manufacturers. The other method of formulating the ink is by blending clear extender varnish and solvent into the ink. A clear extender varnish is a material used to weaken or extend a gravure ink. The purpose of adding the clear extender varnish is to reduce the color concentration without affecting ink film toughness or gloss. A publication gravure printer uses clear extender varnish to adjust the ink pigment concentrations in gravure inks, thus allowing the printer to control the color strength of the gravure inks.

Gravure inks need to be low in viscosity because of the very small cells in a gravure cylinder. Low viscosity is obtained by utilizing inks with a high solvent content. As the solvent evaporates, both the concentration of pigment in

the drying ink film and the viscosity of the ink will increase. Viscosity is defined as "the quality relating to the internal friction of an ink, such friction affecting the ink's ability to flow".[4]

The simplest method of measuring ink viscosity is to use a single orifice viscometer, such as a Zahn Cup. This devise is a bullet shaped cup with a precision drilled hole in the bottom allowing ink to flow through. Ink viscosity is measured by dipping the cup into the ink and measuring the time it takes for the ink to completely flow through the hole in the bottom of the cup. The viscosity measured is expressed in seconds, but the value of viscosity is measured in centipoise.

After the viscosity of the ink has been measured, the pressman controls the ink by adding and mixing solvent into the ink in order to maintain a constant viscosity. The purpose of controlling the ink is to monitor the viscosity and ink density which changes when solvent is either added or taken away. "Density in gravure is a function of the amount of ink transferred and at least in midtones and highlights, the degree to which ink is spreading on the surface and into the paper."[5]

Gravure inks consist of a colorant and a vehicle. Colorants are associated with hues, and can consist of pigments, dyes or both. Insoluble colorants in a vehicle solution are called pigments. Soluble colorants in a vehicle solution are referred to as dyes. Pigments and dyes are very important in maintaining a particular hue in gravure ink.

The vehicle's purpose is to keep the colorant scattered throughout the ink. Also, the vehicle can carry the colorant through the printing operation and onto the printed product. The vehicle contains a binder which is dissolved in a solvent. When the solvent dries, a solid film of binder and colorant are left on the printed product. This solid film is actually the ink film that forms the printed image. The final printed color consists of ink film thickness, color of substrate, and the amount of light falling on the printed color. There are three attributes of color:

"HUE - is that attribute of certain colour sensations in respect of which they differ characteristically from the gray of the same brightness and which permits them to be classed as reddish, yellowish, greenish, bluish,

SATURATION - is that attribute of all colour sensations possessing a hue which determines the degree of difference from a gray of the same brightness,

BRIGHTNESS - is that attribute of any colour sensation in respect of which it may be classed as equivalent to some member of a series of grays ranging between black and white."[6]

D. Measuring Color

This section describes the three instruments; colorimeter, spectrophotometer, and reflection densitometer, used in this project and their unique characteristics.

Colorimeter:

Colorimetry can convert most colors within a range of human perception into a common numerical code to enable individuals to identify with a particular color. When color is expressed in a numerical system, the code might be L-star a-star b-star. Brightness is L*, hue is a*, and saturation is labeled b*. The system will allow an individual to plot and identify a particular color.

A colorimeter tries to simulate human eye responses. It uses a filter pack which gives red, green, and blue responses corresponding to the sensitivity curves of the CIE standard observer.

The Minolta Chroma Meter CR-121 is a hand-held reflected subject colorimeter. This colorimeter converts colors to a numerical code for calculating L*a*b* values. Also, this instrument has the capability of calculating the "ΔE" value from a particular color represented by L*a*b*. A "ΔE" value consists of equal parts of hue, saturation, and brightness.

<u>Spectrophotometer</u>:

Another instrument to measure color is a spectrophotometer. A spectrophotometer measures "the light absorption or reflection of a color in small increments (10 or 20 nanometers or NM bands) across the visible spectrum from 380NM to 760NM and determines the three tristimulus values (X,Y,and Z) for the color and plots a spectrophotometric curve which is a fingerprint of the color."[7] When two objects have the same spectrophotometric curves, they will always be of the same color.

<u>Reflection Densitometer</u>:

A reflection densitometer is a production or quality control instrument used by the graphic arts industry. It uses filters chosen for production purposes, not for visual evaluation purposes. There are wide band filters and narrow

band filters used in densitometers for which each serves their specific or practical requirement. It is a good instrument for process monitoring and process feedback (For instance: dot gain information from the pressroom to the camera room).

A reflection densitometer is very useful when measuring density of the same inks on the same substrate. However, a reflection densitometer has problems comparing different colors and determining whether two colors will produce a visual match. The reason for this is that the reflection densitometer does not see color as the human eye sees color. Two colors can have the same density reading and look different to the eye.

FOOTNOTES FOR CHAPTER TWO

1 Charles Rinehart, "The Color Proof: Issues and Objectives." Gravure Bulletin, 1983, V.34, No.4, p. 28.

2 Charles Rinehart, "Off-Press Proofing." Gravure Bulletin, Summer 1985, V.36, No.2, p. 94.

3 Miles Southworth, "Offset/Gravure Conversion (Halftone Gravure).", The Quality Control Scanner, Graphic Arts Publishing Company, Livonia, NY, 1983 V.3, No.5.

4 GTA Staff, The Publication Gravure Ink Manual. Technical Education Library of the Gravure Technical Association, Inc.

5 Jitendra N. Shah, Robert H. Oppenheimer, Harvey F. George, "Gravure Ink Mileage Study." GRI Report Project No. 167-1, Report No. 1-6. Gravure Research Institute, November 2-5, 1975.

6 H.D. Murray and P.A. Spencer, "Colour in Theory and Practice." American Photographic Publishing Company, Boston, MA., 1939, p. 78.

7 Michael H. Bruno, "The Critical Role of Color Proofing in Printing's Fastest Growing Market.", NAPL Special Report No. 5261, September 1985, p. 4.

Chapter Three

LITERATURE SEARCH

Some of the technical information concerning the differences in hue, saturation, and brightness in offset and halftone gravure has been provided by the TAGA proceedings, GTA Bulletins, GRI Reports, and trade articles.

> "Halftone gravure has built a bridge between offset and gravure prepress operations. Halftone separations, the main device in offset prepress, have been adopted by gravure. However, gravure printers have found very quickly that the differences between true printing processes are not limited to halftone versus continuous tone formats. The inks, the paper, and the ink laydown are different too."[1]

There is a limited amount of published information available concerning the modification of gravure inks when compared to offset prints that will affect hue, saturation, and brightness.

In 1985, TAGA reported a study which compared a gravure print to an off-press proof. The experimental design involved ink dilutions to maintain an average printing

density in the highest volume cells of the gravure cylinders. The study concluded that a close similarity between an off-press proof and a gravure print can be achieved by diluting the inks and changing the gradation curve on the Heliokischograph.

John Souter, Graphic Preparation Systems Division, 3M Corporation, has investigated color saturation between both printing methods of gravure and offset. He calculated a color gradient that would allow offset to reproduce the color saturation which is needed to match that of gravure.

In 1983 at the 17th International Conference of IARIGAI (International Association Research Institute for the Graphic Arts Industry), a paper was presented on the issue "Can a lithographic print match a gravure print?". The study emphasized the importance of understanding the different aspects of a lithographic print and a gravure print. The following aspects were covered;

A. maximum attainable color intensity,
B. color mixing performance,
C. hues of the primary inks,
D. gloss,
E. gradation.

FOOTNOTES FOR CHAPTER THREE

1 Yair, Toor and Harvey F. George, "Halftone Gravure, A Stepping Stone to Universal Data for Printing.", Gravure Research Institute, June 1985. p. 61-71.

Chapter Four

METHODOLOGY

A. Overview of the Process

1. Test Objects:

   - (6) four-color images
   - (4) single color bars
   - (1) three-color combination color bar
   - (1) four-color combination color bar

2. Equipment and materials needed to run the test:

   - The R.I.T. Gravure Program set of universal films (same set for offset and gravure)
   - Gravure - Champlain Web Press
   - Harris Four-Color Sheetfed Offset Press
   - Offset Inks (4 process colors)
   - Gravure Inks (4 process colors)
   - Gravure - Clear Extender Varnish
   - 40lb. Gloss - Gravure Paper Stock Brightness = 75
   - 60lb. Coated - Offset Paper Stock Brightness = 81
   - Minolta Chroma Meter CR-121
   - Applied Color Systems (ACS) - Spectrophotometer
   - Cosar 61 - Wide Band Densitometer
   - Matchprint Proofing System
   - #2 Zahn Viscometer and Stop Watch

B. Process

Off-Press Proof

1. Made a Group VI/SWOP off-press proof from the universal films. Followed the Matchprint Proofing System instructions.

Offset Press Proof

1. Converted universal films to offset plates and ran on the four-color Harris sheetfed offset press. The printing sequence was black, cyan, magenta, and yellow.

2. The offset press proof was printed in accordance to the Recommended Specifications for Web Offset Publications (SWOP), Edition May 1986.

See APPENDIX B

Gravure Production Prints

1. The R.I.T. Gravure Program's set of films were converted into cylinders before this thesis project started which did not affect the validity of the project. This particular set of cylinders have been used for many different types of testing at the R.I.T. Gravure Laboratory.

2. A total of six gravure prints were produced on the Champlain four-color web press. The printing sequence was yellow, magenta, cyan, and black. The procedure to produce these prints follows.

   a. Approximately 5 gallons of full strength Group VI ink was added to each ink station of the press (full strength ink refers to ink without clear extender varnish added). The viscosity of each of the four-color inks was constantly measured. Each color ink viscosity was kept constant at approximately 20 seconds with a #2 Zahn cup viscometer. Xylene solvent was used to cut the full strength inks to a 20 second viscosity reading.

      See APPENDIX C

   b. A set of production prints were printed on the web press using electro-static assist at approximately 1500 volts and .5m amps. The press speed was 600 feet per minute. After this particular press run, the set of production prints were labeled and set aside.

c. Xylene solvent was added to the clear extender varnish to maintain a 2Ø second viscosity reading.

d. Approximately 1Ø% (64 ounces) of clear extender varnish was added to each of the four ink units on the web press. A period of 25 minutes elapsed between running each set of prints so that the clear extender varnish would be thoroughly blended into the ink.

e. Steps b, c, and d were repeated four (4) times in order to achieve levels of 2Ø%, 3Ø%, 4Ø% and 5Ø% of clear extender varnish in the four ink units.

C. Test Results and Evaluations

Colorimeter:

1. Identified ten specific image areas (A - J) on the SWOP standard offset press proof. Using the six gravure production prints (Full strength through 5Ø% extender added), the same image areas were identified. These specific areas were used for the colorimeter measurements and evaluations.

2. Using the SWOP standard offset press proof as the standard, the "ΔE" values were measured for each specific image area on the six gravure production prints. The measurement reading was determined by using the Minolta Chroma Meter CR-121.

3. To reduce the chance error in measuring "ΔE" values with the Minolta Chroma Meter CR-121, each image area was measured five times and an average "ΔE" value was determined.

   See APPENDIX D

4. The "ΔE" values were the determinants for evaluating the gravure production prints.

5. A comparison between the gravure prints and the off-press proof is shown on Table D7.

6. The "ΔE" values were based on the Yxy values of the SWOP standard offset press proof as indicated on Table D8.

7. Using the "ΔE" value for each gravure production print, a determination was made on the basis of whether each print had a tolerance within six "ΔE" values. If a gravure production print had a tolerance within six "ΔE" values, the print would then support the hypothesis.

   See APPENDIX E

8. To verify the "ΔE" values, the L*a*b* values are shown on Tables F1-F8.

   See APPENDIX F

Spectrophotometer:

1. Identified the ten specific image areas (A - J) on the SWOP Standard Offset Press Proof. Using the six gravure production prints (Full strength through 50% extender added) the same image areas were identified. These specific areas were used for the spectrophotometric measurements and evaluations.

2. Using the Applied Color System, the six gravure prints and the off-press proof (Matchprint) were compared to the offset press proof (Standard) with spectrophotometric curves.

3. The gravure and Matchprint substrates were compared to the offset substrate using the Applied Color System.

   See APPENDIX G

4. The spectrophotometric curves were based on their specific nanometer values.

   See APPENDIX H

<u>Reflection Densitometer</u>:

1. The SWOP Standard High-Low color values were read from the SWOP color reference of June 1986. The following values were used as parameters for printing the SWOP standard offset press proof.

	HIGH	LOW
YELLOW	1.04	.89
MAGENTA	1.43	1.30
CYAN	1.34	1.20
BLACK	1.57	1.44

2. Identified the ten specific image areas (A - J) on the SWOP Standard offset press proof. Using the six gravure production prints (Full strength through 50% extender added) the same image areas were identified. These specific areas were used for the densitometer measurements.

   See APPENDIX I

Chapter Five

CONCLUSIONS

This study has provided interesting answers to the hypothesis stated in Chapter One; there is no significant difference, defined as a "$\triangle$E" value of less than six (allowable color tolerance), between an offset press proof produced in accordance with SWOP recommendations, and a halftone gravure print from cylinders produced with the same set of universal films, when using properly extended Group VI gravure inks. The ten image areas that were evaluated had distinctive characteristics as follows:

Colorimeter:

Figure E1: A-Yellow.

This particular image area started with a high "$\triangle$E" value and as clear extender varnish was added, the "$\triangle$E" value slowly decreased. This image area was not within six "$\triangle$E" values to support the hypothesis.

Figure E2: B-Magenta.

This image area had similar characteristics as Figure E1.

Figure E3: C-Cyan.

Throughout the process of adding the five intervals of clear extender varnish to the image area, each "ΔE" value fell within six "ΔE" values of the standard. This result <u>did</u> support the hypothesis.

Figure E4: D-Black.

This image area had an increase of "ΔE" values toward the 40% and 50% clear extender varnish intervals. The result suggested that after adding a large amount of clear extender varnish to the black ink, the image area appeared to become transparent. This allowed a portion of the paper to show through, which increased the "ΔE" values when compared to the standard.

Figure E5: E-3 Color Combination.

This image area started with a high "ΔE" value and gradually decreased to a level which did not support the hypothesis.

Figure E6: F-4 Color Combination.

Near the 50% clear extender varnish interval, the "ΔE" values fell within six "ΔE" values. This was particularly significant because all four colors were printed in the image area. This result <u>did</u> support the hypothesis.

Figure E7: G-Helio.
Figure E8: H-Wall.
Figure E9: I-Fleshtone.

These three image areas started with high "ΔE" values and decreased through the 10% and 20% clear extender varnish intervals. At the 30% and 40% intervals the "ΔE" values leveled off at a point which did not support the hypothesis.

Figure E10: J-Red Coat.

This image area started with a high "ΔE" value and decreased slowly to a point which did not support the hypothesis.

Spectrophotometer:

The spectrophotometric curves were read from the Applied Color System (ACS) under C.I.E. 10 degree observer with the specular component included. The ACS-Spectrophotometer is a computerized system for finger printing a color by reading reflectance values through the visible spectrum.

The importance of this section was to identify the color of each image area through the visible spectrum and to establish a finger print of color for each image area.

Reflection Densitometer:

The densitometer readings were taken from a Cosar 61 Smart (reflection and wide band) Densitometer, serial number 5132080213. The densitometer readings were important to this study in that the majority of the offset and gravure publication printers use a reflection densitometer for quality control purposes.

Summary:

This study rejects the stated hypothesis. With the range of clear extender varnish concentrations used in the series of experiments, the "ΔE" values were less than six in only two of the ten representative image areas chosen for measurement.

There is a suspicion that further addition of clear extender may not improve the situation as indicated by the general flattening of the percentage of clear extender varnish versus "ΔE" values after approximately 30% in the case of image areas G, H, I, and J, the actual picture image areas. From a viewer's standpoint, these areas are more important than the color bar image areas, A, B, C, D, E, and F.

Why an allowable color tolerance has not been accomplished is not quite clear. The results of this analysis raise some valid questions for further investigation, which are addressed in Chapter Six, Recommendations.

Chapter Six

RECOMMENDATIONS

Are there significant differences between Group VI gravure inks and SWOP offset inks which influence the appearance attributes of proofs or prints with such inks as far as hue, saturation, and brightness are concerned?

If the answer to the above is negative, what then is the effect of addition of clear extender varnish on a gray scale (A step wedge, for instance) created by 3-color over-printing? The question of tone reproduction hinges on the answer to this question. If tone reproduction of the offset press proof and the halftone gravure print becomes significantly different, it follows that the "ΔE" value will still be high, primarily due to saturation and brightness differences.

The continuance of this study will be further enhanced by the investigation of the difference, if any, between Group VI gravure inks and the SWOP offset inks in relation to hue, saturation, and brightness.

GLOSSARY OF TERMS

BROMIDES -- A black and white opaque print made from supplied separation film either in continuous tone or halftone. This print is used as input material for the scanning head on an electronic engraving machine.

CLEAR EXTENDER VARNISH -- A solution made up of binders dissolved in solvents. Its purpose is to weaken or extend a gravure ink.

FULL STRENGTH INKS -- Ink without extender varnish added.

OFF-PRESS PROOF -- A proof made without a printing press. Generally, an off-press proof is made by a photochemical, photomechanical, or electrophotographic process. The purpose of the off-press proof is to present an accurate image of the printed job prior to a press run.

OFFSET PRESS PROOF -- A proof which is printed on an offset press before a production run takes place.

SWOP SPECIFICATIONS -- Specifications for Web Offset Publications, the specifications are for the engravers or color separators who supply material for reproduction to the web offset publication printer. The purpose of the SWOP specifications is to ensure a uniform input to the printers. The SWOP specifications are also for the printer, who has the responsibility of matching the supplied proofs in a quality controlled manner. It is the publisher's responsibility to make sure these specifications are implemented throughout the printing process.

UNIVERSAL FILMS -- Films which can be used in the gravure and/or offset printing processes.

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APPENDIX A

Measuring Mode for "ΔE".

Reference: Manual for the Minolta Chroma Meter CR-121.

MEASURING MODES

The Chroma Meter CR-100/CR-110 offers five measuring modes selectable according to your needs. Chromaticity-measuring modes are Yxy and $L^*a^*b^*$; color-deviation measuring modes are $\pm\Delta(Yxy)$, $\pm\Delta(L^*a^*b^*)$, and ΔE_{ab}^*.

NOTE
- Color-deviation measuring mode ΔE_{ab}^* is referred to as "ΔE" throughout the text.

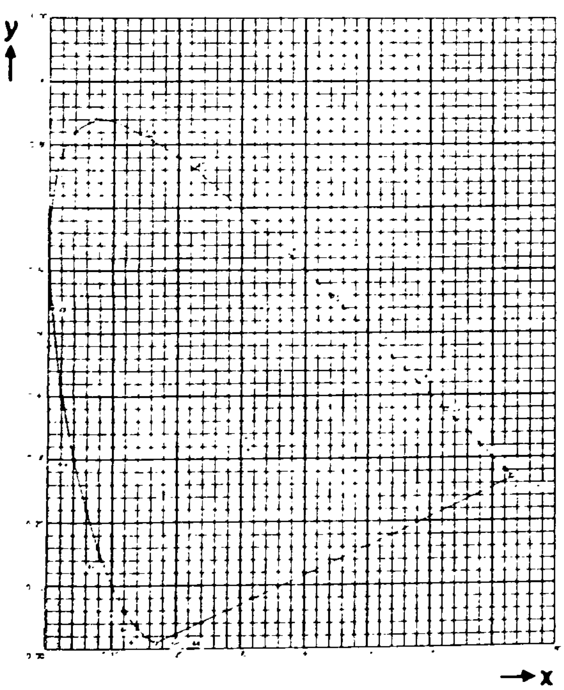
For two colors to appear to match, three quantities defining these colors must be identical. These three quantities are called tristimulus values X, Y, and Z, as determined by the CIE (Commission Internationale de l'Eclairage) in 1931.

Color as perceived has three dimensions: hue, chroma and brightness. Chromaticity includes hue and chroma (saturation), specified by the x and y coordinates in the CIE Chromaticity Diagram (below). Since this two-dimensional diagram cannot describe a specific color completely, a brightness factor must also be included to identify a sample precisely.

In the Yxy measuring mode, Y is a brightness factor expressed as a percentage based on a white surface with a reflectance of 100%. x and y correspond to chromaticity coordinates of the CIE Chromaticity Diagram, defined by the equations below:

$$x = \frac{X}{X+Y+Z} \qquad y = \frac{Y}{X+Y+Z}$$

CIE 1931 (x,y) — Chromaticity Diagram



Equal distances in Y, x, y do not represent eq distances in color as perceived. The $L^*a^*b^*$ mea: ing mode, however, is concerned with human se tivity to color. Equal distances in this system re| sent approximately equal visual distances. L^* i brightness variable; a^* and b^* are chromaticity coc nates.

$$L^* = 116\left(\frac{Y}{Y_0}\right)^{1/3} - 16$$

$$a^* = 500\left[\left(\frac{X}{X_0}\right)^{1/3} - \left(\frac{Y}{Y_0}\right)^{1/3}\right]$$

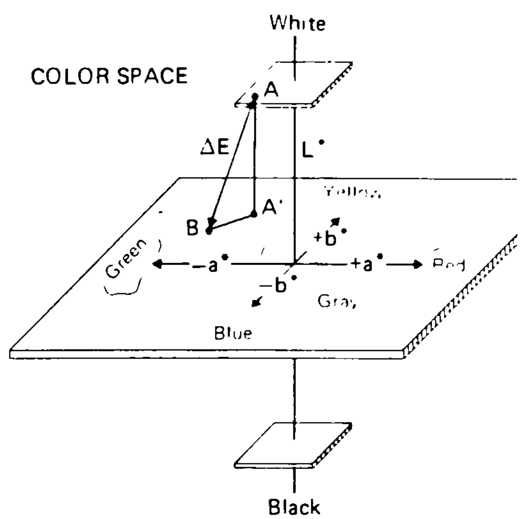
$$b^* = 200\left[\left(\frac{Y}{Y_0}\right)^{1/3} - \left(\frac{Z}{Z_0}\right)^{1/3}\right]$$

(X_0, Y_0 and Z_0 are tristimulus values of the illı nant light source.)

ΔE color-deviation measuring mode repres total color difference. The equation assumes that c space is Euclidean (three-dimensional) and calcul ΔE as the square root of the sum of the square the three components representing the difference tween coordinates of the sample and the standar shown by the equation below:

$$\Delta E = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$$

$L^*a^*b^*$ color space and color deviation ΔE



A : Reference color
B : Material's color
A': Reference color at the same illuminance as material's color

APPENDIX B

Specifications for Web Offset Publications

Reference: SWOP Manual, May 1986.

REGISTER MARKS

Film for color ads should have four center register marks located approximately ½ inch outside the bleed area. Register marks should be "line" copy at least ½ inch long.

MULTIPLE INSERTIONS

The specified number and kind of film sets along with the required proofs and progressives should be supplied to each publication. Appropriate control elements should be used in contacting these final films to ensure that all are identical and accurate reproductions of the master films.

PRESS PROOFING

PAPER — PROOFING STOCK

Standard proofing paper is 60# basis weight paper of 70 (nominal) brightness. This approximates the appearance of publication papers used by a majority of web-offset printed publications. The paper may be a coated groundwood stock, or a sheet coated to simulate the appearance of such a groundwood sheet.

Two papers known to meet these specifications are *Champion-Textweb* and *Appleton Papers Inc Ad Proof Proofing Enamel*. Other papers meeting the specifications for basis weight, shade, and brightness may be used — See Reference Section.

> Since 1975 standard proofing stock has been 60# basis weight, 78 brightness Consolidated Fortune Gloss, or equivalent. For six months after publication of these Specifications, proofs on any of the above papers will be accepted by publishers. After six months from the date of this publication only 70 brightness proofing paper will be acceptable.

INKS

Use Standard SWOP Proofing Inks. These inks can be obtained from most local ink suppliers. Specify "SWOP Proofing Inks" in ordering.

Samples of proofing inks for voluntary verification should be sent to NAPIM/SWOP Proofing Ink Verification Program, c/o GATF, 4615 Forbes Avenue, Pittsburgh, Pennsylvania 15213.

Standard second color inks are also available. These are Process Yellow, Process Blue (cyan), Red—which is equivalent to the solid overprint of magenta and yellow; and Green—which is equivalent to the solid overprint of cyan and yellow.

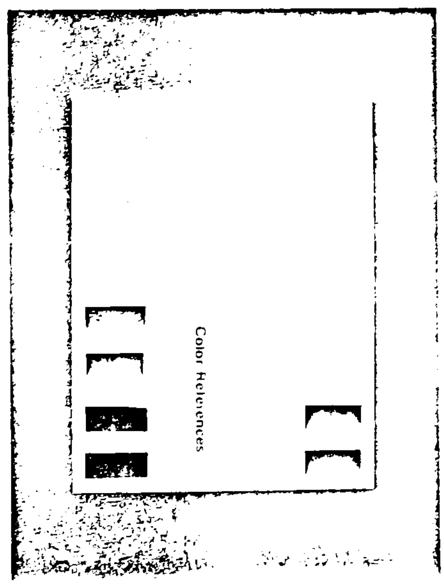
COLOR REFERENCES/DENSITOMETRY

The International Prepress Association (formerly PERI) is responsible for production, selection, and distribution of Standard Color References. These are printed on Standard paper, using Standard proofing inks. These inks have been verified as being correct by the NAPIM/SWOP Proofing Ink Verification Program. Two types are available on a subscription basis.

a. Hi-Lo Reference. Consists of printed swatches of Standard Proofing Inks, two per color, illustrating values plus 0.07 and minus 0.07 of standard as measured in the IPA laboratory. Proofers should control inking so that ink amounts on dry proofs are between these illustrated limiting values.

Use of these Hi-Lo References minimizes communication difficulties that may be caused by using different densitometers having different sensitivities.

b. Single Level Color Reference. Consists of printed swatches of the standard process and second color inks. Marked reference areas are within plus or minus 0.02 density of the standard values, as read in the IPA Laboratory. Densities on the dry proof should be within plus or minus 0.07 of the value read by the proofer on the Standard Color Reference.



PRINT CONTRAST

Print Contrast is an objective characteristic of printing relating to the amount of shadow detail rendered by the process.

This value correlates relatively well to subjective visual evaluation and terminology such as "flat" (low Print Contrast) or "punchy" (high Print Contrast).

The value is affected by solid ink density, substrate brightness, the density of the 75% tint region, and gloss. While absolute values or tolerances cannot be specified at this time, it is felt that Print contrast is important to quality reproduction and a useful parameter for production control.

Print Contrast can be calculated using densitometer measurements and the equation:

$$\% PC = \frac{D_s - D_{75}}{D_s} \times 100$$

where:

$\% PC$ = Print Contrast (%)

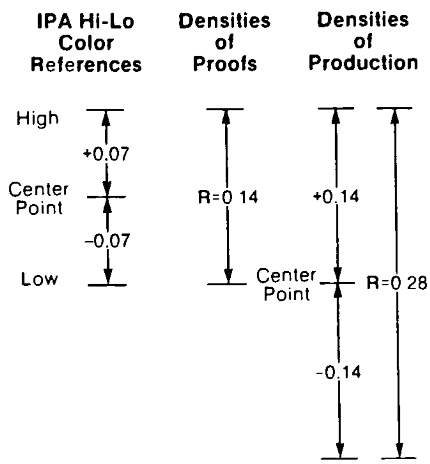
D_S = Density of a solid (including paper)

D_{75} = Density of 75% tint (including paper)

A value of 25%* PRINT CONTRAST is considered a general guideline for publication printing

INK DENSITY

Ink density for the center point of the printer's range is to be the density read at the Lo of the SWOP Hi-Lo Reference. The acceptable deviation from this center point is to be obtained by taking the measured density difference between the Hi and the Lo, which becomes the allowable deviation above or below the center aim point



Acceptable density ranges for proofs and production from IPA Hi-Lo Color References. (Note: Actual density ranges will vary depending on the densitometer used to read the IPA color references)

VIEWING OF PROOFS AND PRINTED SIGNATURES

Proofs and printed signatures should be viewed and compared under illumination conditions specified in the applicable ANSI or ISO standard This calls for correlated color temperature of 5000 K, and a color rendering index of 90-100 See reference section for information on standard viewing areas

* For more information see Reference Section

* Using Densitometers conforming to Status T Standards

Use of Single Level Color References

Some null-reading or scanning densitometers must be set to the "standard" density value in order to function correctly

Single-level Ink References display ink amounts within plus or minus 0.02 of standard values for ink-paper proofs as read in the IPA Laboratory. A proof having solid ink swatches of these amounts, plus or minus 0.07 density units (as read on a wide-band densitometer) is acceptable, according to this specification.

The proofer's densitometer should be calibrated per manufacturer's instructions. Each densitometer must be referenced to the swatches separately. *Do not* use numerical readings from one machine as references for another.

These References also display the Standard SWOP Second Colors, which are Red and Green.

Reflection Densitometry

A reflection densitometer is a device for measuring the amount of light reflected from a surface.

When readings are made on color subjects, filters complementary to the color being read are placed in the light path of the instrument. Thus cyan ink is read through a red filter, magenta ink through a green filter, and yellow ink through a blue filter. An amber filter is usually used when measuring black.

Color filters generally used are the wide band filters traditionally used in color separations. The choice was based on (1) availability, (2) the expectations that readings through these filters would relate to the densities obtained on color separations photographed through similar filters (equivalent neutral density), and (3) similarities of instrument responses to those from colorimeters which can, in some cases, relate to the response of the human eye

The use of different filter systems having narrower band passes has been proposed in order to minimize differences between readings of different instruments made on the same specimen. Numerical readings made with narrow and wide band instruments can differ significantly

Until 1984 there were no published standards for instrument responses at various wave lengths of light. In 1984 the American National Standards Institute published ANSI National Standard PH 2.18 for Density Measurements—Spectral Conditions defining standard densitometer performances. The portion of this standard which is relevant to graphic arts is that describing "Status T" densitometer response. It is expected that all manufacturers of reflection densitometers will, within a limited time, produce instruments conforming to this standard and that a means of determining instrument conformance to this standard will be available

The geometric conditions for reflection density measurements are described in ANSI PH 2.17-1977, American National Standards Institute, Inc., 1430 Broadway, New York, New York 10018

Densitometer Calibration

The densitometer should be allowed to "warm up" according to the specifications of the manufacturer before the daily adjustments for calibration are made. Make sure that the optics are cleaned regularly, as well as the filters and the plaque used for "calibrations". Follow manufacturers recommendation for frequency of maintenance. Protect all elements from light, dirt and fingerprints.

Reflection densitometers are supplied with calibration plaques or scales to be used in following the manufacturer's directions as the means for assuring the linearity of the photometric response. This adjustment is made using the "visual filter". It should be repeated at least daily.

The Color Reference described previously involve printed ink samples on paper. Keep them protected and free of fingerprints and other damage. The Reference must be used on a flat, even surface. It should be backed by unprinted paper stock in sufficient amount to prevent the subsurface from affecting the reading

Once a proof that matches the Color Reference has been pulled, it can be used as the guide for the day as a "secondary reference"

Densitometer Control of Proofing

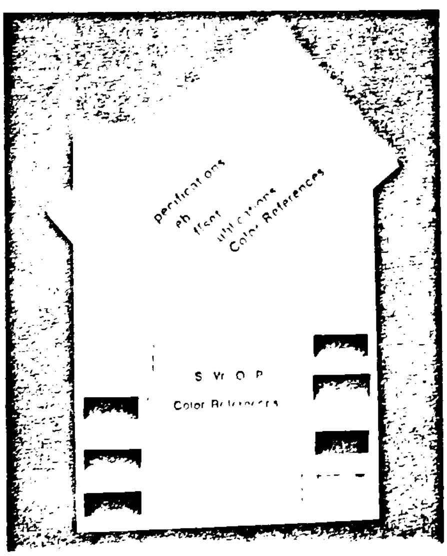
In implementing these Specifications, the use of instrumentation to compare a printed proof to an ink reference is essential. The human eye can make comparisons, but visual impressions cannot be recorded or accurately communicated, hence the need for instrumentation.

The reflection densitometer responds to differences in reflected light and thus detects variations in ink densities. Adjustments to the inking system may then be made so that the proof will match the reference in ink amounts.

Individual instruments tend to differ somewhat in their response to different colored samples, therefore it is not feasible to communicate standard values for inking in terms of numerical readings. Two instruments are likely to give different readings on the same sample, and are likewise apt to differ in sensitivity, and measure differences in ink amount differently.

When communicating measurements to others, always indicate the deviation of numerical value from the numerical value read with your instrument on your color reference. When Hi-Lo References are used, indicate whether deviations are measured from the high- or low-reference swatch as well as the amount and direction (+ or −) of the deviation.

When Single Level References are used, so indicate.



Compensation for Dryback

The gloss of the wet ink on a proof will affect the readings of the densitometer. Read the density of printed color bars approximately four minutes after printing and again when the ink is dry. The reduction in the readings is the result of the dryback in the surface gloss of the ink.

Adjustments should then be made in the ink flow to give a wet ink reading equal to the density of the dry ink on the standard bar plus the additional density to allow for the dryback of the ink.

When making density readings the measurements should be consistent across the entire bar affecting the illustration. Only those areas in line with the color illustrations should be used. Whenever possible, the direction of proofing should be the same as the eventual press run.

Most important, do not try to make the proof acceptable to the customer by manipulating the press improperly. Excessive addition or reduction of inking during proofing defeats the purpose of the Specification and frequently results in lost press time and unsatisfactory reproduction. Adherence to specifications will provide production press results which will better match your proofs and satisfy everyone.

WET PROOFING

It is not possible at the present time to specify a sequence of inks for ink-on-paper proofing.

Attention to trap and gray balance is most important in producing press proofs. The "gray balance" bars incorporated in the standard proofing bars are the most effective device for checking on these aspects of proof-press performance.

Web printing commonly uses the color sequence cyan-magenta-yellow with black either first or last. This sequence is reported to produce the best overprints in most cases (see "The Quality Control Scanner", Vol. 3, No. 6, M.F. Southworth and D.K. Southworth, editors, Graphic Arts Publishing Co., Livonia, NY, 1983, pp. 1-2). With some presses and press forms it may be necessary to proof in a different sequence in order to minimize contamination of later printed colors by the first- and second-down inks.

APPENDIX C

Ink Viscosity Readings.

1. Each ink viscosity reading was an average of five independent viscosity readings. The instrument used for the viscosity readings was a #2 Zahn viscometer.

2. With the particular press conditions and press speed used (600 feet per minute), a 20 second (plus or minus one tenth of a second) viscosity reading was recommended for use with all four units of the gravure Champlain web press.

Table C1: Ink Viscosity Readings for the #1 unit on press-YELLOW.

		Clear Extender Varnish - Percent Added				
	* FS	10%	20%	30%	40%	50%
1	20.7					
2		20.4				
3			20.8			
4				20.9		
5					20.6	
6						20.7

* = Full Strength Ink.

Table C2: Ink Viscosity Readings for the #2 unit on press-MAGENTA.

		Clear Extender Varnish - Percent Added				
	* FS	10%	20%	30%	40%	50%
1	21.3					
2		20.3				
3			20.1			
4				20.3		
5					20.3	
6						20.3

* = Full Strength Ink.

Table C3: Ink Viscosity Readings for the #3 unit on press-CYAN.

	* FS	Clear Extender Varnish - Percent Added				
		10%	20%	30%	40%	50%
1	20.5					
2		20.1				
3			20.3			
4				20.1		
5					20.1	
6						20.0

* = Full Strength Ink.

Table C4: Ink Viscosity Readings for the #4 unit on press-BLACK.

	* FS	Clear Extender Varnish - Percent Added				
		10%	20%	30%	40%	50%
1	20.4					
2		20.4				
3			20.2			
4				20.1		
5					20.1	
6						20.1

* = Full Strength Ink.

APPENDIX D

"ΔE" Values.

TABLE D1: "ΔE" Values, Full Strength Inks - No Clear Extender Varnish Added.

Gravure Print #	1	2	3	4	5	AVE "ΔE"
A-Yellow	17.5	17.8	17.2	17.7	17.Ø	17.4
B-Magenta	21.3	21.5	21.1	21.2	21.2	21.2
C-Cyan	7.3	6.5	6.6	7.2	6.1	6.7
D-Black	8.2	7.8	8.8	8.1	8.Ø	8.1
E-3-Color Combination	15.3	15.4	14.9	15.5	15.3	15.2
F-4-Color Combination	6.6	6.4	6.6	6.7	6.1	6.4
G-Helio	14.9	17.Ø	15.2	15.4	15.9	15.6
H-Wall	15.7	16.9	16.7	16.4	15.6	16.2
I-Fleshtone	21.5	21.6	22.Ø	19.4	19.7	2Ø.8
J-Red Coat	21.Ø	2Ø.9	21.Ø	21.1	21.4	21.Ø

TABLE D2: "ΔE" Values, 10% Clear Extender Varnish Added.

Gravure Print #	1	2	3	4	5	AVE "ΔE"
A-Yellow	16.7	16.1	16.0	16.0	16.0	16.1
B-Magenta	19.0	18.9	18.7	18.6	19.2	18.8
C-Cyan	5.9	6.2	6.1	5.8	5.7	5.9
D-Black	9.0	9.3	9.0	8.8	8.5	8.9
E-3-Color Combination	14.6	14.9	14.7	14.8	14.8	14.7
F-4-Color Combination	7.2	6.7	6.9	6.8	6.7	6.8
G-Helio	15.0	14.0	14.9	14.9	14.8	14.7
H-Wall	15.4	16.4	15.8	14.8	14.6	15.4
I-Fleshtone	18.5	17.6	17.2	19.3	16.7	17.8
J-Red Coat	20.8	21.0	21.0	20.8	20.9	20.9

TABLE D3: "ΔE" Values, 2Ø% Clear Extender Varnish Added.

Gravure Print #	1	2	3	4	5	AVE "ΔE"
A-Yellow	14.4	13.6	13.5	13.6	13.8	13.7
B-Magenta	17.5	17.Ø	17.6	18.Ø	17.2	17.4
C-Cyan	5.3	5.1	6.Ø	5.7	5.3	5.4
D-Black	9.1	8.8	8.3	8.1	9.Ø	8.6
E-3-Color Combination	14.1	13.9	14.Ø	14.3	13.8	14.Ø
F-4-Color Combination	6.4	6.7	6.4	6.6	5.8	6.3
G-Helio	12.7	13.Ø	12.6	13.Ø	12.4	12.7
H-Wall	13.6	14.4	14.3	13.Ø	13.2	13.7
I-Fleshtone	16.4	16.6	18.6	2Ø.Ø	12.4	16.8
J-Red Coat	2Ø.7	2Ø.7	2Ø.7	2Ø.8	2Ø.7	2Ø.7

TABLE D4: "ΔE" Values, 30% Clear Extender Varnish Added.

Gravure Print #	1	2	3	4	5	AVE "ΔE"
A-Yellow	13.3	12.5	12.4	12.7	12.2	12.6
B-Magenta	15.8	16.0	15.4	15.2	15.3	15.5
C-Cyan	5.4	5.7	5.6	5.6	5.5	5.5
D-Black	9.1	8.6	8.7	8.8	9.3	8.9
E-3-Color Combination	13.2	13.4	13.6	13.4	13.1	13.3
F-4-Color Combination	5.6	6.3	6.2	6.3	6.1	6.1
G-Helio	10.5	11.2	10.6	8.9	8.3	9.9
H-Wall	10.8	10.7	12.2	9.9	9.2	10.5
I-Fleshtone	11.6	13.7	12.5	12.8	12.2	12.5
J-Red Coat	20.2	20.0	20.0	20.0	19.8	20.0

TABLE D5: "ΔE" Values, 40% Clear Extender Varnish Added.

Gravure Print #	1	2	3	4	5	AVE "ΔE"
A-Yellow	11.3	11.2	10.5	10.8	10.8	10.9
B-Magenta	14.3	14.3	14.6	13.9	14.2	14.2
C-Cyan	5.8	5.1	5.7	6.2	6.2	5.8
D-Black	8.1	8.9	8.8	8.8	8.7	8.6
E-3-Color Combination	12.7	12.9	12.7	13.0	13.2	12.9
F-4-Color Combination	5.0	6.0	5.7	5.9	5.5	5.6
G-Helio	9.9	6.9	10.1	8.1	9.7	8.9
H-Wall	10.6	9.8	9.4	10.4	10.7	10.1
I-Fleshtone	13.2	11.9	12.9	13.7	11.3	12.6
J-Red Coat	17.9	19.5	19.2	19.6	19.5	19.1

TABLE D6: "ΔE" Values, 50% Clear Extender Varnish Added.

Gravure Print #	1	2	3	4	5	AVE "ΔE"
A-Yellow	9.9	10.2	9.9	8.6	9.4	9.6
B-Magenta	12.7	13.2	12.9	13.5	13.0	12.8
C-Cyan	6.4	5.7	5.1	6.0	5.9	5.8
D-Black	9.7	9.3	9.2	9.1	9.1	9.2
E-3-Color Combination	12.0	12.5	11.9	12.4	12.3	12.2
F-4-Color Combination	5.4	5.1	5.5	5.5	5.4	5.3
G-Helio	10.5	9.9	8.5	9.7	10.6	9.8
H-Wall	9.6	10.6	9.9	10.8	9.8	10.1
I-Fleshtone	15.0	12.0	12.0	12.9	13.9	13.1
J-Red Coat	19.1	19.1	19.2	19.1	18.7	19.0

TABLE D7: "ΔE" Values, Off-Press Proof (Matchprint).

Gravure Print #	1	2	3	4	5	AVE "ΔE"
A-Yellow	3.5	3.6	3.8	3.9	3.9	3.7
B-Magenta	8.2	8.2	8.1	8.2	8.4	8.2
C-Cyan	7.7	7.9	7.8	7.7	7.7	7.7
D-Black	5.4	5.5	5.5	5.5	5.6	5.5
E-3-Color Combination	11.6	11.6	11.6	11.4	11.5	11.5
F-4-Color Combination	3.9	4.1	4.1	4.1	4.3	4.1
G-Helio	5.7	5.7	5.4	5.3	5.3	5.4
H-Wall	Ø.3	Ø.4	Ø.3	Ø.5	Ø.6	Ø.4
I-Fleshtone	6.6	6.7	6.5	6.4	6.3	6.5
J-Red Coat	8.5	8.6	8.6	8.5	8.7	8.5

The image areas (A - J) on one selected off-press proof were measured five times, then averaged to avoid chance error within the "ΔE" values.

TABLE D8: "ΔE" values based on the Yxy values of the SWOP standard offset press proof.

	Y	x	y
A-Yellow	73.6	.433	.496
B-Magenta	15.4	.477	.256
C-Cyan	25.1	.176	.227
D-Black	3.9	.299	.318
E-3-Color Combination	3.1	.343	.265
F-4-Color Combination	1.Ø	.347	.322
G-Helio	38.8	.286	.3Ø1
H-Wall	46.6	.312	.324
I-Fleshtone	39.8	.354	.339
J-Red Coat	13.Ø	.436	.315

APPENDIX E

Graphs

"ΔE" versus Percent of Clear Extender Varnish.

Figure E1: "△E" Values - % of Clear Extender Varnish Added, A - Yellow.

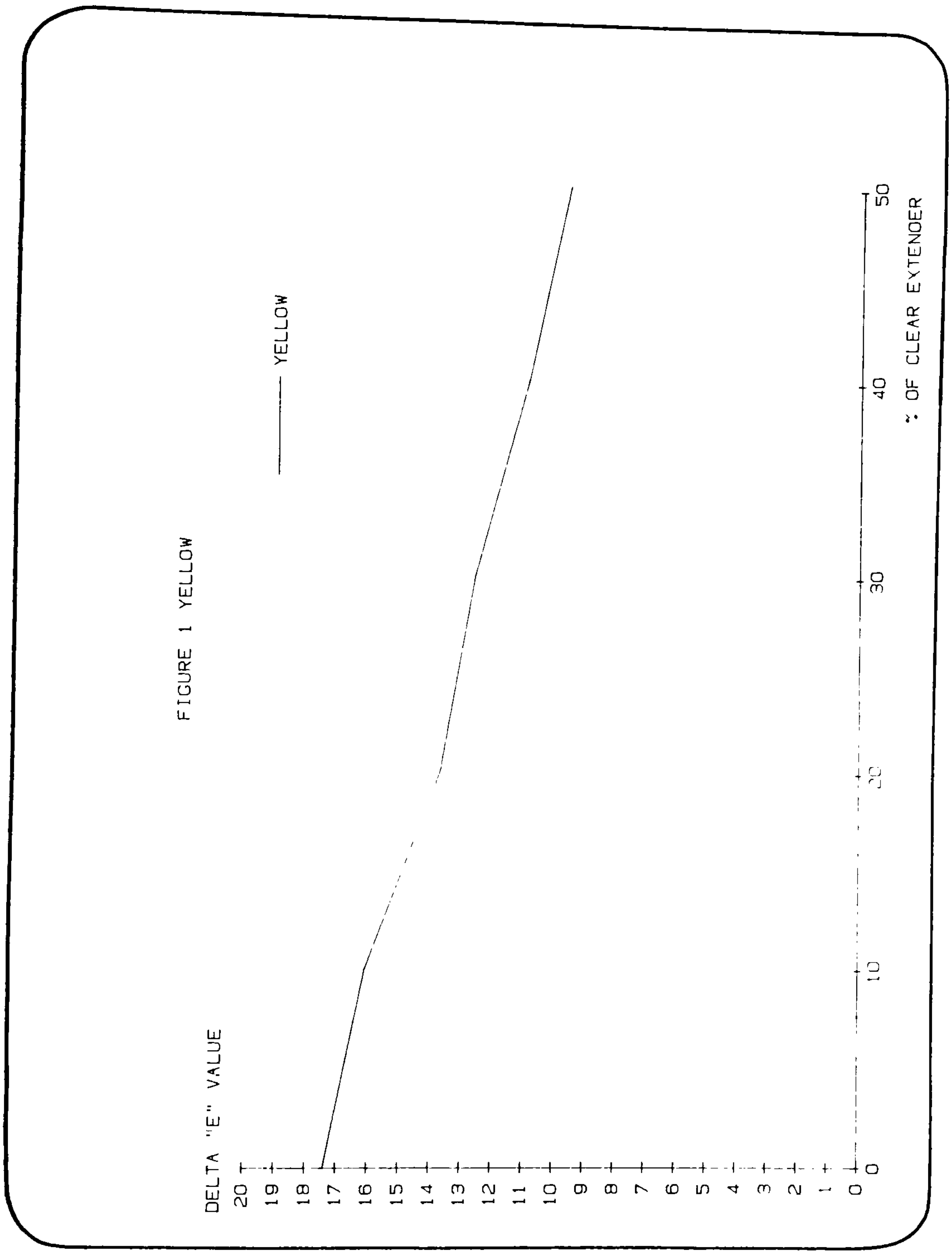


Figure E2: "ΔE" Values - % of Clear Extender Varnish Added, B - Magenta.

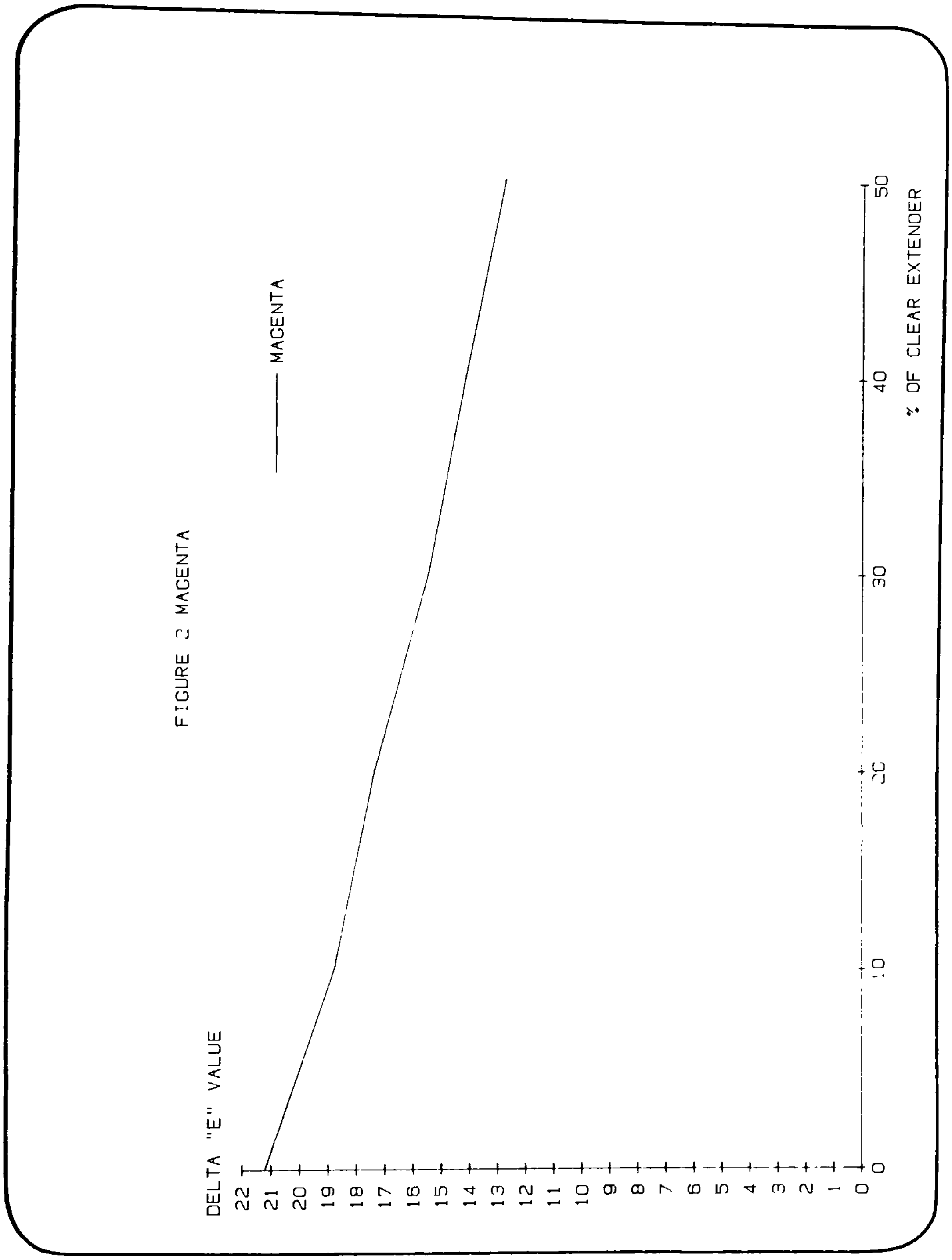


Figure E3: "$\triangle$E" Values - % of Clear Extender Varnish Added, C - Cyan.

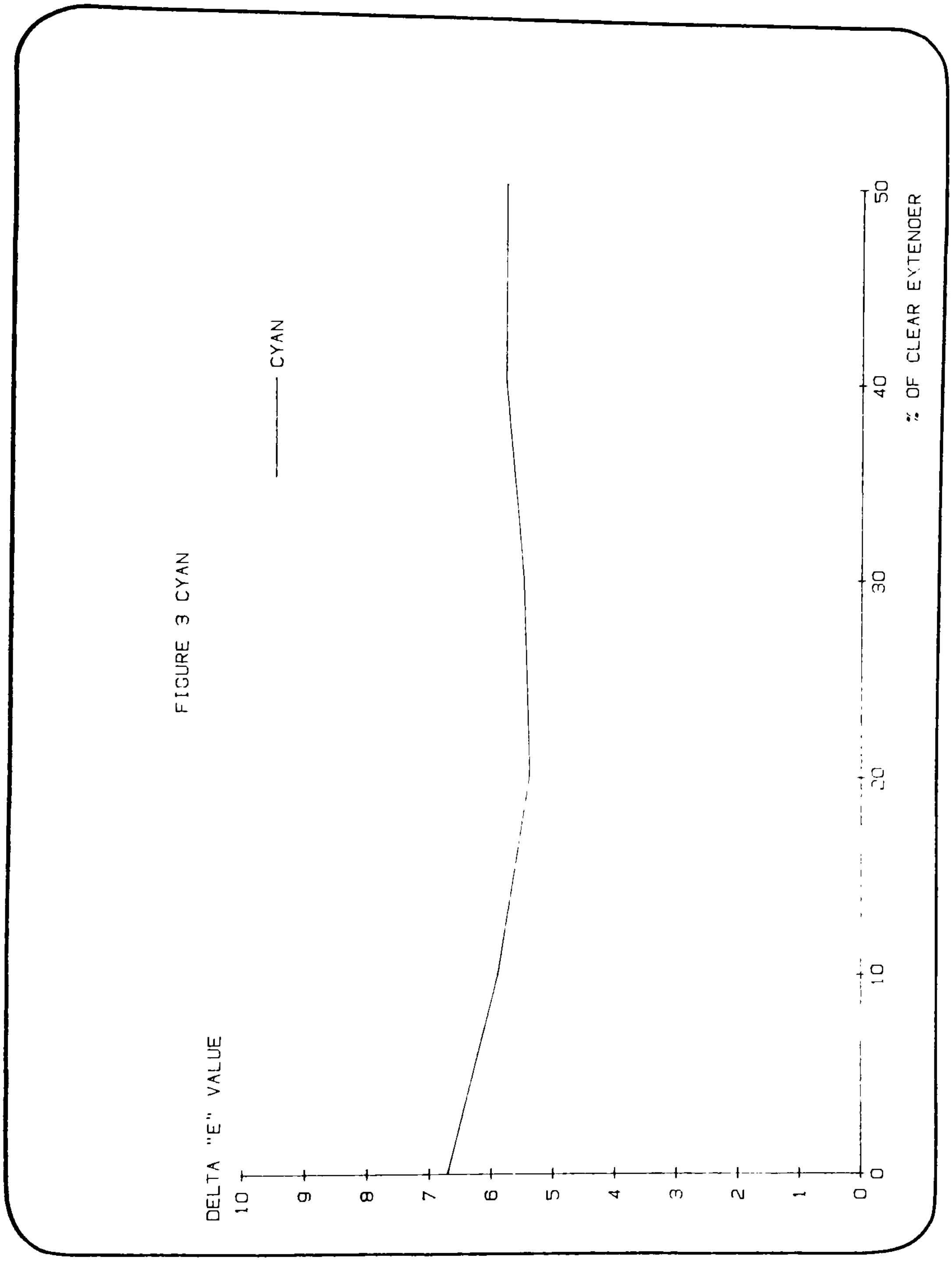


Figure E4: "ΔE" Values - % of Clear Extender Varnish Added, D - Black.

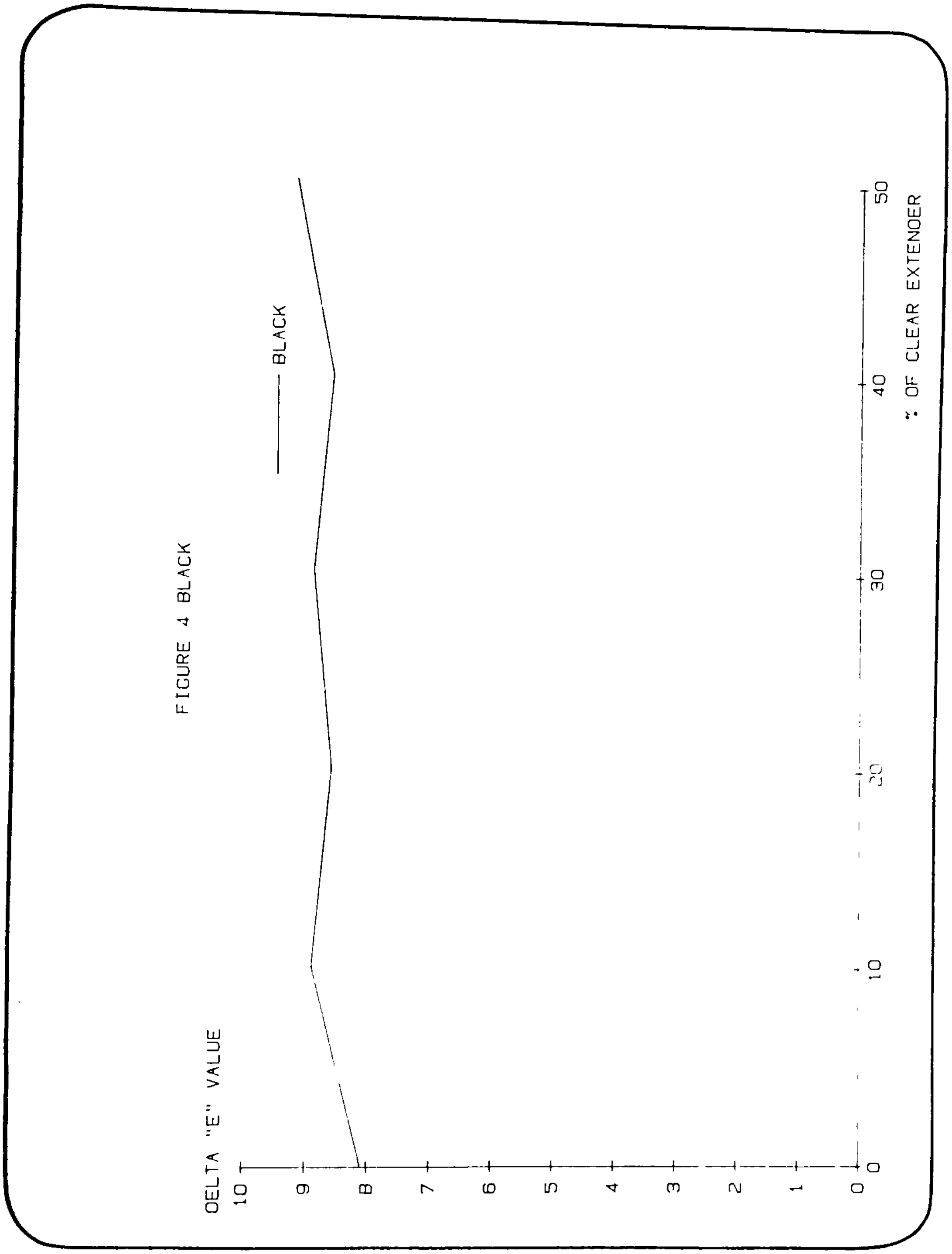


Figure E5: "$\triangle$E" Values - % of Clear Extender Varnish Added, E - 3-Color Combination.

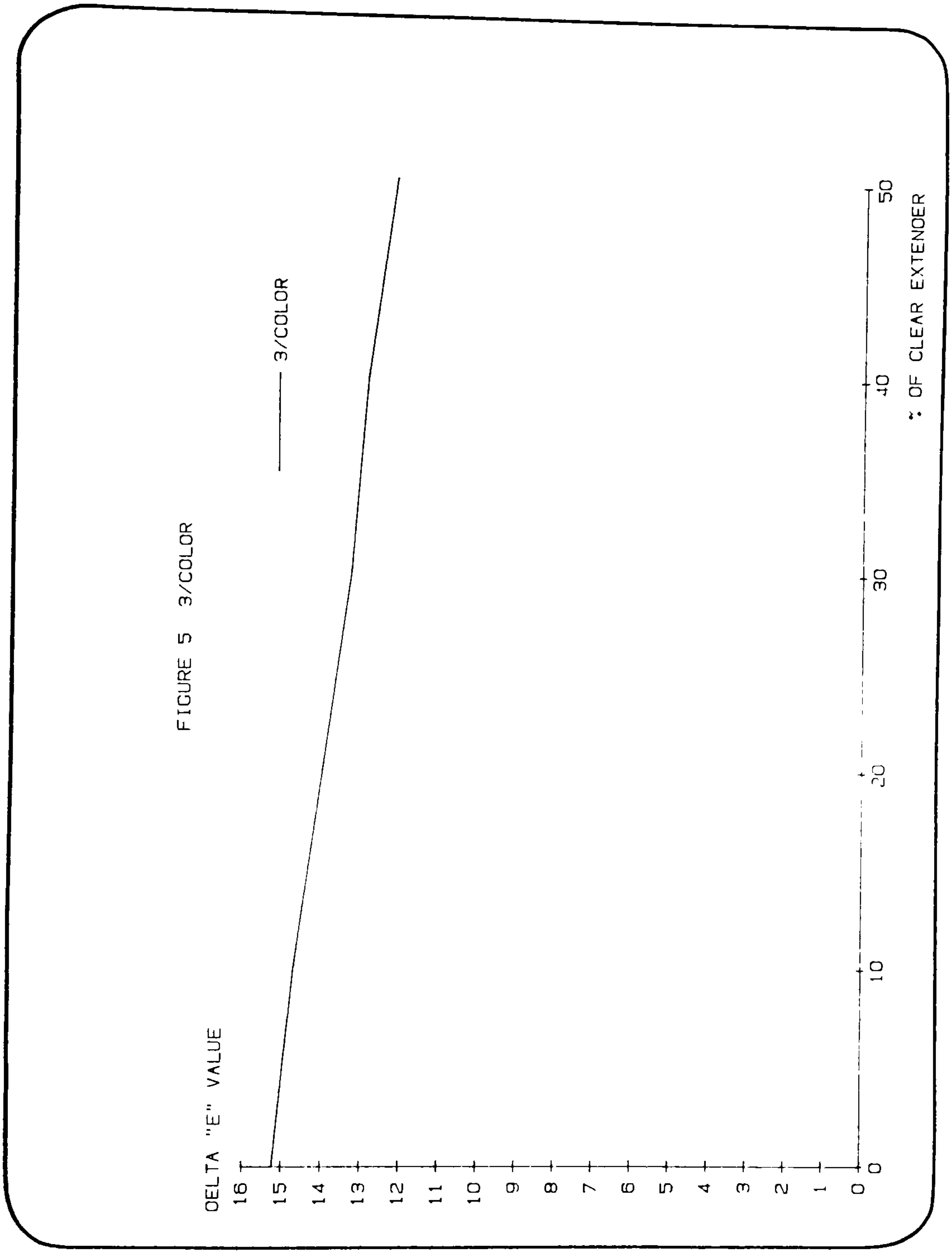


Figure E6: "$\triangle$E" Values - % of Clear Extender Varnish Added, F - 4-Color Combination.

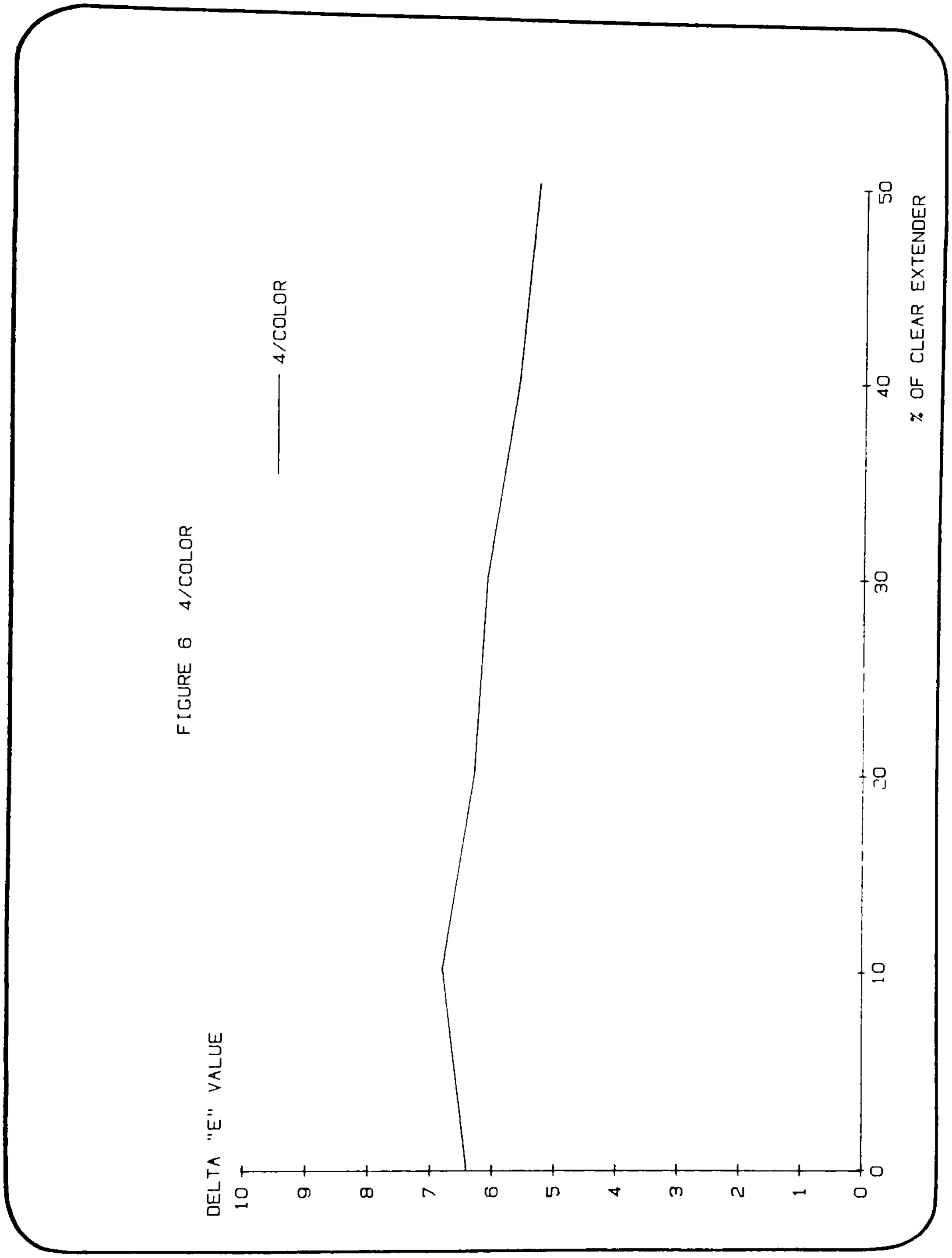


Figure E7: "△E" Values - % of Clear Extender Varnish Added,
G - Helio.

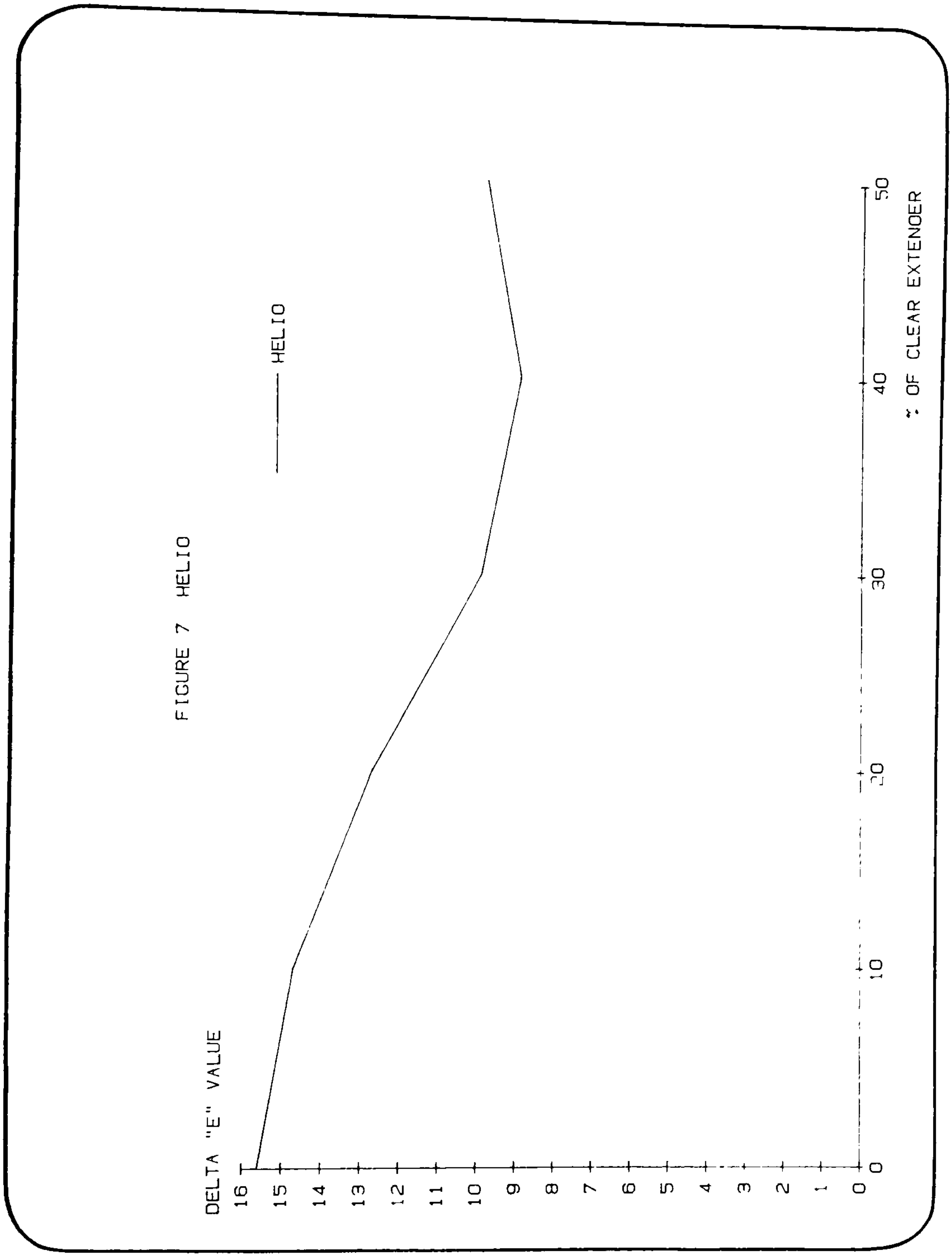


Figure E8: "$\triangle$E" Values - % of Clear Extender Varnish Added, H - Wall.

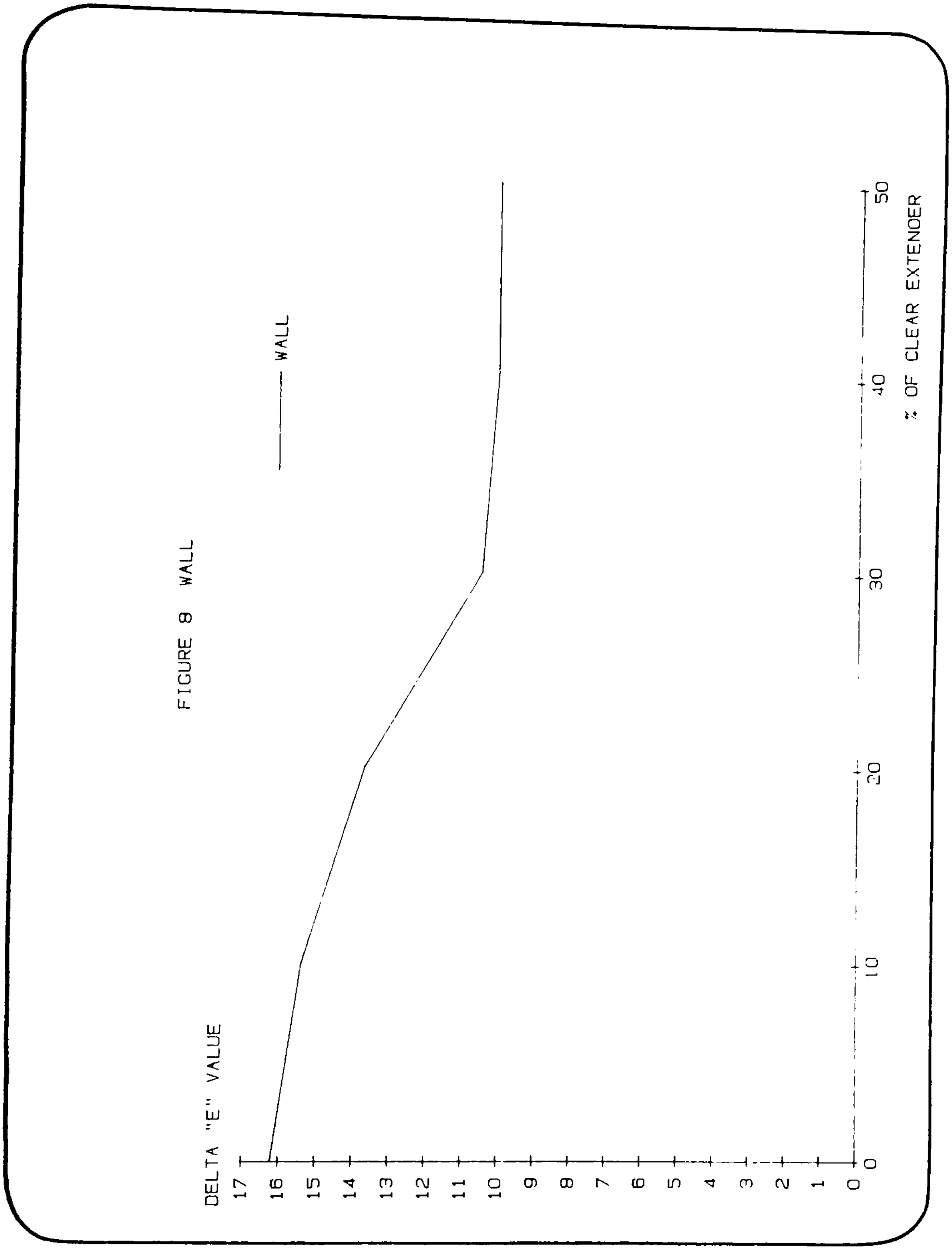


Figure E9: "$\triangle$E" Values - % of Clear Extender Varnish Added,
I - Fleshtone.

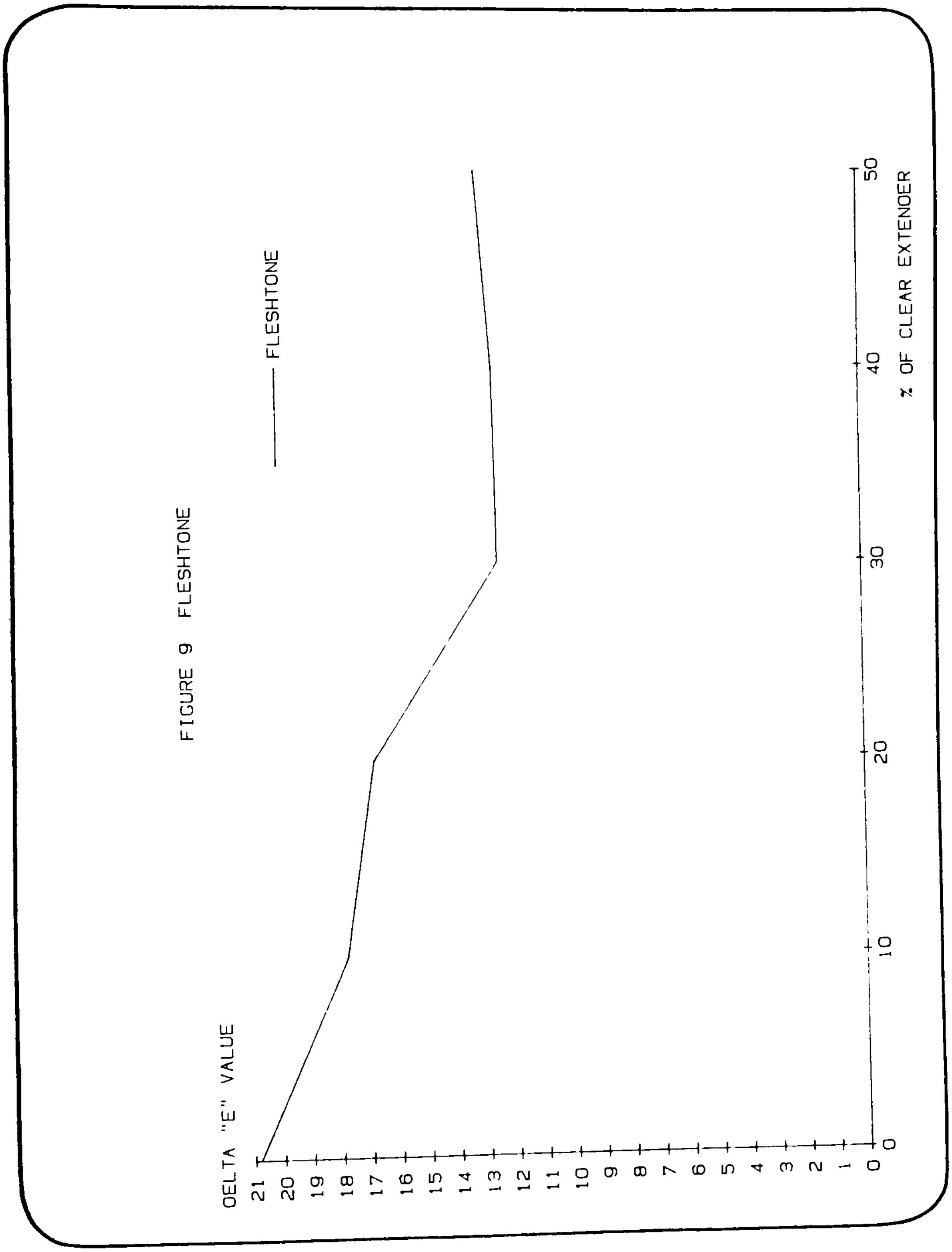
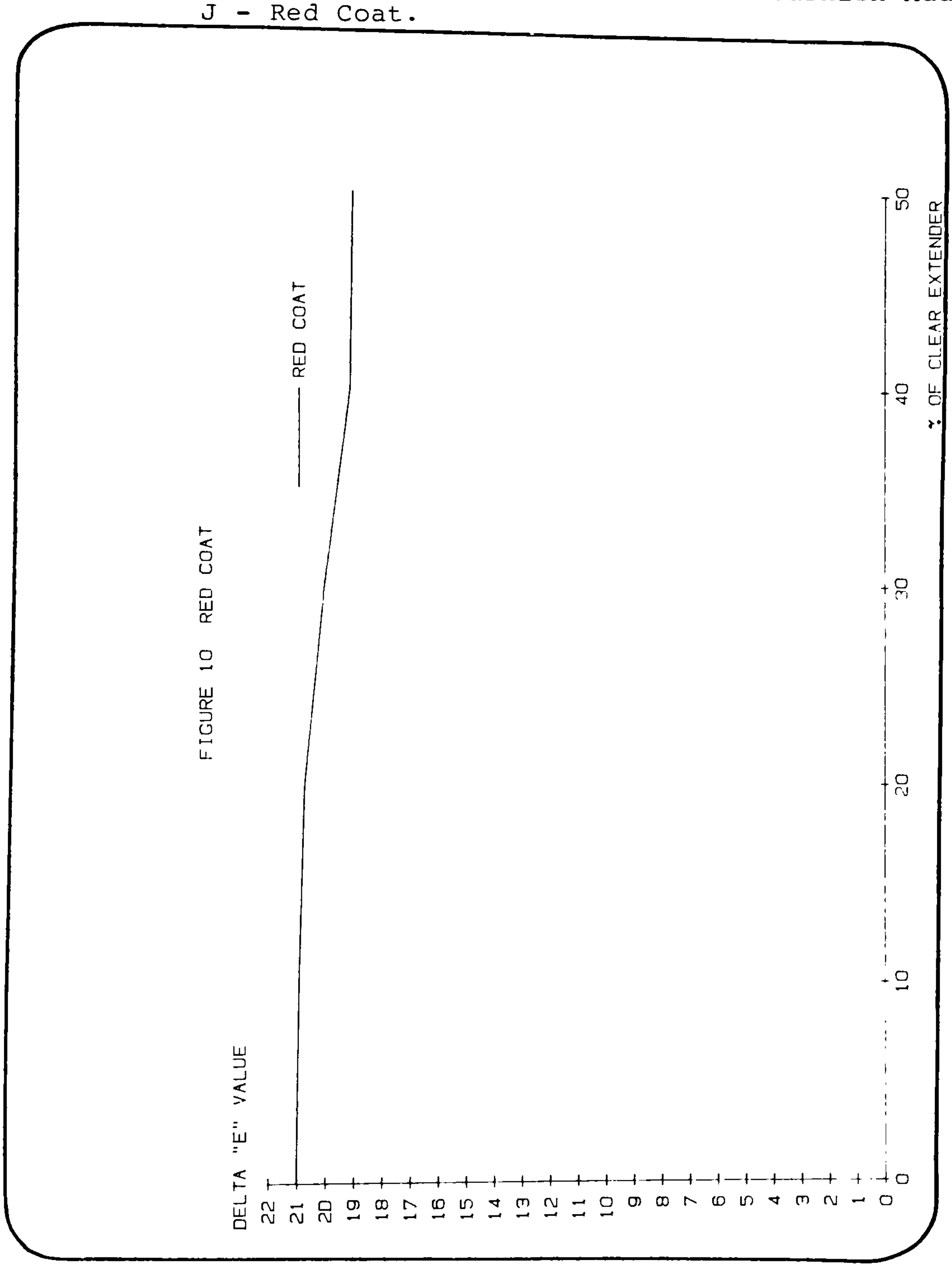


Figure E1Ø: "△E" Values - % of Clear Extender Varnish Added, J - Red Coat.



APPENDIX F

L*a*b* Values.

TABLE F1: L*a*b* Values, SWOP Standard Offset Press Proof.

	L*	a*	b*
A-Yellow	88.9	(17.4)	90.7
B-Magenta	46.2	63.7	5.0
C-Cyan	57.3	(23.7)	(38.5)
D-Black	23.5	(2.0)	(0.4)
E-3-Color Combination	20.2	16.1	(4.6)
F-4-Color Combination	9.2	2.6	3.0
G-Helio	66.5	(3.6)	9.2
H-Wall	73.1	(2.5)	2.4
I-Fleshtone	67.0	9.2	12.0
J-Red Coat	42.8	30.4	12.8

TABLE F2: L*a*b* Values, Full Strength Inks - No Clear Extender Varnish Added.

	L*	a*	b*
A-Yellow	84.7	(13.4)	1Ø8.Ø
B-Magenta	39.1	6Ø.2	23.9
C-Cyan	51.6	(21.5)	(36.6)
D-Black	16.8	(1.6)	(4.4)
E-3-Color Combination	9.3	7.9	2.1
F-4-Color Combination	6.1	(2.2)	Ø.4
G-Helio	53.5	6.Ø	(8.9)
H-Wall	57.5	4.8	2.5
I-Fleshtone	52.9	17.4	11.2
J-Red Coat	23.5	35.4	18.7

TABLE F3: L*a*b* Values, 10% Clear Extender Varnish Added.

	L*	a*	b*
A-Yellow	84.8	(13.7)	107.0
B-Magenta	39.5	61.3	21.8
C-Cyan	52.0	(22.1)	(36.0)
D-Black	16.8	(1.1)	(4.9)
E-3-Color Combination	10.0	8.9	2.5
F-4-Color Combination	6.6	(2.1)	0.4
G-Helio	53.4	3.0	(3.2)
H-Wall	60.8	1.7	7.0
I-Fleshtone	55.1	13.8	12.6
J-Red Coat	23.0	36.8	18.3

TABLE F4: L*a*b* Values, 20% Clear Extender Varnish Added.

	L*	a*	b*
A-Yellow	84.9	(14.2)	104.0
B-Magenta	39.7	60.8	20.3
C-Cyan	53.4	(23.3)	(34.8)
D-Black	16.4	(1.3)	4.9
E-3-Color Combination	10.9	10.9	3.3
F-4-Color Combination	6.7	(2.0)	0.6
G-Helio	55.7	1.5	(6.0)
H-Wall	61.3	1.0	5.7
I-Fleshtone	58.3	3.7	15.2
J-Red Coat	23.8	37.4	17.6

TABLE F5: L*a*b* Values, 3Ø% Clear Extender Varnish Added.

	L*	a*	b*
A-Yellow	84.6	(14.3)	1Ø3.Ø
B-Magenta	4Ø.1	6Ø.9	18.7
C-Cyan	54.1	(23.5)	(34.2)
D-Black	16.4	(1.2)	5.3
E-3-Color Combination	11.1	1Ø.9	3.1
F-4-Color Combination	5.4	(2.1)	Ø.5
G-Helio	59.3	(2.9)	(4.7)
H-Wall	65.1	Ø.Ø	Ø.7
I-Fleshtone	57.4	5.7	15.Ø
J-Red Coat	24.Ø	37.1	16.3

TABLE F6: L*a*b* Values, 4Ø% Clear Extender Varnish Added.

	L*	a*	b*
A-Yellow	84.6	(14.4)	1Ø1.Ø
B-Magenta	4Ø.2	61.6	17.1
C-Cyan	55.1	(23.5)	(33.4)
D-Black	17.8	(1.1)	5.7
E-3-Color Combination	11.4	11.5	3.5
F-4-Color Combination	6.7	(1.8)	Ø.6
G-Helio	58.9	(2.7)	(3.1)
H-Wall	64.7	(1.5)	3.4
I-Fleshtone	58.8	5.8	14.6
J-Red Coat	25.7	37.Ø	15.2

TABLE F7: L*a*b* Values, 5Ø% Clear Extender Varnish Added.

	L*	a*	b*
A-Yellow	84.4	(14.6)	99.8
B-Magenta	4Ø.6	61.6	15.4
C-Cyan	55.6	(23.8)	(32.Ø)
D-Black	17.Ø	(1.7)	6.1
E-3-Color Combination	12.4	12.Ø	3.4
F-4-Color Combination	5.5	(1.2)	Ø.9
G-Helio	59.Ø	(3.9)	(4.1)
H-Wall	64.5	(1.7)	4.2
I-Fleshtone	6Ø.5	7.4	5.1
J-Red Coat	25.Ø	37.3	12.9

TABLE F8: L*a*b* Values, Off-Press Proof (Matchprint).

	L*	a*	b*
A-Yellow	86.3	(16.8)	92.9
B-Magenta	46.3	55.1	6.2
C-Cyan	55.4	(27.Ø)	(32.3)
D-Black	19.4	(3.7)	2.5
E-3-Color Combination	19.1	6.6	2.8
F-4-Color Combination	8.7	(1.1)	Ø.5
G-Helio	64.1	(4.2)	(4.7)
H-Wall	68.4	(2.9)	4.2
I-Fleshtone	63.Ø	7.5	16.2
J-Red Coat	34.6	35.1	16.Ø

APPENDIX G

Spectrophotometric Curves.

Figure G1: Spectrophotometric Curve, A-Yellow.

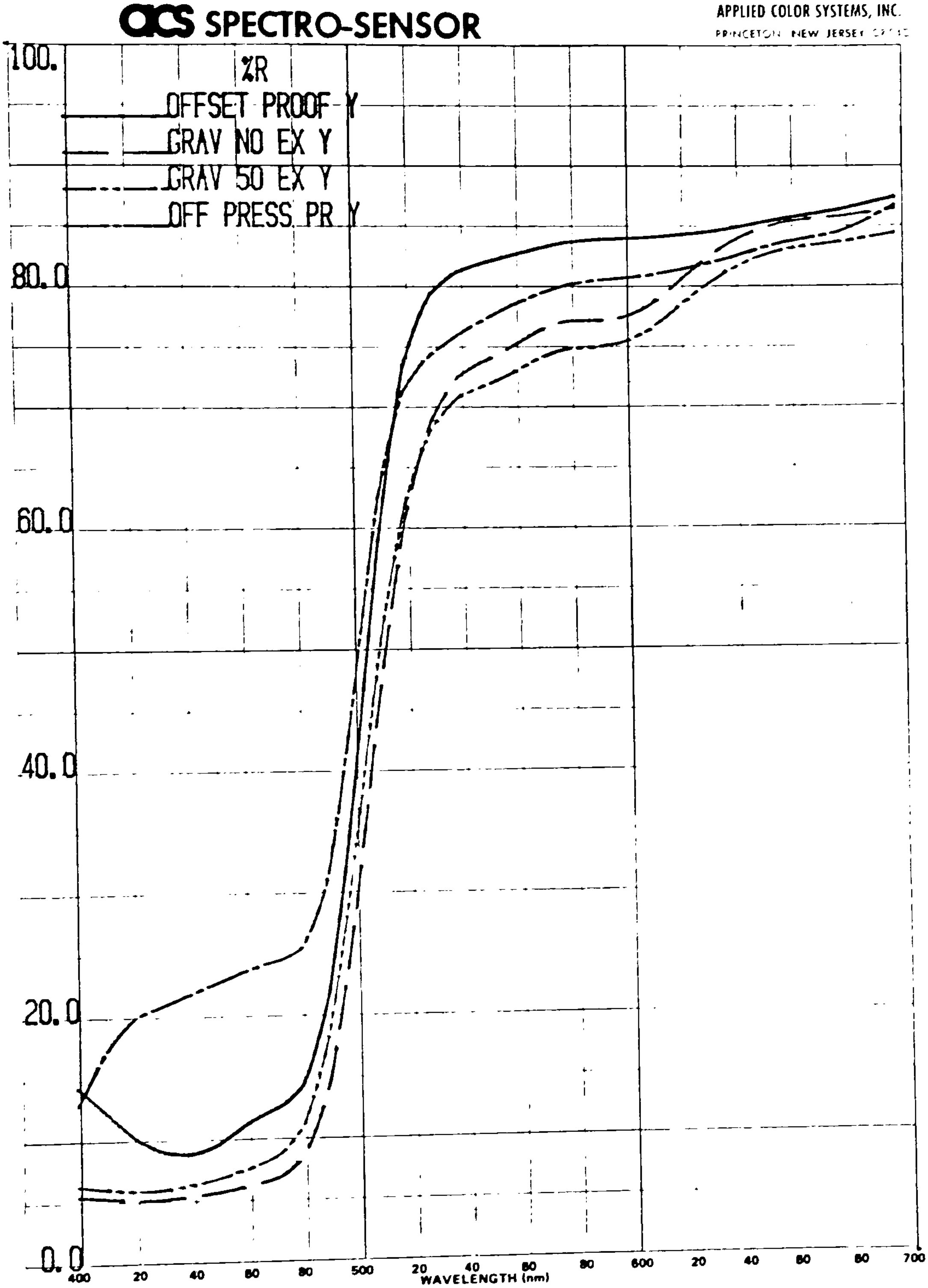


Figure G2: Spectrophotometric Curve, B-Magenta.

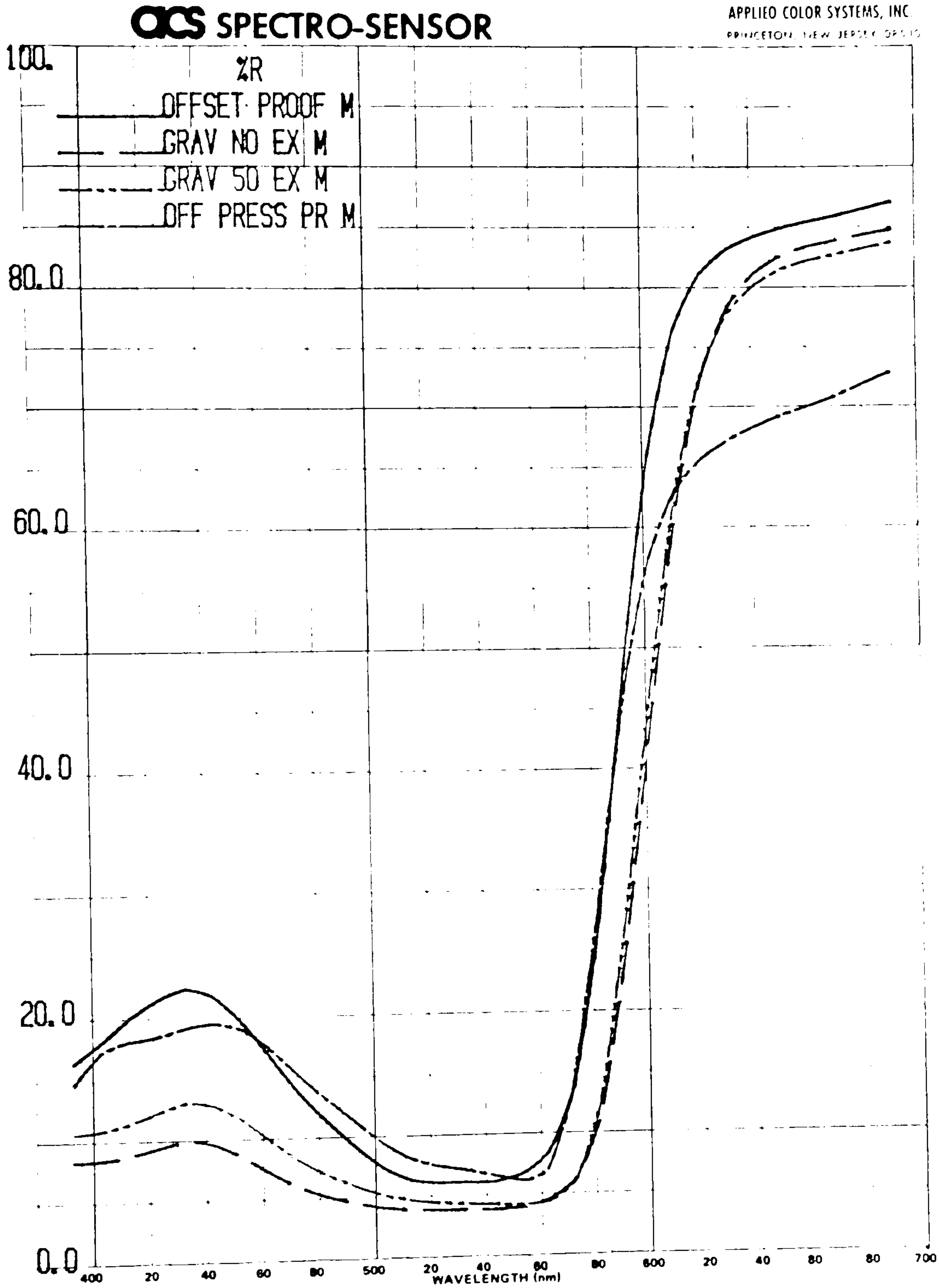


Figure G3: Spectrophotometric Curve, C-Cyan.

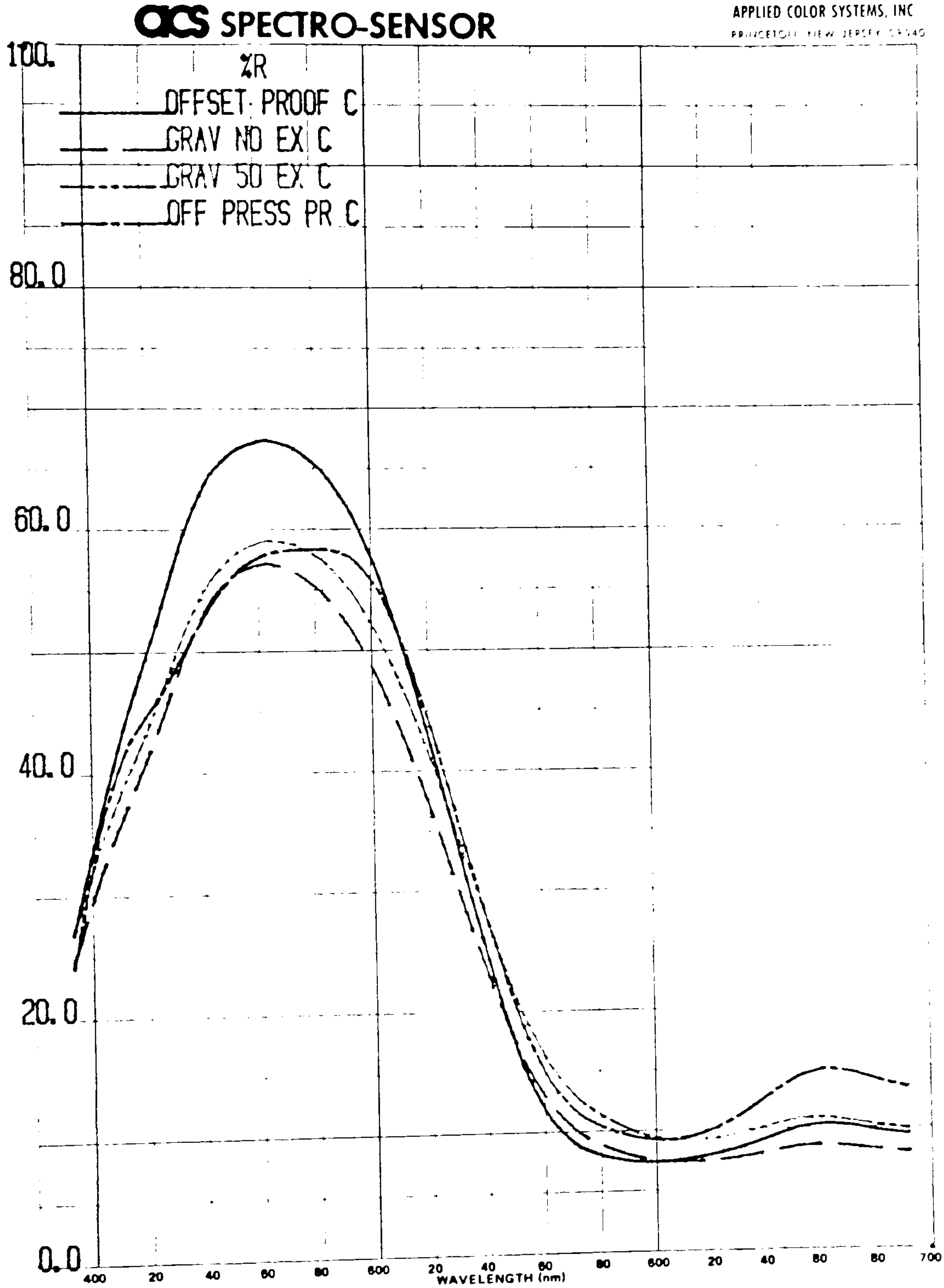


Figure G4: Spectrophotometric Curve, D-Black.

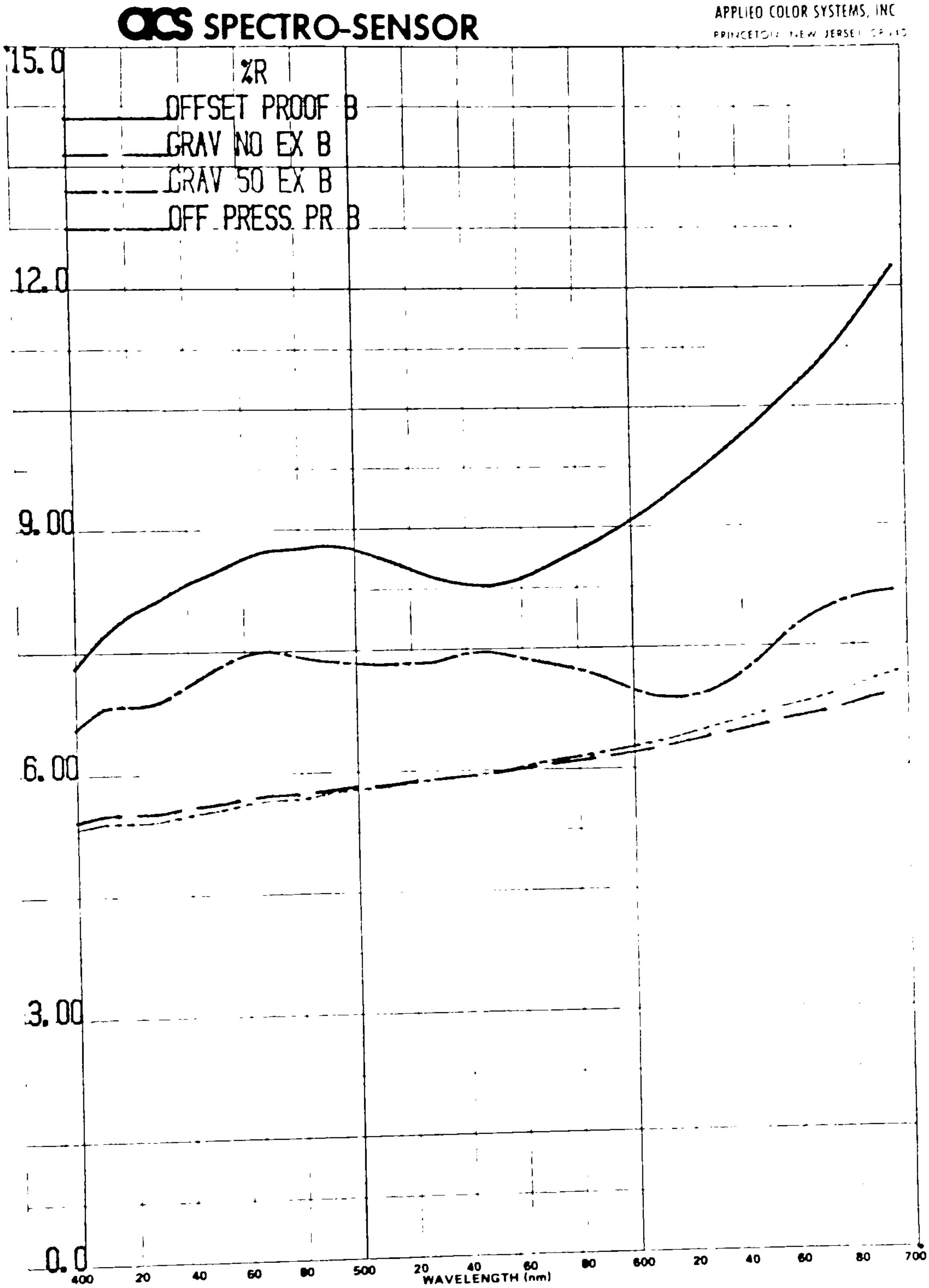


Figure G5: Spectrophotometric Curve, E-3-Color Combination.

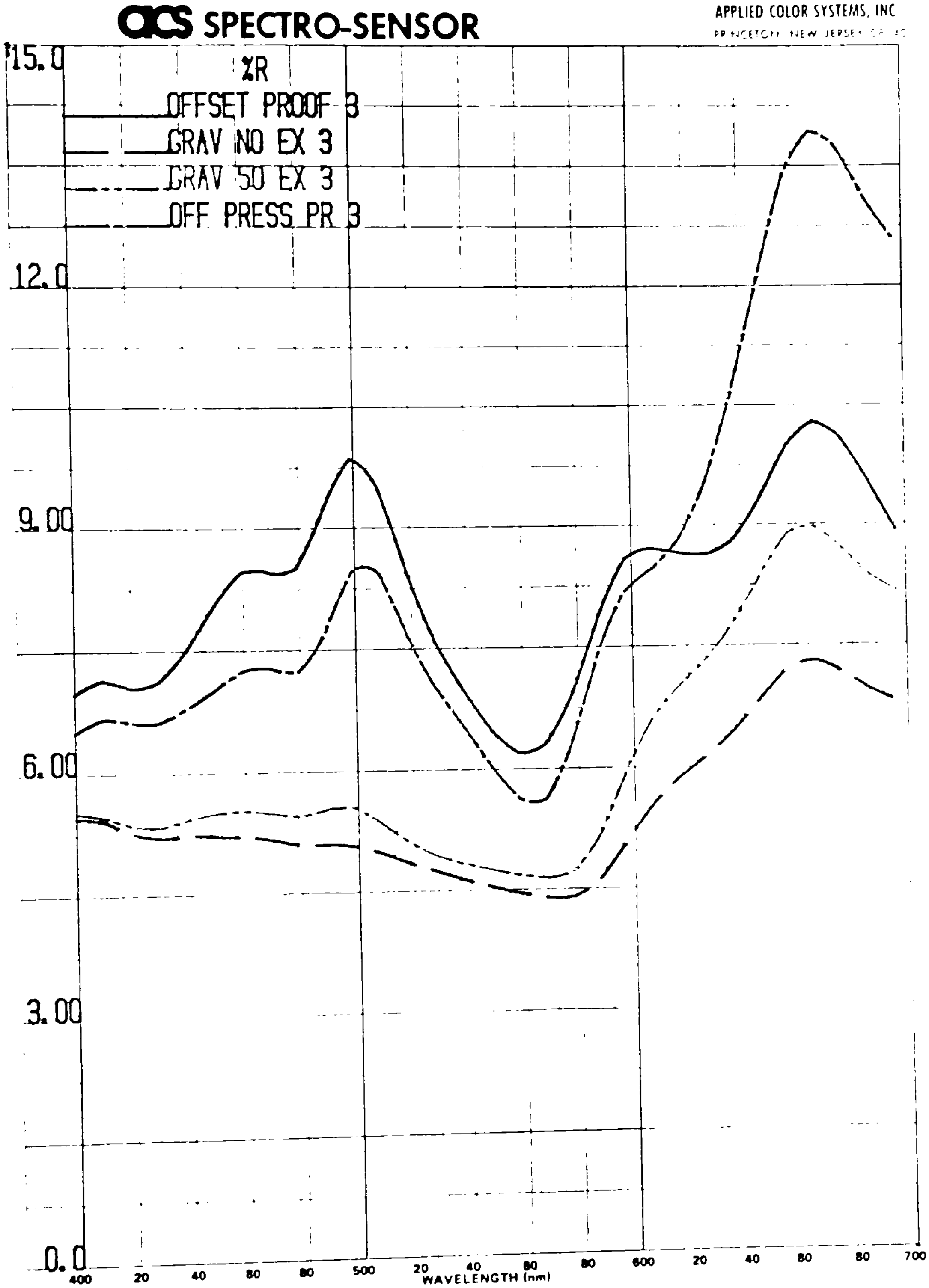


Figure G6: Spectrophotometric Curve, F-4-Color Combination.

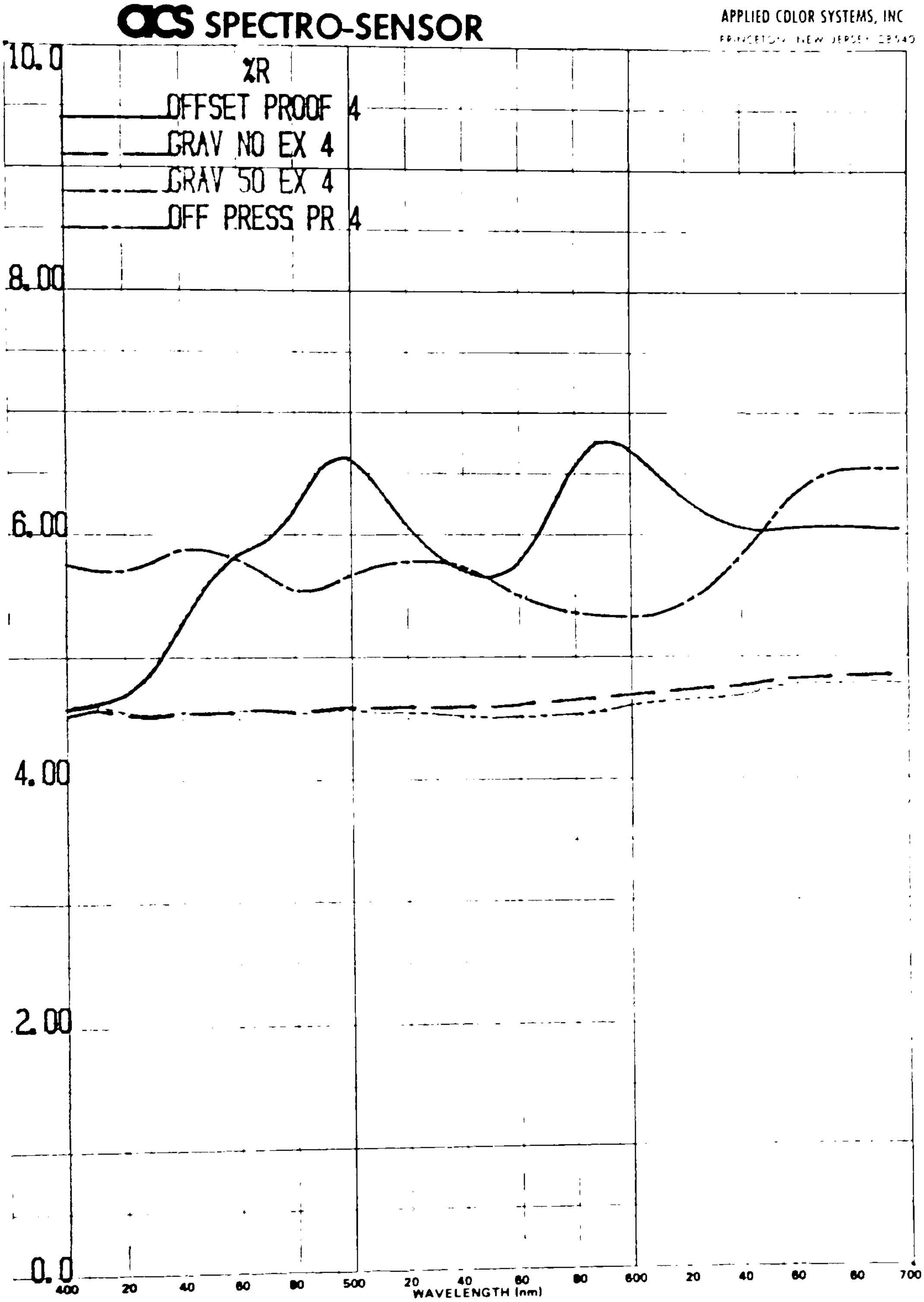


Figure G7: Spectrophotometric Curve, G-Helio.

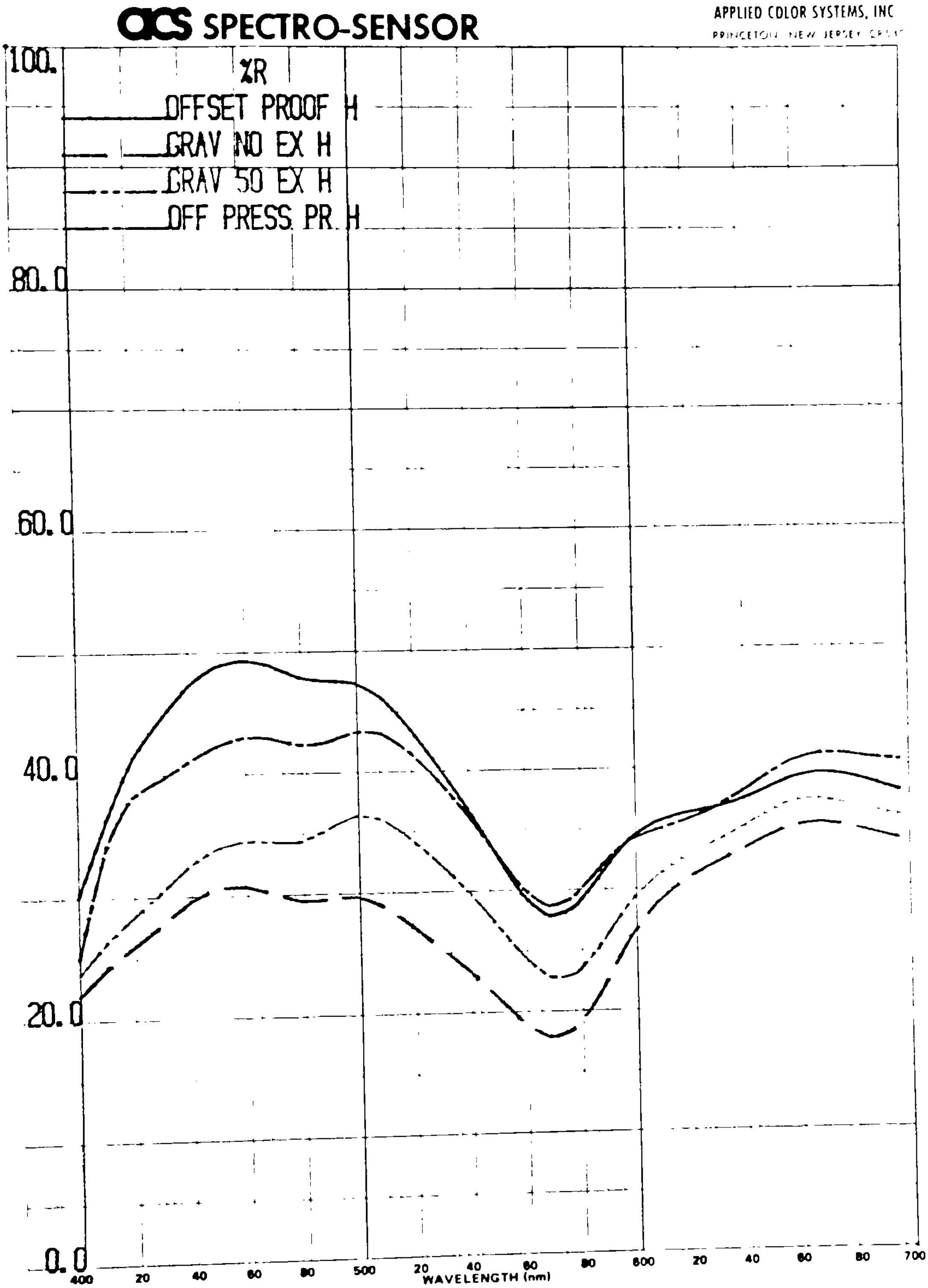


Figure G8: Spectrophotometric Curve, H-Wall.

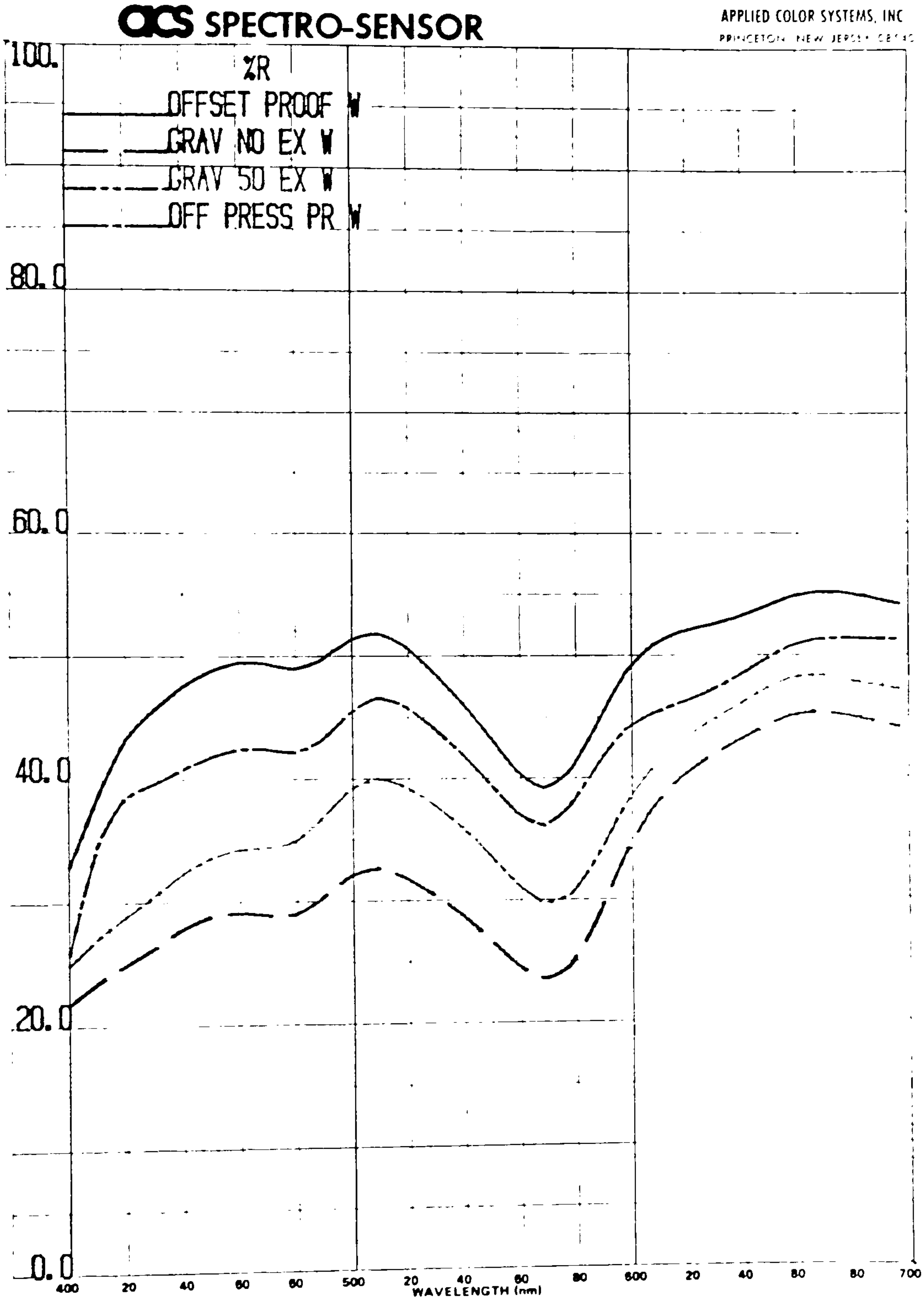


Figure G9: Spectrophotometric Curve, I-Fleshtone.

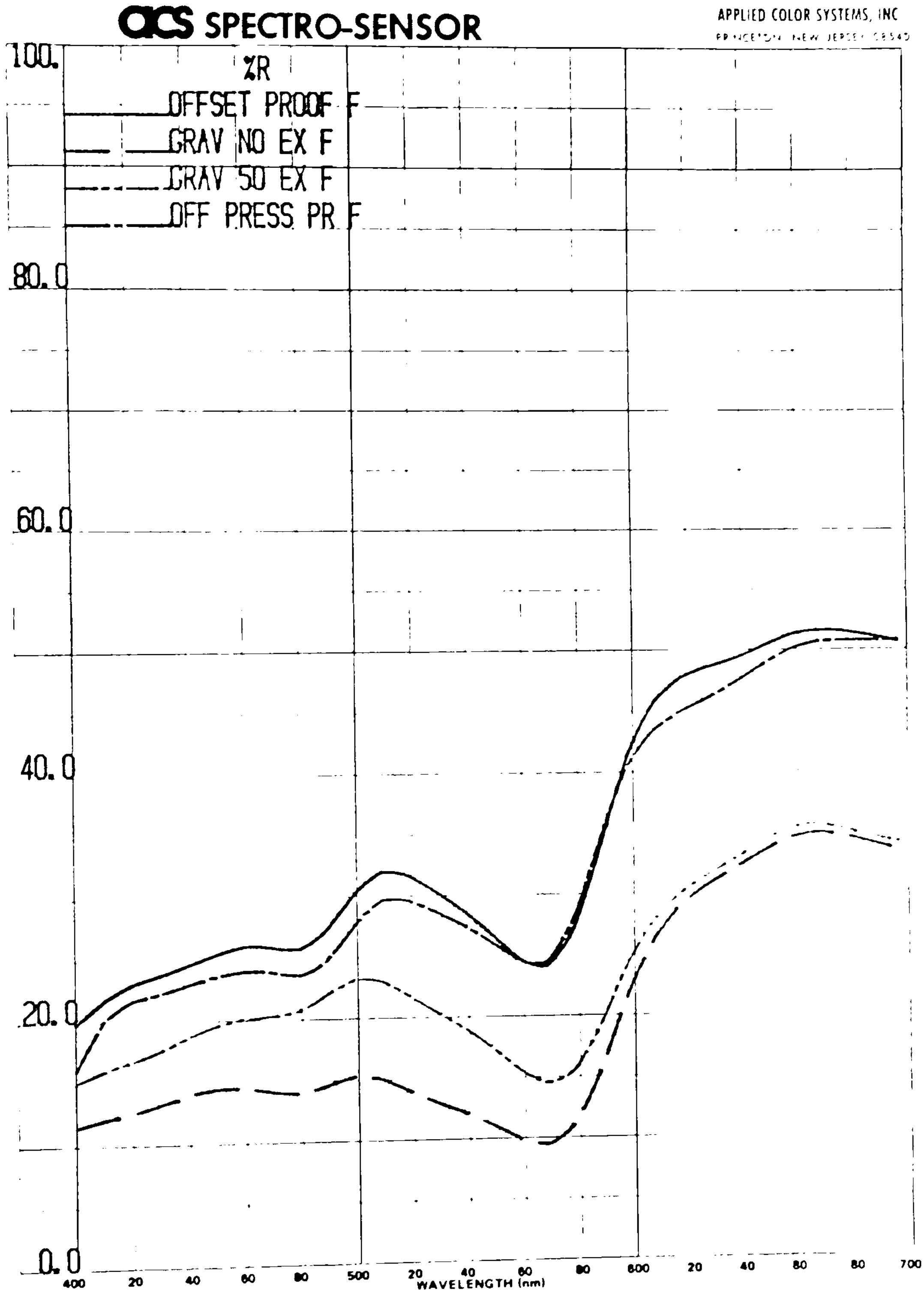


Figure G1Ø: Spectrophotometric Curve, J-Red Coat.

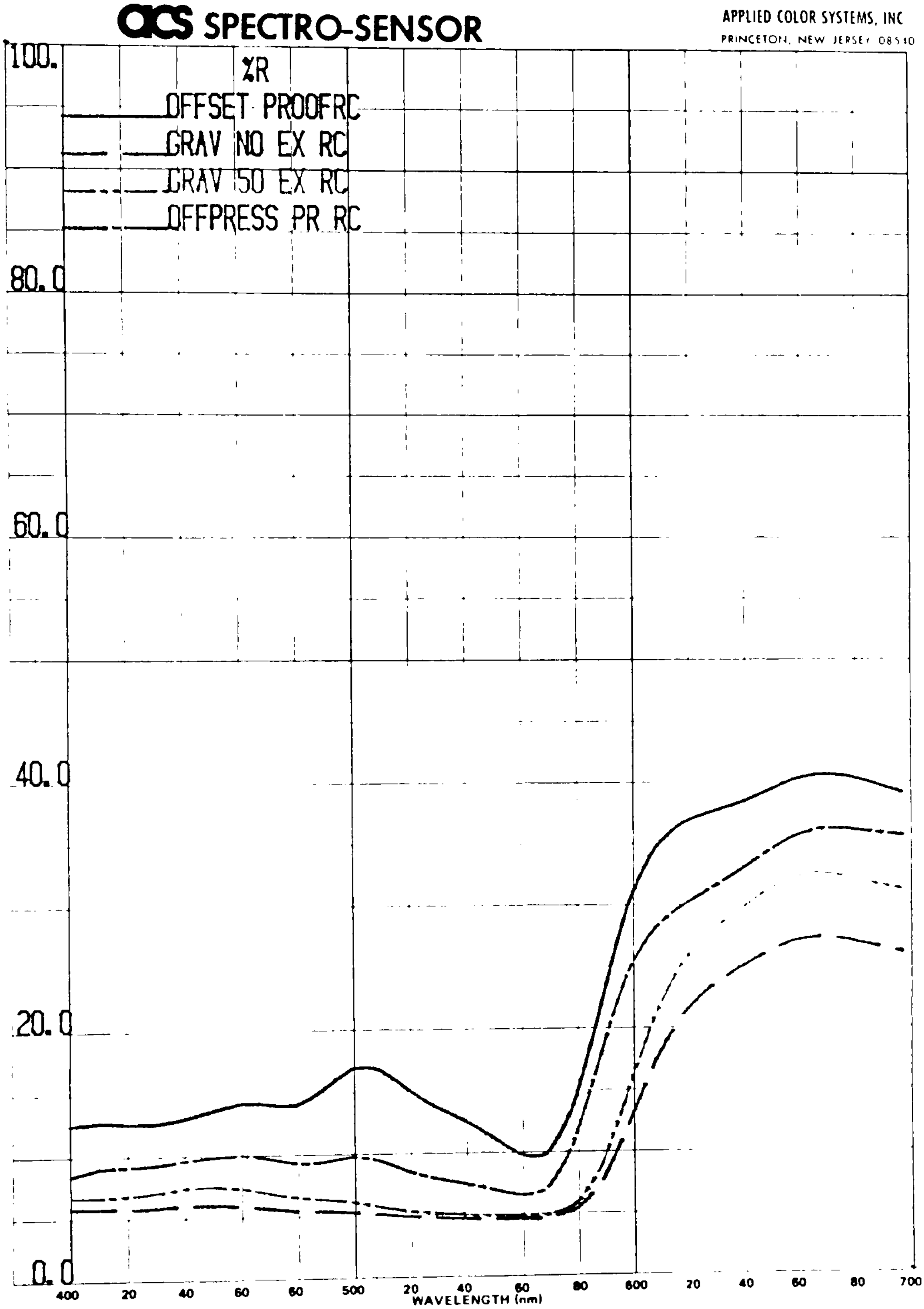
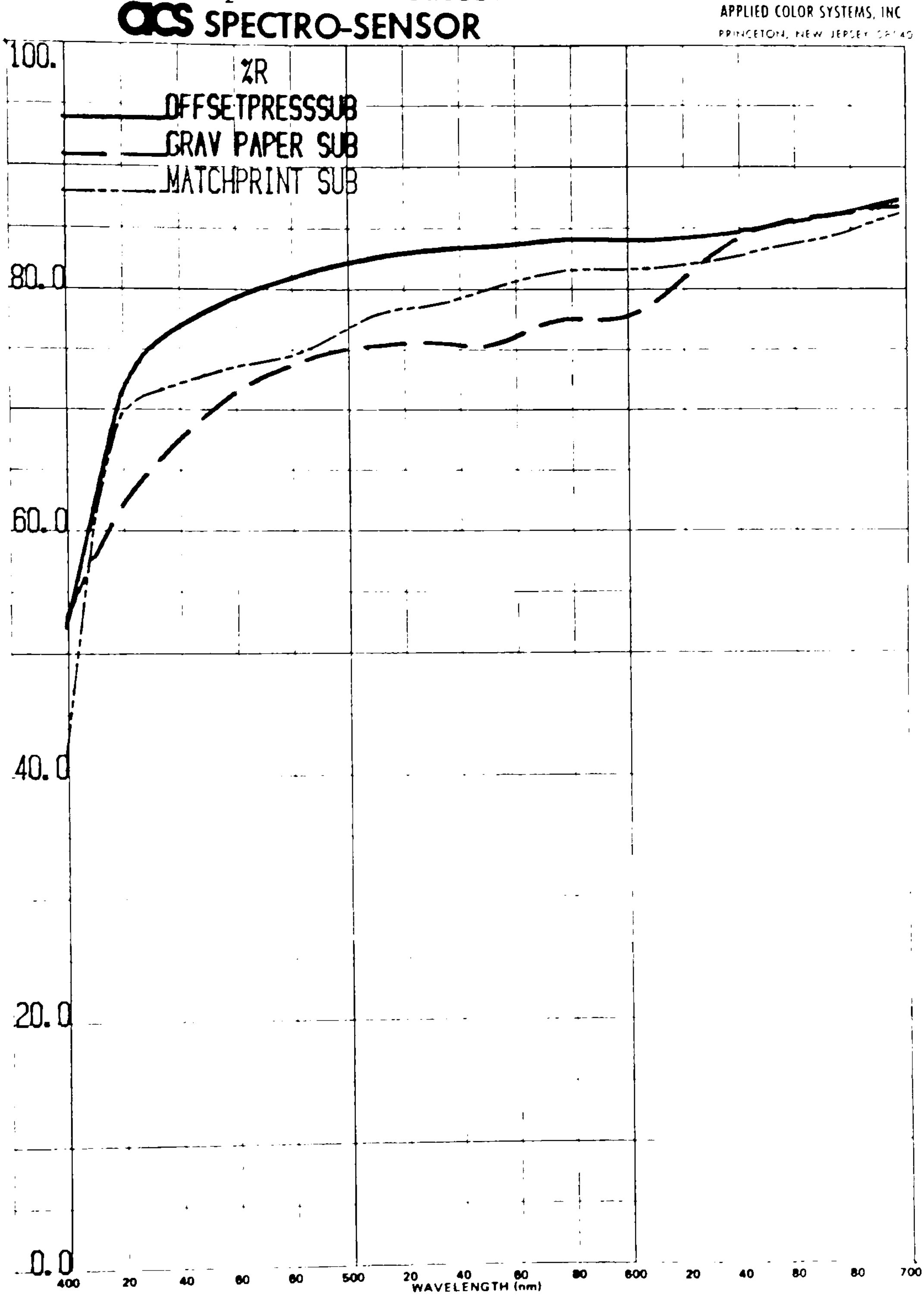


Figure G11: Spectrophotometric Curve; Offset, Gravure, Matchprint Substrates.



APPENDIX H

Nanometer Values.

Table H1: Nanometer Values, A-Yellow.

Measured Values %R's
Small Area View Spec. Included
19-JAN-87 13:09:48

Standard : OFFSET PROOF Y
Batch #1 : GRAV NO EX Y
Batch #2 : GRAV 50 EX Y
Batch #3 : OFF PRESS PR Y

NM	Standard	Batch #1	Batch #2	Batch #3
400	14.52	5.68	6.52	13.13
410	12.45	5.51	6.26	17.46
420	10.38	5.36	6.10	20.10
430	9.26	5.42	6.19	21.09
440	9.03	5.62	6.51	21.99
450	9.86	5.92	7.04	22.89
460	11.45	6.36	7.75	23.82
470	12.61	6.95	8.67	24.51
480	14.45	8.66	11.09	25.58
490	21.89	14.84	18.54	31.24
500	38.39	28.59	33.00	45.91
510	58.92	46.43	49.71	62.47
520	73.41	60.85	61.87	71.70
530	79.23	68.22	68.05	74.3[illegible]
540	81.12	72.49	70.77	75.9[illegible]
550	81.89	73.83	71.77	77.[illegible]
560	82.49	75.00	72.79	78.1[illegible]
570	83.08	76.31	74.01	79.36
580	83.58	77.06	74.78	80.08
590	83.81	77.12	74.93	80.1[illegible]
600	83.89	77.34	75.26	80.44
610	83.97	78.31	76.27	80.94
620	84.16	80.09	78.02	81.26
630	84.38	82.00	79.81	81.7[illegible]
640	84.69	83.54	81.25	82.27
650	85.11	84.59	82.27	82.98
660	85.54	85.22	82.93	83.58
670	85.89	85.51	83.28	83.95
680	86.25	85.70	83.54	84.43
690	86.75	85.99	83.88	85.39
700	87.27	86.31	84.26	86.63

Table H2: Nanometer Values, B-Magenta.

Measured Values %R's
Small Area View   Spec. Included
19-JAN-87   13:34:13

Standard : OFFSET PROOF M
Batch #1 : GRAV NO EX M
Batch #2 : GRAV 50 EX M
Batch #3 : OFF PRESS PR M

NM	Standard	Batch #1	Batch #2	Batch #3
400	16.64	8.64	10.89	14.90
410	18.31	8.72	11.14	17.51
420	20.25	9.07	11.74	18.35
430	21.71	9.68	12.61	18.7[illegible]
440	22.57	10.19	13.34	19.38
450	21.86	9.85	13.05	19.74
460	19.77	8.78	11.81	19.[illegible]1
470	16.93	7.42	10.10	17.61
480	14.01	6.22	8.45	15.44
490	11.60	5.41	7.23	13.45
500	9.51	4.85	6.26	11.59
510	7.72	4.43	5.49	9.74
520	6.61	4.20	5.01	8.42
530	6.35	4.13	4.76	7.74
540	6.36	4.11	4.63	7.39
550	6.34	4.09	4.52	6.92
560	6.88	4.23	4.46	6.42
570	8.57	4.79	4.68	7.[illegible]2
580	13.96	6.39	6.32	11.28
590	27.49	11.90	13.06	29.10
600	48.32	25.66	28.38	46.30
610	65.98	44.40	47.26	57.43
620	76.37	61.50	63.13	63.04
630	81.03	72.46	72.73	65.68
640	83.06	78.29	77.72	67.23
650	84.10	81.09	80.15	68.37
660	84.81	82.53	81.45	69.29
670	85.32	83.28	82.16	70.03
680	85.80	83.75	82.63	70.86
690	86.37	84.22	83.12	71.90
700	86.94	84.64	83.57	72.87

Table H3: Nanometer Values, C-Cyan.

Measured Values %R's
Small Area View Spec. Included
19-JAN-87 13:42:08

Standard : OFFSET PROOF C
Batch #1 : GRAV NO EX C
Batch #2 : GRAV 50 EX C
Batch #3 : OFF PRESS PR C

NM	Standard	Batch #1	Batch #2	Batch #3
400	26.84	24.65	26.84	24.16
410	36.66	31.92	34.14	35.72
420	45.13	37.66	39.88	42.46
430	52.00	43.19	45.26	45.85
440	59.37	49.53	51.29	49.79
450	64.40	54.11	55.67	53.70
460	66.54	56.35	57.98	56.56
470	67.25	57.05	58.92	57.86
480	66.58	56.34	58.59	58.16
490	64.71	54.61	57.32	58.22
500	61.33	51.66	54.87	57.59
510	56.04	47.33	51.04	54.81
520	48.86	41.78	45.91	49.48
530	40.43	35.34	39.76	42.17
540	31.31	28.33	32.85	33.80
550	22.85	21.82	26.14	25.91
560	15.61	16.16	20.01	18.94
570	11.11	12.32	15.62	14.23
580	8.88	10.09	12.77	11.55
590	8.00	8.79	11.20	10.71
600	7.57	8.00	10.08	9.61
610	7.50	7.56	9.41	9.36
620	7.74	7.47	9.23	9.51
630	8.12	7.59	9.38	10.22
640	8.69	7.86	9.77	11.42
650	9.44	8.26	10.36	12.95
660	10.17	8.64	10.89	14.35
670	10.45	8.73	10.96	14.95
680	10.25	8.55	10.65	14.69
690	9.83	8.29	10.28	13.99
700	9.56	8.08	10.01	13.41

Table H4: Nanometer Values, D-Black.

Measured Values %R's
Small Area View   Spec. Included
19-JAN-87   13:49:51

Standard : OFFSET PROOF B
Batch #1 : GRAV NO EX B
Batch #2 : GRAV 50 EX B
Batch #3 : OFF PRESS PR B

NM	Standard	Batch #1	Batch #2	Batch #3
400	7.32	5.43	5.34	6.57
410	7.70	5.51	5.41	6.83
420	7.97	5.52	5.41	6.85
430	8.14	5.53	5.43	6.90
440	8.33	5.59	5.50	7.09
450	8.47	5.63	5.55	7.29
460	8.63	5.68	5.62	7.45
470	8.74	5.73	5.67	7.51
480	8.76	5.74	5.68	7.44
490	8.80	5.78	5.74	7.38
500	8.76	5.82	5.79	7.45
510	8.65	5.83	5.81	7.33
520	8.52	5.87	5.86	7.34
530	8.39	5.90	5.90	7.35
540	8.31	5.93	5.94	7.44
550	8.28	5.96	5.97	7.47
560	8.34	6.01	6.03	7.40
570	8.48	6.06	6.10	7.33
580	8.65	6.10	6.15	7.26
590	8.82	6.14	6.20	7.16
600	9.02	6.19	6.26	7.02
610	9.23	6.24	6.32	6.90
620	9.48	6.31	6.40	6.88
630	9.74	6.38	6.49	6.94
640	10.02	6.45	6.58	7.11
650	10.31	6.52	6.67	7.36
660	10.63	6.60	6.76	7.67
670	10.95	6.66	6.84	7.90
680	11.32	6.74	6.94	8.05
690	11.76	6.84	7.06	8.14
700	12.23	6.91	7.17	8.18

Table H5: Nanometer Values, E-3-Color Combination.

Measured Values %R's
Small Area View   Spec. Included
19-JAN-87   14:11:32

Standard : OFFSET PROOF 3
Batch #1 : GRAV NO EX 3
Batch #2 : GRAV 50 EX 3
Batch #3 : OFF PRESS PR 3

NM	Standard	Batch #1	Batch #2	Batch #3
400	6.97	5.45	5.51	6.50
410	7.14	5.41	5.46	6.67
420	7.04	5.26	5.35	6.62
430	7.12	5.20	5.33	6.62
440	7.50	5.22	5.42	6.79
450	8.03	5.21	5.49	7.01
460	8.44	5.20	5.51	7.24
470	8.44	5.16	5.48	7.27
480	8.49	5.09	5.44	7.22
490	9.21	5.09	5.52	7.69
500	9.84	5.06	5.53	8.44
510	9.47	4.97	5.33	8.42
520	8.43	4.84	5.09	7.65
530	7.57	4.73	4.92	7.01
540	6.98	4.62	4.82	6.53
550	6.48	4.53	4.74	6.03
560	6.19	4.45	4.67	5.63
570	6.29	4.39	4.63	5.61
580	6.90	4.40	4.72	6.33
590	7.85	4.63	5.19	7.43
600	8.56	5.10	5.98	8.17
610	8.69	5.55	6.62	8.44
620	8.63	5.88	7.01	8.81
630	8.61	6.14	7.34	9.51
640	8.79	6.45	7.78	10.63
650	9.30	6.84	8.35	12.03
660	9.95	7.20	8.86	13.33
670	10.26	7.29	8.95	13.90
680	10.07	7.15	8.68	13.69
690	9.53	6.93	8.35	13.07
700	8.91	6.78	8.15	12.58

Table H6: Nanometer Values, F-4-Color Combination.

Measured Values %R's
Small Area View Spec. Included
19-JAN-87 14:32:52

Standard : OFFSET PROOF 4
Batch #1 : GRAV NO EX 4
Batch #2 : GRAV 50 EX 4
Batch #3 : OFF PRESS PR 4

NM	Standard	Batch #1	Batch #2	Batch #3
400	4.59	4.53	4.58	5.76
410	4.63	4.58	4.61	5.71
420	4.70	4.54	4.56	5.71
430	4.90	4.52	4.54	5.78
440	5.26	4.55	4.56	5.88
450	5.61	4.55	4.56	5.87
460	5.83	4.57	4.57	5.80
470	5.94	4.58	4.57	5.69
480	6.17	4.56	4.55	5.55
490	6.53	4.58	4.56	5.56
500	6.63	4.60	4.58	5.66
510	6.41	4.59	4.55	5.74
520	6.11	4.60	4.55	5.79
530	5.87	4.60	4.54	5.78
540	5.72	4.60	4.52	5.75
550	5.65	4.60	4.51	5.65
560	5.73	4.61	4.51	5.52
570	6.04	4.64	4.52	5.43
580	6.48	4.65	4.53	5.37
590	6.75	4.67	4.55	5.34
600	6.73	4.69	4.60	5.33
610	6.54	4.71	4.63	5.34
620	6.33	4.73	4.65	5.42
630	6.17	4.75	4.66	5.55
640	6.07	4.76	4.68	5.76
650	6.03	4.79	4.72	6.01
660	6.05	4.82	4.78	6.28
670	6.06	4.83	4.78	6.45
680	6.06	4.84	4.78	6.53
690	6.05	4.85	4.79	6.54
700	6.04	4.85	4.78	6.54

Table H7: Nanometer Values, G-Helio.

Measured Values %R's
Small Area View Spec. Included
19-JAN-87 14:43:42

Standard : OFFSET PROOF H
Batch #1 : GRAV NO EX H
Batch #2 : GRAV 50 EX H
Batch #3 : OFF PRESS PR H

NM	Standard	Batch #1	Batch #2	Batch #3
400	30.11	22.10	23.87	25.17
410	36.28	24.35	26.47	34.16
420	41.49	26.14	28.57	38.30
430	44.61	27.87	30.52	39.67
440	47.28	29.68	32.58	41.12
450	48.86	30.67	33.94	42.35
460	49.34	30.76	34.48	43.05
470	48.90	30.17	34.40	42.93
480	47.95	29.55	34.40	42.38
490	47.61	29.66	35.38	42.59
500	47.41	29.77	36.37	43.31
510	46.17	28.93	36.04	43.21
520	43.64	27.31	34.47	41.67
530	40.52	25.51	32.46	39.34
540	37.11	23.64	30.21	36.58
550	33.41	21.49	27.60	33.48
560	29.82	19.26	24.81	30.41
570	27.91	17.94	22.93	29.73
580	28.68	18.73	23.17	29.58
590	31.40	21.93	25.71	32.00
600	34.09	25.96	28.88	34.00
610	35.50	28.81	31.03	34.89
620	36.18	30.64	32.49	35.58
630	36.58	31.86	33.61	36.44
640	37.16	32.96	34.79	37.68
650	38.06	34.08	36.02	39.13
660	39.02	35.01	37.04	40.45
670	39.46	35.30	37.27	41.06
680	39.26	35.02	36.85	41.03
690	38.63	34.46	36.28	40.70
700	37.88	33.89	35.80	40.45

Table H8: Nanometer Values, H-Wall.

Measured Values %R's
Small Area View   Spec. Included
19-JAN-87   14:50:57

Standard : OFFSET PROOF W
Batch #1 : GRAV NO EX W
Batch #2 : GRAV 50 EX W
Batch #3 : OFF PRESS PR W

NM	Standard	Batch #1	Batch #2	Batch #3
400	32.88	21.76	24.94	25.80
410	38.54	23.51	27.09	34.62
420	43.24	24.93	28.86	38.50
430	45.62	26.31	30.51	39.63
440	47.48	27.83	32.29	40.76
450	48.73	28.78	33.54	41.74
460	49.42	29.08	34.21	42.48
470	49.32	28.89	34.38	42.39
480	48.91	28.93	34.85	42.14
490	49.66	30.24	36.72	43.11
500	51.17	32.00	39.02	45.27
510	51.77	32.60	39.96	46.54
520	50.72	31.82	39.28	45.85
530	48.68	30.45	37.84	41.15
540	46.28	28.84	36.04	42.09
550	43.48	26.84	33.78	39.66
560	40.59	24.71	31.33	37.19
570	39.14	23.51	29.77	34.07
580	40.61	24.66	30.42	37.71
590	44.48	28.62	33.63	41.07
600	48.48	33.70	37.73	43.87
610	50.73	37.45	40.75	45.19
620	51.82	39.89	42.85	46.06
630	52.36	41.48	44.37	46.94
640	52.96	42.79	45.73	48.09
650	53.78	43.99	47.02	49.42
660	54.65	44.95	48.04	50.63
670	55.07	45.27	48.30	51.22
680	55.01	45.04	47.98	51.31
690	54.61	44.54	47.53	51.24
700	54.10	44.03	47.15	51.23

Table H9: Nanometer Values, I-Fleshtone.

Measured Values %R's
Small Area View   Spec. Included
19-JAN-87   15:05:26

Standard : OFFSET PROOF F
Batch #1 : GRAV NO EX F
Batch #2 : GRAV 50 EX F
Batch #3 : OFF PRESS PR F

NM	Standard	Batch #1	Batch #2	Batch #3
400	19.67	11.43	15.06	16.04
410	21.57	12.04	16.00	19.99
420	22.89	12.56	16.74	21.62
430	23.61	13.19	17.57	22.18
440	24.44	13.96	18.65	22.89
450	25.26	14.39	19.51	23.51
460	25.88	14.40	20.02	23.89
470	25.77	14.07	20.21	23.77
480	25.60	13.92	20.63	23.50
490	27.20	14.53	21.95	24.69
500	30.06	15.21	23.11	27.54
510	31.82	14.92	22.91	29.57
520	31.49	13.90	21.67	29.49
530	30.12	12.91	20.29	28.53
540	28.53	12.05	18.94	27.41
550	26.60	11.01	17.32	25.97
560	24.59	9.87	15.52	24.48
570	23.94	9.40	14.44	24.30
580	26.98	11.06	15.49	27.90
590	33.74	15.67	19.28	34.38
600	41.11	21.75	24.24	40.29
610	45.55	26.30	27.83	43.32
620	47.59	29.03	30.01	44.84
630	48.44	30.65	31.43	45.94
640	49.14	31.97	32.73	47.20
650	50.07	33.27	34.08	48.59
660	51.02	34.36	35.20	49.84
670	51.42	34.74	35.47	50.46
680	51.33	34.49	35.05	50.59
690	50.97	33.92	34.47	50.58
700	50.49	33.32	33.98	50.63

Table H1Ø: Nanometer Values, J-Red Coat.

Measured Values %R's
Small Area View Spec. Included
19-JAN-87 15:13:49

Standard : OFFSET PROOFRC
Batch #1 : GRAV NO EX RC
Batch #2 : GRAV 50 EX RC
Batch #3 : OFFPRESS PR RC

NM	Standard	Batch #1	Batch #2	Batch #3
400	12.42	5.74	6.65	8.33
410	12.63	5.73	6.68	8.95
420	12.52	5.70	6.76	9.08
430	12.54	5.79	6.99	9.22
440	12.92	5.94	7.32	9.53
450	13.51	5.95	7.43	9.79
460	14.06	5.83	7.25	9.90
470	13.98	5.61	6.85	9.65
480	13.91	5.39	6.46	9.23
490	15.17	5.31	6.27	9.32
500	16.76	5.20	6.04	9.68
510	16.69	5.01	5.64	9.36
520	15.11	4.84	5.28	8.18
530	13.65	4.71	5.06	7.86
540	12.56	4.61	4.92	7.13
550	11.21	4.54	4.80	6.91
560	9.79	4.51	4.74	6.44
570	9.71	4.60	4.82	6.87
580	13.64	5.14	5.59	10.64
590	21.54	7.31	8.69	17.41
600	29.77	11.98	14.78	24.35
610	34.45	17.13	20.95	27.96
620	36.49	20.94	25.20	29.80
630	37.35	23.13	27.62	31.11
640	38.07	24.63	29.35	32.52
650	39.00	25.88	30.89	34.01
660	39.98	26.88	32.10	35.33
670	40.44	27.21	32.43	35.97
680	40.27	26.96	32.05	35.96
690	39.67	26.44	31.49	35.66
700	38.93	25.96	31.05	35.44

Table H11: Nanometer Values; Offset, Gravure, and Matchprint Substrates.

Measured Values %R's
Small Area View   Spec. Included
19-JAN-87   11:53:39

Standard : OFFSETPRESSSUB
Batch #1 : GRAV PAPER SUB
Batch #2 : MATCHPRINT SUB

NM	Standard	Batch #1	Batch #2
400	52.14	53.07	41.84
410	61.98	57.87	60.64
420	71.30	62.13	69.63
430	75.11	65.04	71.36
440	76.88	67.50	72.18
450	78.18	69.59	72.91
460	79.31	71.41	73.58
470	80.22	72.76	74.04
480	80.94	73.72	74.50
490	81.63	74.57	75.41
500	82.18	75.12	76.67
510	82.63	75.41	77.85
520	83.01	75.62	78.46
530	83.26	75.68	78.69
540	83.47	75.51	79.21
550	83.58	75.36	79.92
560	83.74	75.99	80.61
570	83.98	77.07	81.17
580	84.17	77.64	81.57
590	84.16	77.58	81.67
600	84.09	77.73	81.67
610	84.10	78.71	81.74
620	84.23	80.52	81.97
630	84.40	82.42	82.25
640	84.64	83.96	82.64
650	85.04	85.02	83.17
660	85.47	85.69	83.67
670	85.84	86.04	84.06
680	86.26	86.28	84.62
690	86.81	86.58	85.46
700	87.36	86.86	86.23

APPENDIX I

Densitometer Readings.

Table 11: Densitometer Readings, SWOP Standard Offset Press Proof.

	YELLOW	MAGENTA	CYAN	BLACK
A-Yellow	.92	.16	.12	.15
B-Magenta	.79	1.46	.22	.75
C-Cyan	.24	.50	1.31	.84
D-Black	1.40	1.48	1.53	1.57
E-3-Color Combination	1.32	1.58	1.25	1.55
F-4-Color Combination	1.77	1.86	1.72	1.85
G-Helio	.35	.45	.48	.53
H-Wall	.34	.36	.35	.41
I-Fleshtone	.51	.48	.30	.46
J-Red Coat	.94	1.04	.49	.85

Table I2: Densitometer Readings, Full Strength Inks - No Clear Extender Added.

	YELLOW	MAGENTA	CYAN	BLACK
A-Yellow	1.17	.21	.15	.19
B-Magenta	1.29	1.88	.35	.94
C-Cyan	.33	.59	1.37	.92
D-Black	1.59	1.60	1.60	1.65
E-3-Color Combination	1.83	1.96	1.62	1.90
F-4-Color Combination	1.92	2.01	2.06	2.11
G-Helio	.57	.68	.59	.72
H-Wall	.58	.59	.48	.61
I-Fleshtone	.70	.77	.45	.70
J-Red Coat	1.69	1.94	.79	1.33

Table I3: Densitometer Readings, 10% Clear Extender Varnish Added.

	YELLOW	MAGENTA	CYAN	BLACK
A-Yellow	1.15	.21	.15	.19
B-Magenta	1.22	1.84	.33	.92
C-Cyan	.33	.58	1.35	.91
D-Black	1.60	1.59	1.58	1.64
E-3-Color Combination	1.81	1.96	1.59	1.89
F-4-Color Combination	1.96	2.04	2.10	2.15
G-Helio	.54	.64	.57	.69
H-Wall	.52	.57	.46	.60
I-Fleshtone	.81	.84	.51	.77
J-Red Coat	1.64	1.91	.77	1.31

Table I4: Densitometer Readings, 2Ø% Clear Extender Varnish Added.

	YELLOW	MAGENTA	CYAN	BLACK
A-Yellow	1.11	.2Ø	.15	.18
B-Magenta	1.21	1.84	.33	.92
C-Cyan	.32	.56	1.29	.88
D-Black	1.6Ø	1.6Ø	1.59	1.65
E-3-Color Combination	1.78	1.94	1.55	1.85
F-4-Color Combination	1.94	2.Ø3	2.Ø8	2.13
G-Helio	.56	.63	.59	.69
H-Wall	.57	.57	.47	.6Ø
I-Fleshtone	.74	.78	.5Ø	.74
J-Red Coat	1.59	1.88	.77	1.3Ø

Table I5: Densitometer Readings, 3Ø% Clear Extender Varnish Added.

	YELLOW	MAGENTA	CYAN	BLACK
A-Yellow	1.Ø9	.21	.15	.19
B-Magenta	1.17	1.83	.32	.91
C-Cyan	.3Ø	.54	1.25	.85
D-Black	1.62	1.61	1.6Ø	1.66
E-3-Color Combination	1.76	1.92	1.53	1.84
F-4-Color Combination	1.87	1.96	2.Ø2	2.Ø6
G-Helio	.51	.55	.55	.62
H-Wall	.53	.51	.47	.56
I-Fleshtone	.7Ø	.64	.46	.64
J-Red Coat	1.58	1.88	.75	1.28

Table I6: Densitometer Readings, 4Ø% Clear Extender Varnish Added.

	YELLOW	MAGENTA	CYAN	BLACK
A-Yellow	1.Ø8	.21	.15	.19
B-Magenta	1.15	1.81	.34	.91
C-Cyan	.31	.54	1.22	.84
D-Black	1.57	1.56	1.54	1.6Ø
E-3-Color Combination	1.77	1.94	1.5Ø	1.83
F-4-Color Combination	1.94	2.Ø2	2.Ø5	2.11
G-Helio	.44	.55	.55	.62
H-Wall	.43	.48	.44	.53
I-Fleshtone	.68	.63	.45	.62
J-Red Coat	1.53	1.81	.73	1.26

Table I7: Densitometer Readings, 50% Clear Extender Varnish Added.

	YELLOW	MAGENTA	CYAN	BLACK
A-Yellow	1.05	.21	.15	.19
B-Magenta	1.11	1.78	.32	.90
C-Cyan	.31	.53	1.21	.83
D-Black	1.61	1.58	1.55	1.62
E-3-Color Combination	1.73	1.90	1.47	1.80
F-4-Color Combination	1.92	2.00	2.02	2.09
G-Helio	.51	.57	.55	.63
H-Wall	.52	.51	.45	.55
I-Fleshtone	.58	.59	.42	.59
J-Red Coat	1.47	1.79	.72	1.25

Table I8: Densitometer Readings, Off-Press Proof (Matchprint).

	YELLOW	MAGENTA	CYAN	BLACK
A-Yellow	.95	.2Ø	.16	.18
B-Magenta	.86	1.38	.3Ø	.77
C-Cyan	.32	.52	1.24	.86
D-Black	1.45	1.47	1.55	1.55
E-3-Color Combination	1.48	1.59	1.34	1.61
F-4-Color Combination	1.82	1.91	1.93	1.99
G-Helio	.44	.51	.54	.58
H-Wall	.42	.43	.41	.47
I-Fleshtone	.6Ø	.55	.35	.51
J-Red Coat	1.24	1.44	.63	1.Ø5

Table I9: Densitometer Readings, Substrates.

	YELLOW	MAGENTA	CYAN	BLACK
Offset Press	.13	.11	.11	.12
Gravure	.18	.15	.13	.15
Off Press	.20	.17	.16	.17