1-1-1993

# A Comparison of the photochemical reproduction quality from color negative films versus color transparency films

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# A Comparison of the Photomechanical Reproduction Quality From Color Negative Films Versus Color Transparency Films

by

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A thesis submitted in partial fulfillment of the
requirements for the degree of Master of Science in the
School of Printing Management and Sciences of the
College of Imaging Arts and Sciences of the
Rochester Institute of Technology

January 1993

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School of Printing Management and Sciences
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Rochester, New York

**Certificate of Approval**

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**Master's Thesis**

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This is to certify that the Master's Thesis of

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**A Comparison of the**

**Photomechanical Reproduction Quality**

**From Color Negative Films Versus**

**Color Transparency Films**

**Acknowledgements**

To the many people who have guided me and offered their assistance, I am most grateful.

To Miles Southworth, my thesis advisor, for all his knowledge, enthusiasm, and patience during this process.

To John Compton whose enduring, endless encouragement and prodding week after week when I was struggling to complete each page, I will never forget.

To Joe Noga for his knowledge, understanding, and assistance during this long, slow journey.

To Wes Kemp for his constant interest, concern, and vast photographic knowledge.

To Barbara Allston for her superb computer skills and patience with so many changes.

To Kelly Laughlin for his donation of many hours of tutoring, assistance and patience in the Color Separation Lab. The learning experience, professional collaboration and friendship will never be forgotten.

Last but not last, I wish to express my deep gratitude to my husband, William W. DuBois, who had continuous patience, understanding, and endless words of support during my rages of total frustration and countless days of procrastination.

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## Abstract

Color transparency film is the most frequently used original material in the color separation process. Recent technological advances in color negative film and electronic color generated scanners capable of working from a color negative have led to new avenues of exploration in the area of color separation. By using a color negative film as the original it may be possible to produce color separations of equal or higher quality than those produced from color transparencies.

This research project has investigated the possibility that a set of color separations made from an Eastman Kodak Ektar color negative could yield a set of color separation proofs of equal or superior quality to those made from an Eastman Kodak Kodachrome color transparency. The attributes that were investigated were image detail, color saturation and tone reproduction.

A total of six original scenes were photographed by the author; six using Kodachrome 25-35mm slide film- and six using Ektar 25-35 mm negative film. Four of the original images were photographed at the same time in a controlled studio environment. The remaining two images were photographed outdoors to include a normal exterior scene.

Twelve color separations were then generated using the Royal Zenith 210-L color scanner. These twelve separations were then proofed using the DuPont Cromalin proofing system.

The last stage of the study involved a visual evaluation by thirty judges with professional experience in either the fields of photography or printing. Under standard viewing conditions, the thirty judges simultaneously compared a color proof created from a Kodachrome original against a color proof created from an Ektar color negative original of the same scene. They were asked to examine the six sets of color proofs and select the one from each set that they judged to be superior for the criteria of: image detail, color saturation and tone reproduction. Their evaluations were then recorded using a carefully designed response sheet.

The results of this experiment indicated that there was no significant difference for the criteria of image detail and tone reproduction between the proofs generated from an Ektar color negative and the proofs generated from a Kodachrome color transparency. For the specific criteria of color saturation the study indicated that the proofs generated from an Ektar color negative were significantly better than the proofs generated from a Kodachrome color transparency. The data indicates that under the conditions tested, it makes little difference in the final proofed images whether the camera original material used is Ektar color negative film or Kodachrome color transparency.

# Chapter I

## Introduction

In 1936 Kodachrome film was introduced by Eastman Kodak Company to the public. For the past 56 years it has been the standard by which all color slide films are judged.[1] Kodachrome has also become the standard for quality measurement of color reproduction through the printing processes.

Professional photographers expect to see their images reproduced on the printed page with the same sharpness and brilliant colors as if the original transparency were being viewed on a light box. Color scanner operators know that it is impossible to reproduce a full range transparency on the printed page with that same original "snap" to it. As a result of this discrepancy, the photographer is displeased and tends to blame the printer. Better understanding of the limitations of the printing process beginning with the original photograph through the separations to the printed page assists everyone involved to improve print quality. Typically, there has been very little communication between the parties involved since they work for different organizations and are occasionally located in different cities. This lack of communication between the photographer, art director, and the printer regarding film characteristics is beginning to change as more

photographers are educated about the limits of the printing process. With constant improvements being made in film emulsions and electronic color scanners, new technological advances for photographers and pre-press operations are occurring rapidly.

**Present Film Standards**

Color transparency film is the most frequently used type of original employed in the color separation process. Because it is a first generation positive original it is visually easy to read on the scanner drum. The use of a transparency makes the scanner operator's job relatively simple. It requires less time to evaluate the correct highlight, midtone and shadow density for the correct dot size requirements than is needed for a color negative original.

**New Color Negative Film Technology**

In 1988, the Eastman Kodak Company introduced Ektar 25, color negative film with micro-fine grain, extremely high sharpness, and strong color saturation. "This new professional film incorporates the newly patented Kodak T-grain (tabular grain) technology, which produces tabular shaped silver halide crystals that capture light more efficiently than conventional cubic shaped silver halide crystals." [2]

The make-up of the film consists of a magenta layer with 100% T-grain emulsion. The yellow layer contains a combination of T-grain and conventional silver halide crystals. The cyan layer is comprised of 100% conventional silver halide grains. The emulsion layers of this film are thin, thus reducing the sharpness robbing effect of light scattering, thicker emulsions. Standard delivery times for processing of the color negatives and a color contact print is approximately four hours.

Previously, professional photographers who needed images with maximum detail had to use color slide film. Now they can shoot Ektar color negative film with no sacrifice of grain or sharpness. Ektar film is more than 50 percent sharper than Kodachrome 25.[3]

The high quality and short processing time of the Ektar film makes it very attractive to the photographer. As described later, there is also the possibility that this new film would be advantageous to the color separator as well. The changes in the technology of color scanners has opened the door for new capabilities with color negative films.

**New Color Scanner Technology**

In 1987, ITEK introduced the Royal Zenith 210-L color scanner. It is important to state at this time, the author selected the Royal Zenith scanner because of her working knowledge of it's operational procedures and it's availability at Rochester Institute of Technology. This machine is an electronic dot generating color scanner capable of

producing either positive or negative separations from color negative film. The Royal Zenith scanner operates with a different technology than the majority of color scanners currently available. The machine's analyzing light is split by a prism and the original image is scanned sequentially in the three spectral wavelengths of red, green and blue. Therefore, three separate sets of color data are produced in three revolutions of the analyzing drum and are fed through a single photomultiplier with each revolution.[4] The remainder of the light is reflected onto a second photomultiplier to be used for unsharp masking.[5] Unsharp masking accentuates the contrast between adjacent tones and increases the edge effects where tones change. This accentuation gives the appearance of a sharper picture with more detail.[6]

**Objectives of Study**

The objective of this study was to provide evidence which supports this author's belief that an electronically produced color reproduction made from an Ektar color negative will demonstrate significant improvement in sharpness, saturation and tone reproduction over an electronically produced reproduction made from a Kodachrome transparency.

The availability of scanners to work from a color negative and the introduction of Ektar film now permit new color reproduction opportunities. The photographer will be able to utilize the versatility of the Ektar film and still provide a high quality original to the scanner operator for color separations. The characteristics of the new scanners may allow

the scanner operator to produce a set of separations with higher quality than is possible from a transparency. These two technologies working together could possibly produce a printed page of higher quality than was previously possible.

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## Chapter II

## Color Image Production

### What Is Color?

In 1666 Isaac Newton first demonstrated that light is the source of all color. While light is the physical source of color, the human brain and the eyes create the perception of color. This perception is a psychological effect that is created by stimulation of the brain. The spectral sensitivity of the human eye detects light reflected from an object. Objects absorb portions of the blue, green and red spectrum, and reflect the unabsorbed light. The reflected portions of the spectrum stimulate receptors in the eye to create the sensation of color.[1]

The brain, the eyes and the light source are the critical mechanisms in color perception. The eye contains light detectors called rods and cones. The retina has three types of cone receptors that respond to blue, green and red light wavelengths. These cones react to the stimuli of the wavelength and transmit this information to the brain for color interpretation.

### Color Theory

There are two methods for producing color; the additive method and the subtractive

method. In the additive method, the primary colors of light (red, green, and blue) can be mixed in varying proportions to create other colors, or in equal proportions to create white.

With the subtractive method, the primary colorants (inks, dyes, or pigments) are cyan, magenta and yellow. These colors are the complementary colors to the three additive primaries of red, green and blue. Properly combined, the subtractive primaries can absorb all colors of light, producing black.[2] When combined in varying proportions cyan, magenta and yellow can create a color gamut of colors.

Both the fields of photography and printing utilize the subtractive color theory. Photography places the three primary colorants (dyes) onto three different emulsion layers on the film. The varying proportions of those overlapping colors allows the viewer to see the color photographed.

The printing process places the three primary colorants onto paper with the halftone process. A fourth color, black is also used to correct for the impurities found in process inks. The overlaying of the four colors provides for the absorption and reflection of the appropriate wavelengths. Again, the viewer sees the correct color as a result of the process.

**The Photographic (Light Sensitive) Process**

All film emulsions contain silver halide crystals suspended in gelation. When light strikes the film an invisible latent image is recorded. Each light sensitive crystal is struck by varying amounts of light, dependant on the light intensity reflected from the subject.

An image is formed when the exposed crystals are converted to a silver metal during development. After development the areas of the color negative emulsion that received the most light are dark and the areas that received less light are more transparent after development. This results in a negative image. Positive color images are created by transmitting this negative image onto another light sensitive material or by manipulation of the original film to reverse the effects. The two methods provide the photographer with two different types of film, positive (transparency) film or negative film.

**Color Emulsions**

Color films used in photography, positive or negative, are comprised of three layers of emulsion. Each layer is made sensitive to one-third of the visible spectrum comprised of blue, green and red. The top emulsion layer is only sensitive to blue light thus permitting the green and red light to pass through it without any effect. Because the green and red emulsion layers are also blue sensitive, it is necessary to add a yellow filter layer to the film just below the blue emulsion layer. The addition of this yellow filter layer absorbs the blue light thereby preventing it from striking the green and red sensitive

emulsion layers. When the film is exposed to the original scene, light of each color strikes the emulsion forming the invisible latent image. Where there is red light, only the red layer forms a latent image. Where there is no light no emulsion is exposed, and where white light is present all three layers are exposed equally. Combinations of the three colors as well as the intensity of light cause the variety of colors and densities to be formed.

In color negative films the color image is modified with an automatic masking device in two of the emulsion layers. This makes the color of the negative a light reddish-tan. The masking overcomes the effect of incorrect color absorptions that are characteristic of unmasked color negative films, thus making them print colors more accurately. The tan comes from yellowish dye in the magenta layer and reddish dye in the cyan layer.[3]

After development, the color negative film is used to recreate the original scene back into a positive image for the viewer. The color negative is projected from an enlarger first through a tungsten or a tungsten halogen light source through an optical system to the color photographic paper. To achieve the correct color balance on the reflection paper cyan, magenta and yellow filtration is placed between the light source and the paper. The cyan, magenta, and yellow filtration is used to absorb color from the white light passing through them from the enlarger.

The process described above is the basis for all color films. Exposure to light produces an invisible latent image on the emulsion. The three superimposed emulsion layers are developed into a negative. The negative color is created with dyes during the first color development where the developer and color couplers react to form a dye. When the darkened silver has been bleached out, the three layers contain superimposed images of cyan, magenta and yellow where there was once developed silver crystals. The color negative will have reversed both the colors and the tones of the original scene.

In the color reversal process, the first developer converts the latent image into metallic silver negative images. The undeveloped emulsion is then chemically exposed and a second color development occurs with a different developing agent that generates dyes with three different complementary colors. Magenta dye is produced in the green sensitive layer, yellow dye in the blue layer and cyan dye in the red layer.

After all of the darkened silver has been bleached and removed a positive color image will remain in each superimposed layer. When white light passes through the transparency, colors of the original subject are reproduced by the subtraction of the other colors from light. [4]

**Characteristics of Color Films**

Color films are defined with an assortment of terms used to establish their characteristics.

An understanding of the terminology is necessary to establish the guidelines for comparison. The following terms are the common characteristics utilized for film comparison.

Contrast: The difference in lightness between the darkest and lightest tones.

Definition: The clarity of detail on the film. There are several factors which will affect definition: sharpness, resolving power, and graininess.[5]

Exposure Latitude: The range over which the exposure can be increased and decreased from the "correct" exposure and still produce acceptable results. [6]

Film Speed: refers to the amount of light required to produce an image on the film. The faster the film speed, the higher the ISO rating for that particular film will be. Faster films need less light to expose the image. However, the higher the film speed the grainier the image will be once developed. A film rated at ISO 100 is twice as fast as a film rated at ISO 50. Slower films that have less grain will often appear sharper.

Graininess: Used interchangeably with granularity. A subjective term frequently defined as the sensation of non-uniformity in an image that is produced in the observers mind when viewing the image.[7] Graininess is caused by the irregular distribution of the silver

grains. It results from the apparent clumping of silver grains in black and white film or dye particles in color films. Graininess will increase as film speed increases and has an adverse affect on sharpness. Graininess is most easily detected in the midtone areas of the film.

Granularity: Describes the uniformity of silver or dye deposits in photographic emulsions. Granularity is a purely objective or measured quantity.[8]

Resolving Power: The ability of a film to record fine detail distinguishably.[9] Resolving power is also referred to as resolution. Resolution is expressed in terms of the maximum number of lines per millimeter that can be adequately reproduced by the film.

Saturation: Color saturation is defined as the extend to which a color departs from neutral. Thus grays have no saturation, and spectral colors have high saturation.[10] It is difficult for a person to judge the saturation of a color seen in isolation except in general terms such as low, moderate, and high saturation. In side-by-side comparisons, where the eye functions as a null instrument, it is easy to detect small differences in saturation provided the two samples match in the other two atrributes--hue and brightness.[11]

Sharpness: The corresponding abruptness of an edge in an image. Sharpness and contrast are closely related. As image contrast increases, the image will appear to be sharper to the human eye. Sharpness is a subjective property.[12]

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# Chapter III

## Color Image Reproduction

Today the printed page plays a major role in our daily lives. We are constantly viewing color reproductions. Visual imagery is important to us and we have come to expect high quality color reproductions.

While it is imperative to have control over the many variables on press, they are not the main concern of this project. The problem is in understanding and controlling the photographic portion of the printing process.

The photomechanical process is used to reproduce all originals whether black and white or color. Because the lithographic printing process cannot vary the density of ink on the paper, the continuous tone color original must first be converted into four separation negatives. Briefly, the basic procedure with electronic color scanning is the following for both reflection and transparent copy: the microscope optics in the scanner analyze the original copy and split the information into four light paths with the use of interference filters. Each light path enters a photomultiplier tube (PMT). Three of the PMTs are covered with red, green and blue filters to create the cyan, magenta and yellow separation

signals. The fourth light path activates a PMT used for unsharp masking. The black separation signal is produced by electronically combining information from the cyan, magenta and yellow signals in a subsequent step. The PMTs convert the beam of light into electronic signals in proportion to the light it has received. The electronic signals next enter the color computer which enables color-correction to occur. The modified signals are used to control the exposing mechanism which exposes the film to a density or a dot size proportional to the printing inks required. The black signal is then created by the computer from information taken from the three color signals. When the output is to be an electronically generated dot and the exposing light is an array of laser beams, the signal from the computer modulates the individual light beams to produce micro dots that make up each halftone dot. Only a partial halftone dot is made on each revolution of the exposing drum. Depending on the screen angle used, it may take two or three revolutions to complete a halftone dot.[1]

The halftone process is the means of converting the continuous tone original into dots of equal density but of varying sizes. The halftone process was not widely adopted until 1890 when the glass screen was devised. In 1942, Kodak introduced a new form of halftone screen, the contact screen. This screen is used in direct contact with the film. The contact screen consists of a pattern of vignetted dots. A vignette is a varying amount of density in a specific area, with the greatest density in the center and gradually decreasing to the outer edges. Currently, the contact screen method is primarily used for

black and white reproductions. The majority of color reproductions are produced by means of electronic dot generating scanners.

**Color Scanners**

In the mid 1930's the first practical process for color photography, Kodachrome was developed by the Eastman Kodak Company. During this same time, Alexander Murray, a scientist at the Eastman Kodak Company invented the first color separation scanner.[2] The early color scanner produced a continuous tone film the same size as the original image. It was necessary to scan the image four different times through different filters to produce four continuous tone separation negatives.[3] These films would then be screened for halftone conversion and size adjustments by a process camera. By printing the halftone in register with it's respective ink color, the color image was reproduced on the printed page. The color scanners of today offer far more advantages and speed.

This research project was concerned with only the electronic dot generated color separations because the majority of separation negatives are made on these scanners.

**Process Color Printing**

The printing process works on the subtrative color theory. The process printing inks used are transparent. Light will pass through transparent inks and the substrate will reflect the light back to the viewer. In theory, each process ink will absorb one-third of the light

and transmit two-thirds back. When using transparent inks, two colors overprinted will create a new color. When overprinting cyan and yellow, both the red and blue are absorbed allowing green to reflect back to the viewer. Process inks, however are not ideal inks. Due to unwanted absorption, equal portions of cyan, magenta, and yellow do not produce neutral gray but rather a brownish color. To compensate for this unwanted absorption the magenta and yellow dot sizes on the separations must be reduced throughout all levels of gray in the reproduction. Adding a black separation will yield improved shadow detail, increased shadow density and works to increase overall contrast of the reproduction.[4]

## Criteria for Color Reproduction

### Memory Colors

"Color is a visual experience. It is a perception and therefore the word color refers to physiological and psychological responses to light. [5] Hue, the name of a color has it's strongest identity in our minds. The majority of us can close our eyes and recall white puffy clouds floating across a blue sky or the color of strawberries. These references are examples of what is referred to as memory colors. The goal of the printing process is to achieve an accurate or pleasing reproduction of the original image. Precise color reproduction is not obtainable in the previous step, the photography of the original scene. "The dyes used in color films are not the same colorants that existed in the original subject. This will affect the range of colors that can be reproduced.[6] It is therefore imperative that the memory colors in a reproduction be accurate.

**Tone Reproduction**

Tone reproduction is frequently defined as all the relationships of dot sizes on the printed page to the original continuous tone densities. Two terms used when discussing tone reproduction are gradation and contrast. Gradation refers to the increasing or decreasing of densities from one level to the next level. Contrast is the difference in brightness between the darkest and lightest tones in the original.

A perfect reproduction would yield a straight 45 degree line when each density measurement plotted on the X axis (original) matches the densities plotted on the Y axis (reproduction). A typical color transparency has a maximum density of 3.00. A typical color negative film has a maximum density of 2.50. The tonal ranges of a transparency and color negative film is greater than the tonal range possible on the printed page. Under ideal conditions with a coated stock, the maximum solid ink density on offset lithography will be approximately 1.80.[7]

It is apparent that the tonal range of the original and the tonal range of the printed page are not equal. Some tones in the original must be compressed to fit the printing requirements. Tone compression is practiced to meet this criteria. Tone compression is the reduction of density ranges.[8]

Before tone compression takes place, a decision must be made as to the keyness of the original copy that is being reproduced. In a high key image most of the important information is in the highlight area. In a low key original most of the important information is in the shadow region.

A normal key original contains a more equal distribution of tones from highlight to shadow detail. A standard scanner setup for normal copy is to place the midtones at .90 above the desired highlight density. This setup will cause more tone compression to occur in the shadow end of the scale. This practice is preferred because " the human eye does not respond equally to density differences in the light and dark areas of the picture." [9] Our eyes perceive changes in lighter values far quicker than they distinguish changes in darker tones.

Achieving the correct tone reproduction is the most important objective in good color reproduction. Most color problems can be traced to improper tone reproduction.[10]

**Gray Balance**

Another equally important criteria in the color separation process is gray balance or neutrality. "Gray balance is obtained when the right combination of cyan, magenta, and yellow dot sizes are used to reproduce a neutral gray scale with the printing inks at a certain density for each ink. " [11]

As stated previously, equal amounts of cyan, magenta, and yellow inks do not produce a neutral gray due to unwanted absorptions. The color scanner operator must program the scanner to compensate for this ink contamination. The magenta and yellow dot sizes on the separations must be reduced throughout all levels of gray in the reproduction.[12] The accepted method of controlling gray balance for most printing processes is to render the printing dot percentages unequal in the three process colors.[13]

The variables which influence gray balance most are the specific hue characteristics of the process inks being used, the ink film thickness printed on the paper and the percent dot printed on the paper.[14]

Gray balance and tone reproduction criteria must be established before color correction can occur. Gray balance plays a major role in accurate color reproduction as does tone reproduction. Gray balance refers to the neutrality of the gray scale whereas tone reproduction determines the density of each step. The tone reproduction of the cyan printer will determine how dark the grays will print while tone reproduction of all three printers will determine how neutral the grays will reproduce. [15] The black printer is used to assist in achieving neutrality and increases shadow detail.

### Color Correction

The impurities contained in printing inks require that color correction be performed as

part of the separation process. Each of the process inks cyan, magenta, and yellow absorb a portion of the wavelengths they should be transmitting. Cyan absorbs red light but also some green and blue light. Cyan inks when printed will appear to have a magenta and yellow hue shift. To correct this problem it is necessary to reduce the amount of magenta and yellow ink (reduce the dot sizes) in the cyan image areas.

The wanted absorption with magenta inks is green light. However, a small portion of blue light is also absorbed. When magenta ink is printed it will appear contaminated with yellow due to unwanted absorption of blue light. The correction is to reduce yellow ink (reduce dot sizes) where magenta also prints.

Yellow ink has the least amount of unwanted absorption of the three process inks. There is a slight amount of unwanted green light absorption creating a slight magenta cast. The correction is to reduce the dot sizes in the magenta separation wherever yellow also prints.

**Detail Enhancement**

The last criteria for good color reproduction concerns image quality. The original transparency and color negative is typically extremely sharp with a great deal of detail. Unsharp masking is the technique the scanner utilizes to compensate for the degradation

of the image sharpness caused by the optics of the scanner, the printing process and the lack of sharpness in an original.[16]

The use of unsharp masking will result in an increase of tonal contrast at the areas where light and dark tones come together. This increase in contrast gives the visual appearance of a sharper image with more detail. The unsharp masking signal modulates the color separation signal at adjacent tonal areas so that the lighter tone is slightly reduced and the darker tone is slightly increased.[17]

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# Chapter IV

## Present Film Characteristics

### Transparency Films

Transparency films are classified as reversal color emulsions. With reversal film emulsions an increase in exposure will produce a decrease in the amount of density in the image. In order to achieve the correct contrast and color saturation in the transparency, the midtone slope is typically between a gamma of 1.8 to 2.0. Gamma, the measurement of contrast, is defined as the slope of the straight-line section of the D-log H curve.[1] This midtone slope is much higher than the slope of color negative materials.[2]

The maximum density than can be reached with transparency film is often 3.00 or greater. The gamma for Kodachrome film is between 1.8 and 2.0. Since the slope of color reversal films is steep, the useful log exposure range is narrow. The useful log exposure range of the film is the range of log exposures contained between the minimum and maximum useful densities of the curve.[3] Most reversal films do not exceed a useful log range of 1.90 indicating that an exposure ratio of at best 80 to 1.[4] This translates into an exposure range of six camera stops. As a result, the amount of exposure latitude is very narrow.[5] A 1/2 stop underexposure on transparency film will yield a dark and

muddy slide. There is even less tolerance on the side of overexposure, the colors will quickly lose saturation on the developed transparency.

For many years, Kodachrome has been considered to be the standard by which all color slide films are judge.[6] Kodachrome 25 combines deep color saturation with extremely fine grain and high resolution. It's virtual absence of grain has been widely acclaimed with professional photographers.[7] Kodachrome produces a first generation positive original that is created directly from the original scene with only one lens system (the camera).

**Technical Data for Kodachrome Films**

| | |
|---|---|
| Sharpness: | extremely high sharpness |
| Grain: | extremely fine grain |
| Color Saturation: | high |
| Resolving Power: | 90 lines/mm |
| Density Range: | 3.00 |
| Gamma: | 1.8 to 2.0 |
| Exposure Latitude: | very narrow |

## Color Negative Films

The emulsion of Ektar film is based on a negative working process. The dark areas in the

original scene record as light areas on the emulsion, and the light areas record as dark on the emulsion. Color negative films are classified as first generation originals. First generation originals are considered to be of the highest quality as every generation thereafter will lose sharpness and contrast as compared to the previous generation. For this reason, a color negative film would be the preferred original in the color separation process rather than a color reflection print.

The maximum density that can be achieved on a color reflection print with a color negative film ranges from 2.20 to 2.40. The useful log exposure range of a color reflection print is considered to be between 1.15 to 1.25.[8] Color negative films typically have an exposure range of five stops. The contrast of color negative films is found by measuring the slope of the straight line portion of the characteristic curve. The gamma of color negative films is considered to be between .50 and .60.[9] The lower gamma measurement of Ektar film indicates a lower contrast range than is possible to achieve using Kodachrome film.

While it is true that most color negative films permit a wide exposure latitude, this is not true of Ektar films. Most color negative films have a very long and straight characteristic curve, Ektar 25 has a pronounced S-shaped curve. In this respect, Ektar and Kodachrome are similar in that both have a narrow exposure range.[10]

**Technical Data for Ektar Film**

| | |
|---|---|
| Sharpness: | extremely high sharpness |
| Grain: | micro fine grain |
| Color Saturation: | high |
| Resolving Power: | 120 lines/mm |
| Density Range: | 2.2 to 2.4 |
| Gamma: | .50 to.60 |
| Exposure Latitude: | narrow |

## Notes

1. Stroebel, L.et al., Materials and Processes of Photography, Focal Press, 1990, pg.103

2. Stroebel, L. et al., Materials and Processes of Photography, Focal Press, 1990, p.348

3. Stroebel, L.et al., Materials and Processes of Photography, FocalPress, 1986, pg. 533

4. Stroebel, L. et. al.,Materials and Processes of Photography, FocalPress, 1986, pg. 534

5. Stroebel, L. et al., Materials and Processes of Photography, Focal Press, 1986, p. 533

6. Popular Photography, Special Advertising Section, Kodak Film July, 1990

7. Eastman Kodak Company, Color Films and Papers for Professionals, March, 1986, p.6

8. Stroebel, L. et al., Materials and Processes of Photography, Focal Press, 1986, pg. 534

9. Stroebel, L. et al., Materials and Processes of Photography, Focal Press, 1990, p. 351

10. Ctein, Kodak Ektar Films, Photomethods, January 1990, p.26

# Chapter V

## Statement Of The Problem

The standard practice in photomechanical reproduction for the photographic and printing industries has not changed in recent times. For many years the defacto standard for high quality photographic color film has been Kodachrome. For a similar period of time, the defacto standard film utilized for color reproduction has also been Kodachrome. Kodachrome is a transparency film that is of unquestionably high quality. Until 1988 it was known as the sharpest professional film in the world. In 1988, the Eastman Kodak Company introduced Ektar film. With the introduction of this new color negative film a new benchmark for sharpness was created. Kodachrome is now advertised as the sharpest color slide film, while Ektar is said to have the "best image structure ever achieved".[1] Ektar is a color negative film matching, if not surpassing, the characteristics of Kodachrome in image sharpness.

This new film has the possibility of becoming the film preference for photomechanical reproduction of color images. Color scanner technology has improved to the point where they are now capable of producing color separations from a color negative original. The

combination of Ektar film and this new scanner technology may possibly allow the photographers and printers to set new benchmarks for reproduction quality.

The objective of this study was to provide evidence that color separations produced from an original Ektar color negative will be at least as good as color separations produced from an original Kodachrome in the areas of sharpness, color saturation and tone reproduction.

### Null Hypothesis One

A color separation proof generated from an Ektar 25 color negative original will produce no significant difference in sharpness compared to that achieved from a Kodachrome 25 color transparency original of the same scene as judged by professionals in the fields of photography or printing.

### Alternative Hypothesis One

A color separation proof generated from an Ektar 25 color negative original will produce a significantly sharper image than can be achieved from a Kodachrome 25 color transparency original of the same scene as judged by professionals in the fields of photography or printing.

## Second Alternative Hypothesis

A color separation proof generated from a Kodachrome 25 color transparency original will produce a significantly sharper image than can be achieved from an Ektar 25 color negative original of the same scene as judge by professionals in the fields of photography or printing.

## Hypothesis Two

A color separation proof generated from an Ektar 25 color negative original will produce no significant difference in color saturation compared to that achieved from a Kodachrome 25 color transparency original of the same scene as judged by professionals in the fields of photography or printing.

## Alternative Hypothesis Two

A color separation proof generated from an Ektar 25 color negative original will produce a significant improvement in color saturation than can be achieved from a Kodachrome 25 color transparency original of the same scene as judged by professionals in the fields of photography or printing.

## Second Alternative Hypothesis

A color separation proof generated from a Kodachrome 25 color transparency will produce a significant improvement in color saturation than can be achieved from an Ektar

25 color negative original of the same scene as judged by professionals in the fields of photography or printing.

### Null Hypothesis Three

A color separation proof generated from an Ektar 25 color negative original will produce no significant difference in tone reproduction compared to that achieved from a Kodachrome 25 color transparency original of the same scene as judged by professionals in the fields of photography or printing.

### Alternative Hypothesis Three

A color separation proof generated from an Ektar 25 color negative original will produce a significant improvement in tone reproduction than can be achieved from a Kodachrome 25 color transparency original of the same scene as judged by professionals in the fields of photography or printing.

### Third Alternative Hypothesis

A color separation proof generated from a Kodachrome 25 color transparency original will produce a significant improvement in tone reproduction than can be achieved from an Ektar color negative original of the same scene as judged by professionals in the fields of photography or printing.

## Notes

1. Popular Photography, Special Advertising Section, Kodak Film, July, 1990

# Chapter VI

## Methodology

### The Photography

The research project was begun by creating and photographing four different still life scenes in a controlled studio environment. These four studio scenes included a MacBeth color checker as well as a variety of objects demonstrating color, texture and fine detail. The eighteen percent gray patch on the MacBeth color checker was used to make visual comparisons for neutrality in the scanned images as well as an indicator or aim points for the scanner operator. The studio scenes were illuminated by the Broncolor flash unit. This light source was balanced at 6000 degrees Kelvin.

Two additional scenes were exterior photographs containing an average scene range. The luminance ratio of an average outdoor scene is considered to be 160 to 1 or seven camera stops.[1]

All the photography work was done using two Nikon F-4 cameras mounted on a tripod. Each scene was photographed with Kodachrome 25 and Ektar 25 film under the identical lighting conditions. The camera or tripod position did not vary. The Kodachrome film

was processed at one time under normal K-14 conditions. The Ektar film was also processed at the same time under normal C-41 conditions.

Proper exposure determination for the exterior images was accomplished using a Minolta incident light meter. An incident light meter measures the light falling on a subject as seen from the camera position. The proper exposure determinations for the four studio scenes was done employing a Minolta flash meter.

A critical part of this experiment was to maintain a very close match between the spectral sensitivity of the film and the light source that was used. The two films tested have a color temperature of 5500 degrees Kelvin. The color temperature of the electronic flash unit is 6000 degrees Kelvin which is considered to be an extremely close match to daylight balanced films. The use of the electronic flash in the studio was a valuable part of this experiment due to it's consistency in color output and the quality of light output from flash to flash.[2] The color temperature of daylight is considered to be 5500 degrees Kelvin which is an exact match to daylight balance films.

**The Color Separations**

Twelve color separations were made using the ITEK Royal Zenith 210-L scanner. As mentioned previously, this scanner was chosen because of it's ability to scan color negative images, the author's working knowledge of the operational procedures and it's

availability at the Rochester Institute of Technology. The Royal Zenith scanner is an electronic dot generating scanner that employs a laser to expose film. The laser light is a highly controllable source that will produce a hard dot with no fringe. The argon-ion laser emits a blue-green light in the region of 480 nanometers which maximizes the spectral sensitivity of orthochromatic film.[3] The film used to produce all the separations for this project was Kodak Imagelite scanner film. This is an orthochromatic film with a high resolution capability to produce extremely small halftone dots while at the same time holding open tight shadow dots.[4] The separations were processed in the DuPont rapid access processor located in the Color Separation Lab.

The aim points for the correct highlight, midtone and shadow dot placement were set from the MacBeth Color Checker. The white patch was used to set the highlight dot placement. The black patch was used to establish the shadow dot placement. The gray eighteen percent patch was used to set the midtone dot placement. The exterior scenes were scanned as "normal copy." The highlight was set at a density of .30, the midtone at a density of .90 above the highlight and the shadow from the shadow area containing detail. A carbon wedge continuous transmission scale was mounted on the scanner drum for this purpose next to the original film. The enlargement size for the 35mm originals was 400 percent. The standard color correction settings for each of the two original film types was employed.

As stated earlier, a press run was not incorporated into this study. Each set of separations, therefore, required an off-press proof. All proofs were made employing the DuPont Cromalin system, This proofing system is a single sheet (integral) proofing system employing toners. The system was calibrated to meet DuPont's specifications before the proofs were made. Each final proof measured four by six inches in size and was mounted on a gray matt board eight by ten inches in size.

**Evaluation**

The twelve color proofs were judged by a part of a population of potential judges referred to as a sample. The sample size for this project was thirty people. Each evaluation was done under standard viewing conditions as specified by the American National Standard Institute (ANSI).[5] Standard viewing conditions occur in a viewing booth equipped with a light source equivalent to 5000K. The viewing booth located in the Color Separation Lab was used to evaluate the twelve color proofs. It is widely accepted that different types of color films will not record the colors and tones of the original scene in precisely the same way in the cyan, magenta and yellow emulsion layers. As a result, it can be expected that there will be some color differences between the Kodachrome and Ektar emulsions.

The test method for the evaluation of the twelve color proofs was a paired comparison. Paired comparison, the oldest of the recognized psychometric methods, is based on the

simple act of making a choice between two alternatives.[6] It may be used whenever a quantifiable psychological dimension can be specified and two objects are available for comparison.[7] For this project, two color proofs were presented simultaneously and the judges were asked to select one over the other. A paired comparison can be considered as a preference test; which of the two color proofs do they prefer based on the criteria assigned.

The sample population was comprised of thirty people who have had professional training and/or professional work experience in either the field of photography or printing.

A specifically designed set of instructions was given to each judge to read before their evaluation took place. A standard written definition of image detail, color saturation and tone reproduction was read by this researcher to the judges prior to their evaluation. The judges then proceeded to the viewing booth where they evaluated one pair of proofs at a time. Each set of proofs were of an identical scene; one photographed on Kodachrome and the other on Ektar film. The responses of the judges were recorded by the researcher on a separate specifically designed sheet after each set of color proofs had been judged. Each proof was labeled on the back with a random number and a letter for accurate recording of each response. So as not to show any bias on the author's part the master list identifying the twelve color proofs was not present during the evaluations.

Each of the thirty evaluations consisted of six pairs of color proofs for statistical analysis.

**Statistical Methodology**

The statistical method used to evaluate the data collected from each set of proofs was a test of Significance for Paired-Comparison (binomial) Results using the two-tailed case. Table One from the Manual on Sensory Testing Methods was used to determine the critical value to be exceeded when one of two samples may be selected, the chance probability is 50 percent and the hypothesis is two-tailed. A ninety-five percent confidence level was used. By using the two-tailed test there was no assumption involved regarding the differences.

The statistical methodology used to evaluate the data collected from the total of the six sets of color proofs for each of the three hypotheses was a t-Test for percentages at a ninety-five percent confidence level.

## Notes

1. Stroebel,L. et al., Materials and Processes of Photography, Focal Press, 1990, p. 240

2. Stroebel,L. et al., Materials and Processes of Photography, Focal Press, 1990, p. 20

3. Eastman Kodak Company, The Color-Separation Scanner, Kodak Publication No Q-78, 1981, p.9

4. Eastman Kodak Company, The Color-Separation Scanner, Kodak Publication No. Q-78, 1981, p.7

5. American National Standards Institute, Color Prints, Transparencies and Photomechanical Reproduction, American National Standards for the Graphic Arts and Photography, April, 1989

6. American Society for Testing and Materials, Manual on Sensory Testing Methods,STP 434, 1968, p.16

7. IBID.

## Chapter VII

## Summary of the Experiment

Upon completion of the photography and film development, the author selected the correct exposure for each of the six Kodachrome slides and for the six Ektar negatives. A five by seven color reflection print of each Ektar color negative was custom printed using Kodak Ektacolor Supra paper by Professor Robert Kayser at the Rochester Institute of Technology.

Prior to the color printing, reflection density readings of the gray scale on the original MacBeth Color Checker were made using a MacBeth TR 1224 densitometer in the Color Center. The following data was obtained:

| | Red | Green | Blue | Visual |
|---|---|---|---|---|
| White | .07 | .07 | .07 | .06 |
| N8 | .25 | .25 | .24 | .25 |
| N6.5 | .47 | .46 | .46 | .46 |
| N5 | .75 | .73 | .73 | .73 |
| N3.5 | 1.11 | 1.09 | 1.09 | 1.09 |
| Black | 1.57 | 1.58 | 1.57 | 1.57 |

The recommendation from the Eastman Kodak Company was to match as closely as possible the reflection density readings from the N5 patch (eighteen percent gray) to the reflection densities on the N5 patch on the color reflection print. Professor Kayser reproduced the N5 patch on each of the six color prints to a density reading of .72 for red, green and blue

These six color reflection prints were employed to assist the color scanner operator in adjusting the color correction program on the Royal Zenith 210-L scanner. It is important to note that the thirty judges did not view the six color reflection prints or the original six Kodachrome slides when evaluating the color proofs.

**Separations**

Prior to generating the color separations the scanner was linerazied to the recommended negative gradient curve. This procedure was accomplished by outputting a calibrated gray scale onto scanner film, processing and reading the positive halftone dots on a densitometer. The data was then plotted against an established gradient curve, provided by Royal Zenith, for comparison. Once the recommended gradient curve was correctly established, the six Ektar color negatives were scanned into the Royal Zenith scanner.

The highlight dot placement for each of the four Ektar color negative images originally photographed in the studio was set using the white patch on the MacBeth color checker.

The midtone dot placement was set using the N5 patch (eighteen percent gray) on the MacBeth color checker. The shadow dot placement was set using the black patch on the MacBeth color checker. The two color negative images of an exterior scene were scanned as "normal copy." The highlight dot was set at a density of .30, the midtone dot at a density of .90 above the highlight dot and the shadow dot from a specific image area containing good shadow detail. A screen ruling of 150 lines per inch was used for all six negatives. The reproduction size was 400 percent. The six color negatives were scanned during the same working day to eliminate possible scanner or film development variations. The six sets of positive halftone separations were generated onto Kodak Imagelite scanner film. The six Kodachrome transparencies were scanned following the same exact procedure as stated above. The final image size for each set of separation halftones was four by six inches.

Next, off-press proofs were made from the twelve sets of positive halftone separations using the DuPont Cromalin proofing system. Each proof was made using the Cromalin Commercial grade paper. Upon completion of the proofing process, each proof was mounted on a dove gray matt board measuring eight by ten inches.

**Evaluations**

As described previously in Chapter Six the method of evaluation used was a paired comparison. A sample size of thirty people, each with professional experience in either the field of photography or printing was selected by this author.

Prior to the evaluation process a test for color blindness was given by this author to each judge. This test was administered under standard viewing conditions as specified by the American National Standards Institute (ANSI). Upon successful completion of the H-R-R-Pseudoisochromatic plate test, a set of written instructions was read to each judge. A copy of these instructions is included in Appendix B.

The six pairs of separation proofs were then viewed three consecutive times for evaluation using the paired comparison method by each judge in a viewing booth under standard viewing conditions. Each pair was first evaluated for image detail, second for color saturation and third for tone reproduction. The responses of each judge were recorded by this author on a separate tally sheet. Each proof was labelled on the back with a random number to prevent bias on the part of this author. A copy of the tally sheet is included in Appendix C.

## Chapter VIII

## Analysis of the Data

### Part One

Six color proofs generated from Ektar color negative material were compared with six color proofs of the identical scene generated from Kodachrome transparency material. The criteria used to evaluate the six sets of color proofs was image detail, color saturation and tone reproduction. Part one of the statistical analysis consisted of evaluating each set of color proofs for each of the three separate criteria. The method employed for this experiment was a paired comparison test. This test, the oldest of the recognized psychometric methods, is based on the simple act of making a choice between two alternatives. Almost any kind of psychometric problem can be presented in this form.[1] Two stimuli are presented simultaneously and the subject is asked to select one over the other on the basis of some previously defined dimension.[2]

Table One from the Manual on Sensory Testing Methods was used, since this table contains the critical values for when one of two samples is selected, the chance probability is fifty percent, the hypothesis is two tailed and the confidence level is ninety-five percent. Referring to the Manual on Sensory Testing Methods Table One on page 64, a list is printed showing the "number of correct identifications required for

significance at various levels in a two sample test.[3] For a sample size of thirty judges at a confidence level of ninety-five percent, twenty-one acceptances are required. When the paired comparison statistic is greater than twenty-one, the null hypothesis is rejected.

The results of the data obtained by the thirty judges is listed below. While the six sets of color proofs were randomly coded, to prevent bias on the author's part, during the evaluation process they are listed below in numerical order from one to twelve. All odd numbers represent the Ektar color proofs and all even numbers represent the Kodachrome color proofs. An asterisk indicates a statistically significant difference was found.

**Results of Evaluations**

**Image Detail**

| **Ektar** | **Kodachrome** |
|---|---|
| Proof 1--22 * | Proof 2--8 |
| Proof 3--26 * | Proof 4--4 |
| Proof 5--21 * | Proof 6--9 |
| Proof 7--4 | Proof 8--26 * |
| Proof 9--20 | Proof 10--10 |
| Proof 11--7 | Proof 12--23 * |

## Color Saturation

| Ektar | Kodachrome |
|---|---|
| Proof 1--21 * | Proof 2--9 |
| Proof 3--23 * | Proof 4--7 |
| Proof 5--27 * | Proof 6--3 |
| Proof 7--18 | Proof 8--12 |
| Proof 9--23 * | Proof 10--7 |
| Proof 11--14 | Proof 12--16 |

## Tone Reproduction

| Ektar | Kodachrome |
|---|---|
| Proof 1--12 | Proof 2--18 |
| Proof 3--22 * | Proof 4--8 |
| Proof 5--17 | Proof 6--13 |
| Proof 7--6 | Proof 8--24 * |
| Proof 9--22 * | Proof 10--8 |
| Proof 11--6 | Proof 12--24 * |

Based on the above information, an analysis of the data indicates that three out of six times the Ektar proof was determined to be significantly better for the criteria of image detail. Two out of six times the Kodachrome proof was determined to be significantly

better for the criteria of image detail. One set of color proofs yielded no significant difference for the criteria of image detail.

Based on the above information an analysis of the data indicates that four out of six times the Ektar proof was determined to be significantly better for the criteria of color saturation. Two out of six times the results yielded no significant difference for the criteria of color saturation.

Based on the above information an analysis of the data indicates that two out of six times the Ektar proof was determined to be significantly better for the criteria of tone reproduction. Two out of six times the Kodachrome proof was determined to be significantly better for the criteria of tone reproduction. Two out of six times the results yielded on significant difference for the criteria of tone reproduction.

## Part Two

### The t-Test

Upon completion of the statistical analysis of the paired comparison test results the composite data was analyzed for significance by employing the t-test for percentages. The statistic **t** is used in determining the significance of differences of percentages. It is defined as the difference divided by the standard error of the difference. [4] It's distribution shows the probabilities associated with this ratio for a given number of cases.[5]

The t-test for percentages when used to test for the significance of the difference between two experimentally observed proportions would require using the formula for the standard error of the difference.

The formula employed for the statistical analysis is:

$$SE_{per} = \sqrt{\frac{pxq}{N}}$$

where: p = higher percentage (observed proportion)

q = (1-p) = lower percentage (theoretical proportion)

N = sample size

The calculations of the t-test for the criteria; image detail, color saturation, and tone reproduction are shown in Appendix E. The summary of the **t**-test results are seen below with an asterisk indicating significance.

**Data Table**

| **Hypothesis** | **Table Value** | **Calculated Value** |
|---|---|---|
| One | ± 1.96 | +1.51 |
| Two | ± 1.96 | +5.40 * |
| Three | ± 1.96 | +0.75 |

Table Six from the Manual on Sensory Testing Methods requires the use of n= infinity (nearest value to 180 samples) under the two-tailed columns. It is stated that a **t** of ±1.96 is required for significance at the ninety-five percent confidence level.

**Analysis of the t-test Results**

Based on the results of the **t**-test it is now possible to state the following conclusion relative to Hypothesis One: for the criteria of image detail the null hypothesis is accepted. The **t**-test results yielded a +1.51 calculated value. The null hypothesis is accepted at a confidence level of ninety-five percent ($\propto$=0.05).

Based on the results of the **t**-test it is now possible to state the following conclusion relative to Hypothesis Two: for the criteria of color saturation the null hypothesis is rejected and Alternative Two is accepted. The **t**-test yielded a +5.40 calculated value. Alternative Two is accepted at a confidence level of ninety-five percent ($\propto$=0.05).

Based on the results of the **t**-test it is now possible to state the following conclusions relative to Hypothesis Three: for the criteria of tone reproduction the null hypothesis is accepted. The **t**-test yielded a +0.75 calculated value. The null hypothesis is accepted at a confidence level of ninety-five percent ($\propto$=0.05).

## Notes

1. Manual on Sensory Testing Methods STP 434., American Society for Testing and Materials, Philadelphia, PA., 1968, p.16

2. IBID., p. 17

3. IBID., p. 64

4. IBID., p. 49

5. IBID., p.49

# Chapter IX

## Conclusions

Today, we reside in a highly visual environment. The use of color in advertisements, magazines, journals, billboards, posters and newspapers is most often the norm. The quality and accuracy of a color reproduction is a critical factor in one's response to the image. This research project has attempted to demonstrate the possibility that by using an Ektar color negative film in the color separation process instead of a Kodachrome color transparency film, the color reproduction would show significant improvement for the criteria of image detail, color saturation and tone reproduction.

The image quality characteristics that are frequently considered to be of importance in the printed media should be evaluated visually. Therefore, this experiment required a subjective judgment by a panel of thirty observers with prior experience in either the field of photography or printing. This researcher did not attempt to show a relationship between the particular level of expertise of each observer and their preferences of color proof attributes.

The results statistically demonstrate, under the conditions of this experiment, that for the criteria of image detail (Hypothesis One) and the criteria of tone reproduction (Hypothesis Three) the null hypotheses were accepted. There was no significant difference between the color proofs generated from the Ektar color negative film and the color proofs generated from the Kodachrome color transparency film. This conclusion is based on a confidence level of ninety-five percent.

For the criteria of color saturation (Hypothesis Two) the null hypothesis was rejected. The data demonstrated a significant difference in the color proofs generated from the Ektar color negative film and the color proofs generated from the Kodachrome color transparency film. The judges preferred the color proofs generated from the Ektar color negative film at a confidence level of ninety-five percent.

**Implications**

This study has shown that color separations generated from Ektar color negative film are equal in quality to color separations generated from Kodachrome transparency film. There is evidence that in some cases the Ektar film will yield color separations of superior quality than those generated from Kodachrome.

Previously, photographers and printers have found that Kodachrome was the superior film for capturing images that would eventually be color separated and printed. It is possible

that rather than factual documented evidence in support of the selection of Kodachrome as the superior material for the color separation process we are in reality dealing with long established traditions and habits held by professional photographers and printers. This research demonstrates that there is potential for Ektar film to give superior results in some instances. A drawback to using a color negative film is that color scanner operators and printers have always found it easier to view a transparency rather than interpret the correct densities and colors from a color negative material. A color reflection print made from the original color negative would assist the scanner operator or printer in accomplishing this task.

Color negative films have a lower gamma and a wider exposure latitude than do color transparency films. It was, therefore, surprising to see no preference for the criteria of tone reproduction (Hypothesis Three) for the color separations generated from the Ektar color negative film over the color separations generated from the Kodachrome transparency film. The existence of some grainy patches in a few of the Ektar color separated proofs may have influenced the judges to select two of the Kodachrome generated color proofs as superior. This undesirable attribute was primarily visible in the highlight to midtone regions on the MacBeth color checker. This experimental error suggest that further research is required to demonstrate the benefits of using an Ektar color negative film as your choice for capturing an original image for photomechanical color reproduction.

Perhaps now is the right time to demonstrate to photographers, art directors and printers the benefits of using Ektar color negative film rather that Kodachrome transparency film when photomechanical color reproductions are required.

## Chapter X

## Suggestions for Further Research

One of the purposed advantages of using Ektar 25 color negative film in this research project is that Ektar "incorporates the Kodak T-grain emulsion technology, which produces tabular shaped silver halide crystals that capture light more efficiently than conventional cubic shaped silver halide crystals."[1] Ektar 25 color negative film is described as having micro fine grain, extremely high color sharpness and strong color saturation. In February, 1993, Eastman Kodak Company introduced a new line of professional color transparency films which also incorporates the new technology of the Kodak T-grain emulsions in all imaging areas. Ektachrome Lumiere 50 is described by Eastman Kodak as "providing exceptional sharpness, extremely fine grain and excellent color saturation."[2] According to Eastman Kodak Company "when using Ektachrome Lumiere the vivid colors and advanced image structure enhancements are retained when scanned to an electronic file or transferred to the printed page."[3]

With the advent of this newest technology in color transparency film further paired comparison testing could be performed using Ektar 25 color negative film and the Ektachrome Lumiere 50 color transparency film in lieu of the Kodachrome color

transparency film. Another possible avenue of research might be accomplished using three different film emulsions, the new Ektachrome Lumiere 50, the Kodachrome 25 and the Ektar 25 color negative film.

A second purposed advantage of using Ektar 25 color negative film instead of Kodachrome 25 color transparency film to produce color separations is that the color negative film has a density range of 2.20 to 2.40 and a gamma of .50 to .60. The density range of the color negative material is a closer match to the density range of the printed page. Kodachrome 25 has a density range of approximately 3.00 and a gamma of 1.80 to 2.00. The higher density range and higher gamma of the Kodachrome 25 requires that more tone compression occur during the color separation process.

Further research could be done to compare the results of specific criteria obtained from a set of color separation proofs that had been generated from a first generation Ektar 25 color negative and a set of color separation proofs that had been generated from a color reflection print made from the first generation Ektar 25 color negative.

## NOTES

1. Alfred DeBat, Medium Format Kodak Ektar 25, Professional Photographer, July, 1990, p.49

2. Eastman Kodak Company, Pro Passport Flash, Professional Imaging, 1993

3. IBID.

# Appendix

## Appendix A

## List of Equipment and Materials

1. Film: Kodachrome 25 35mm film and Ektar 25 35mm film.
2. Camera: Nikon F-4 and a tripod.
3. Light meter: Minolta flash meter and a Minolta incident meter.
4. Lighting Equipment: Broncolor electronic strobes, power packs and lamp head units.
5. Test targets; MacBeth Color Checker and Kodak reflection gray scale.
6. Dove gray seamless background.
7. Viewing booth for color proof evaluations corresponding to ANSI standards.
8. Instructions to the judges and a response sheet.
9. Standard written description of the criteria.

## Appendix B

## Instructions to the Judges

I appreciate the time you are now taking to assist me with this research project. Shortly, I will be giving you six separate sets of color proofs for you to visually evaluate. Each set consist of two color proofs of an identical scene. You will be judging one versus the other. Before you begin to evaluate the color proofs, I will be giving you a short color vision test. I will be testing you with the H-R-R- Pseudoisochromatic plates for detecting, classifying and estimating the degree of defective color vision.

You will be examining each pair to allow you to answer the following question: Which of the two proof you are now viewing in your opinion demonstrates a better overall appearance? Your response should be based on the following 1) image sharpness or image detail 2) color saturation and 3) tone reproduction.

Please take your time and examine each proof carefully. If you have any questions, please do not hesitate to stop and ask me.

If you are ready, we may move to the viewing booth and begin with the first of the six sets you have been asked to evaluate. Again, I thank you for your valuable assistance with this project.

## Appendix C

### Response Sheet

Indicated in the spaces below are the responses that this author recorded from one judge during the evaluation process. Each proof has been numbered coded to prevent any bias on the author's part. The master list identifying each proof is not present during the evaluations.

---

**Criteria One: Image Detail**

| | |
|---|---|
| 7_____ | 10_____ |
| 63_____ | 42_____ |
| 35_____ | 74_____ |
| 57_____ | 29_____ |
| 72_____ | 26_____ |
| 47_____ | 52_____ |

**Criteria Two: Color Saturation**

| | |
|---|---|
| 7_____ | 10_____ |
| 63_____ | 42_____ |
| 35_____ | 74_____ |
| 57_____ | 29_____ |
| 72_____ | 26_____ |
| 47_____ | 52_____ |

**Criteria Three: Tone Reproduction**

| | |
|---|---|
| 7______ | 10______ |
| 63______ | 42______ |
| 35______ | 74______ |
| 57______ | 29______ |
| 72______ | 26______ |
| 47______ | 52______ |

# Appendix D

## Results of Evaluations

### Image Detail

| Ektar | Kodachrome |
| --- | --- |
| Proof 7--22 | Proof 10--8 |
| Proof 42--26 | Proof 63--4 |
| Proof 74--21 | Proof 35--9 |
| Proof 57--4 | Proof 27--26 |
| Proof 26--20 | Proof 72--10 |
| Proof 47--7 | Proof 52--23 |

### Saturation

| Ektar | Kodachrome |
| --- | --- |
| Proof 7--21 | Proof 10--9 |
| Proof 42--23 | Proof 63--7 |
| Proof 74--27 | Proof 35--3 |
| Proof 57--18 | Proof 29--12 |
| Proof 26--23 | Proof 72--7 |
| Proof 47--14 | Proof 52--16 |

## Tone Reproduction

| Ektar | Kodachrome |
|---|---|
| Proof 7--12 | Proof 10--18 |
| Proof 42--22 | Proof 63--8 |
| Proof 74--17 | Proof 35--13 |
| Proof 57--6 | Proof 29--24 |
| Proof 26-22 | Proof 72--8 |
| Proof 47--6 | Proof 52--24 |

## Appendix E

## t-Test for Image Detail

Response of Judges: Ektar = 100, Kodachrome = 80, Total = 180

A **t** of ±1.96 is required for significance at the five percent level.

t = observed proportion - theoretical proportion/SE proportion

Observed proportion = 100/180 = 0.556

$$\sqrt{180} = 13.4$$

Theoretical proportion = 1/2

= 0.50(p) and 0.50 (q) = 0.50/13.4 = 0.037

$$t = \frac{0.556 - 0.50}{0.037} = \frac{0.056}{0.037} = 1.51$$

## t-Test for Color Saturation

Response of Judges: Ektar = 126, Kodachrome = 54, Total = 180

A t of ±1.96 is required for significance at the five percent level.

**t** = observed proportion-theoretical proportion/SE proportion

Observed proportion = 126/180 = 0.70

$$\sqrt{180} = 13.4$$

Theoretical proportion = 1/2

= 0.50 (p) and 0.50 (q) = 0.50/13.4 = 0.037

$$t = \frac{0.70 - 0.50}{0.037} = \frac{0.20}{0.037} = 5.40$$

## t-Test for Tone Reproduction

Response of Judges: Ektar = 85, Kodachrome = 95, Total = 180

A **t** of ±1.96 is required for significance at the five percent level.

**t** = observed proportion - theoretical proportion/SE proportion

Observed proportion = 95/180 = 0.528

$$\sqrt{180} = 13.4$$

Theoretical proportion = 1/2

= 0.50 (p) and 0.50 (q) = 0.050/13.4 = 0.037

$$t = \frac{0.528 - 0.50}{0.037} = \frac{0.028}{0.037} = .757$$

**Figure 1**

Proof #1, Kodachrome

**Figure 2**

Proof #2, Ektar

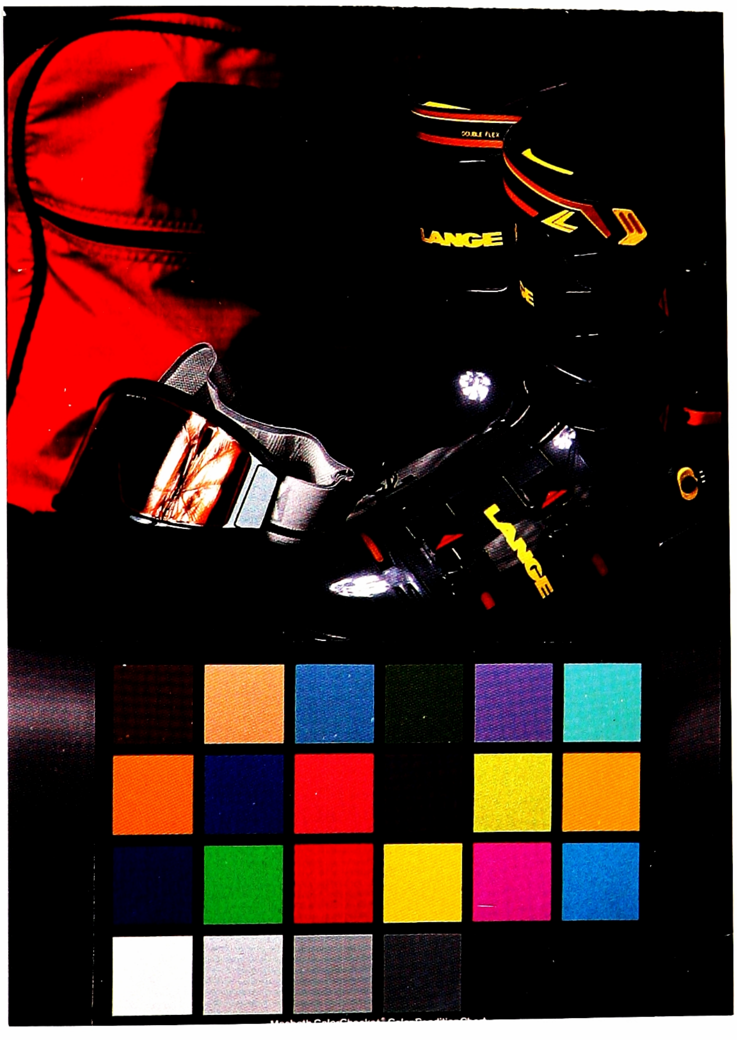

**Figure 3**

Proof #3, Kodachrome

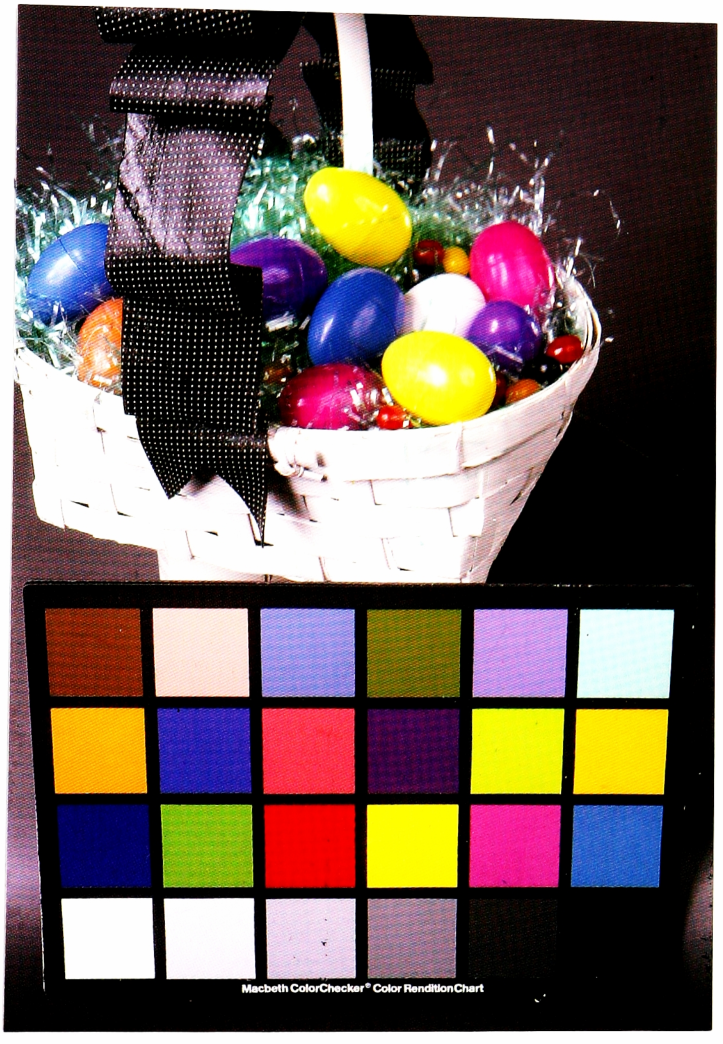

**Figure 4**

Proof #4, Ektar

**Figure 5**

Proof #5, Kodachrome

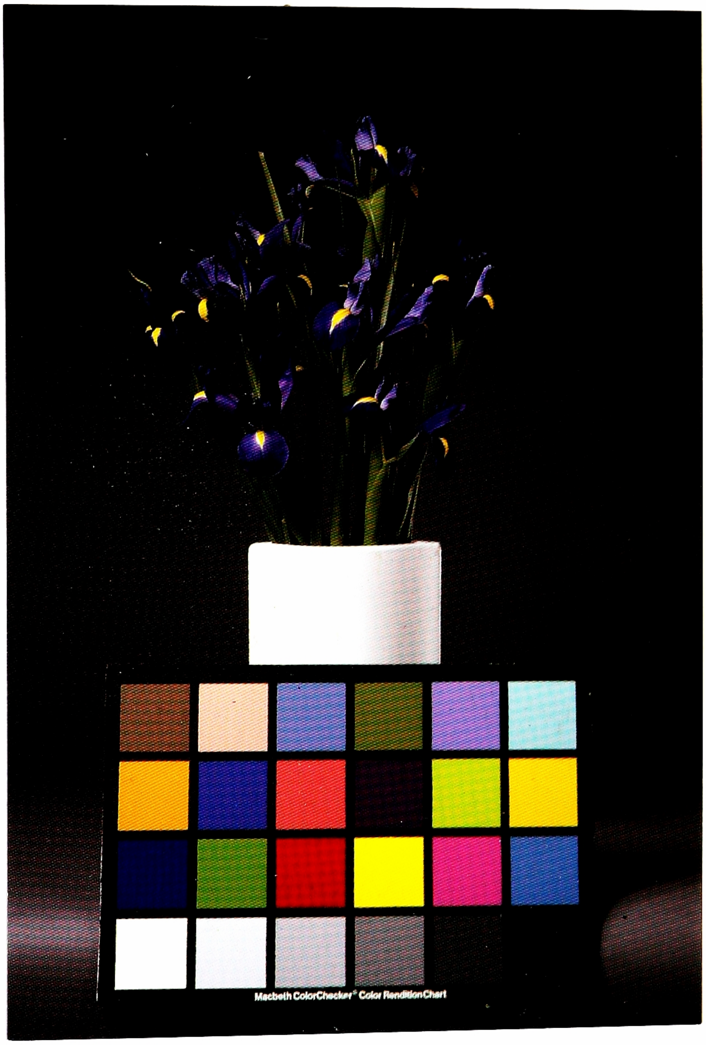

**Figure 6**

Proof #6, Ektar

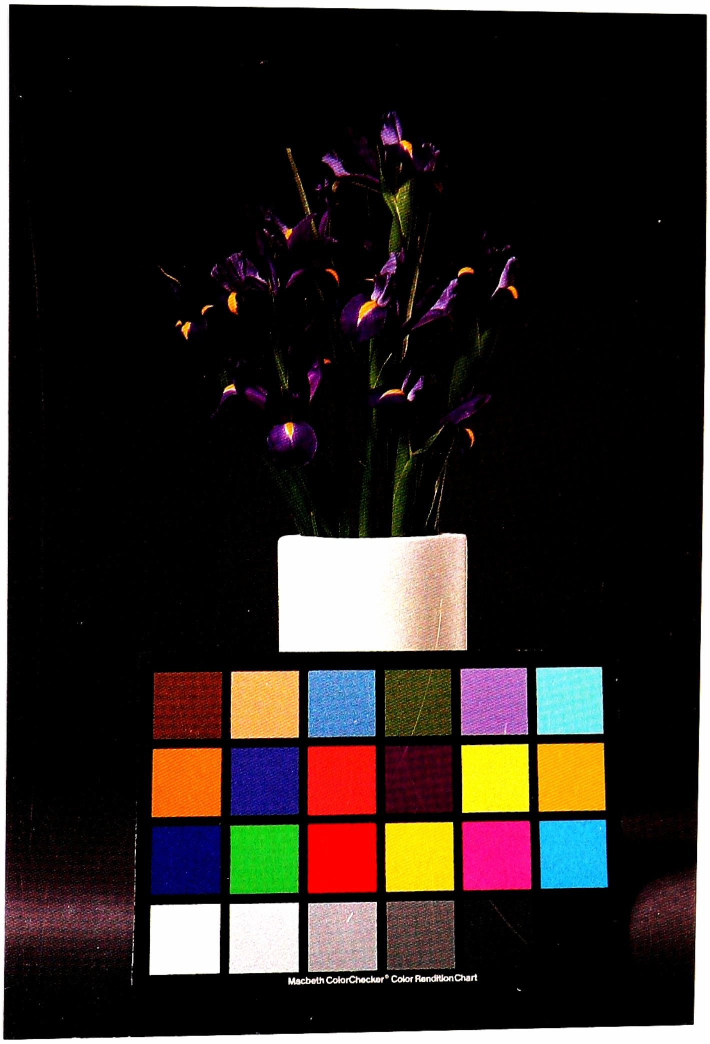

**Figure 7**

Proof #7, Kodachrome

**Figure 8**

Proof #8, Ektar

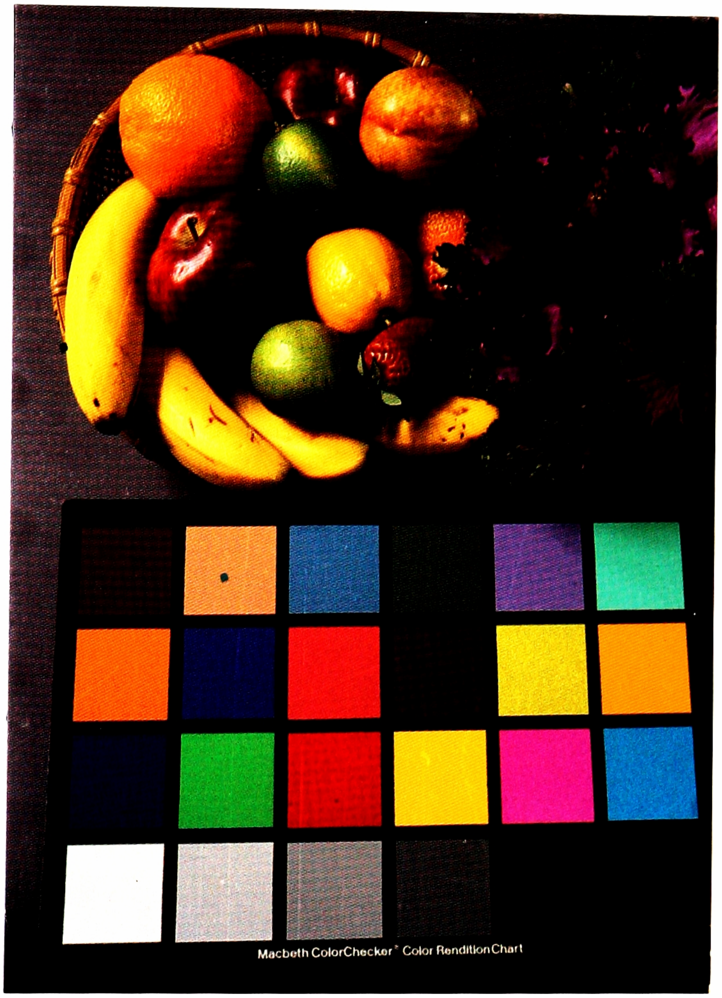

**Figure 9**

Proof #9, Kodachrome

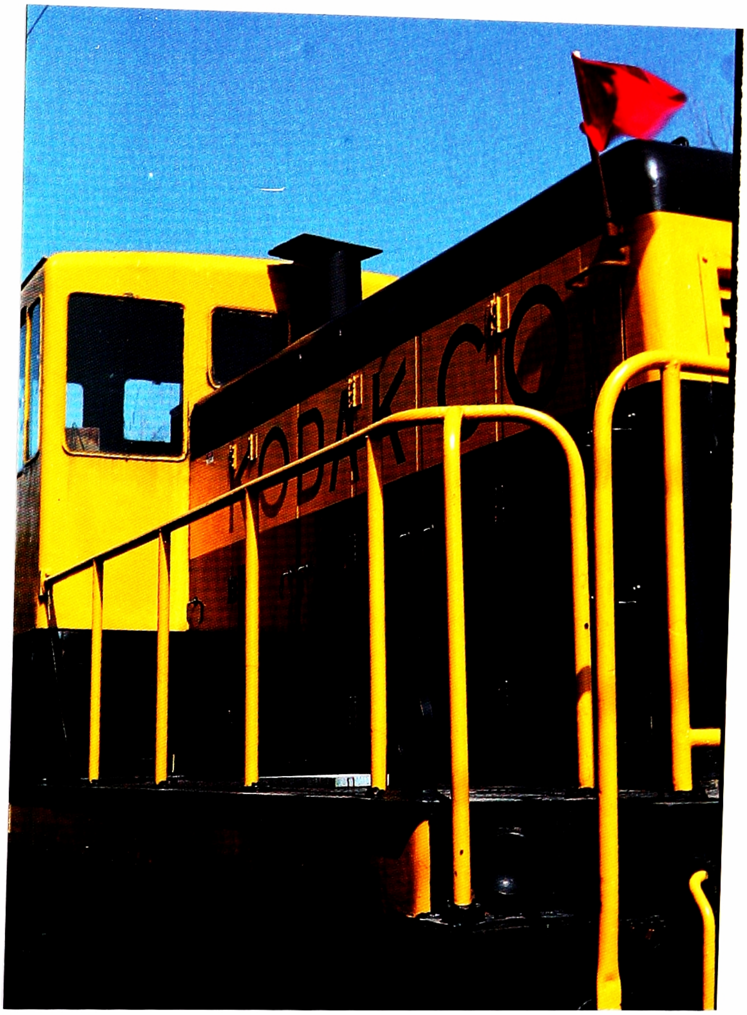

**Figure 10**

Proof #10, Ektar

**Figure 11**

Proof #11, Kodachrome

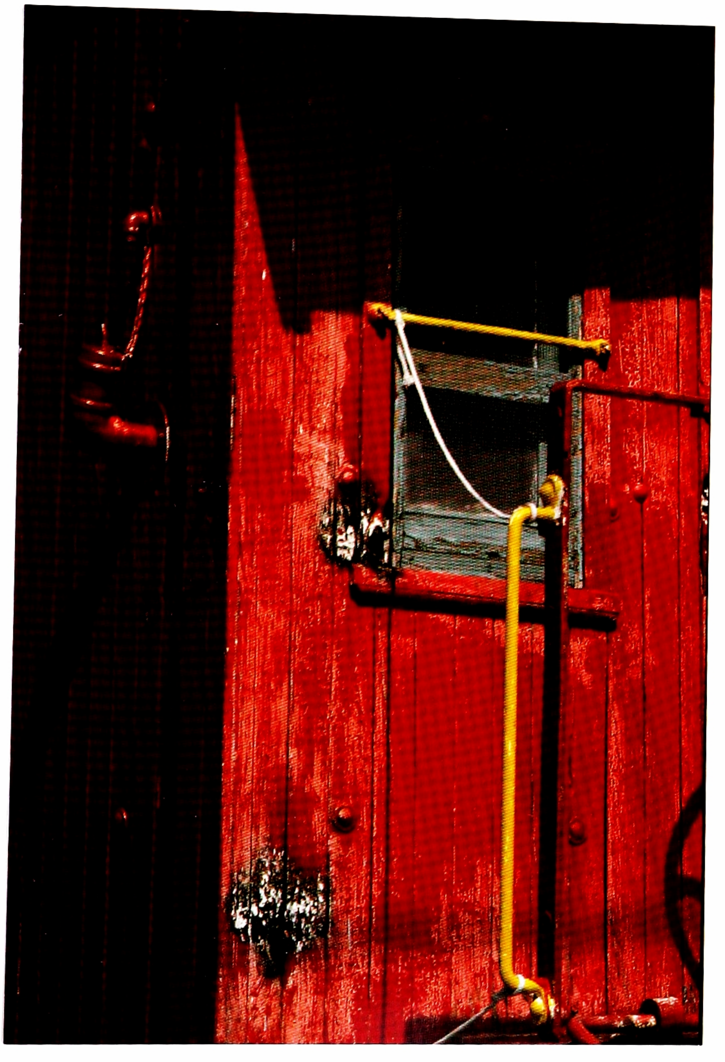

**Figure 12**

Proof #12, Ektar