13.3 Under Color Removal (UCR)

Under color removal is the balanced reduction of cyan, magenta, and yellow in shadow areas. The addition of black in these reduced areas maintains the dark and near neutral shadows. UCR, used in traditional offset separations, is not always best suited for the flexographic printing process. Ideally, if the amount of color in the three process colors could be reduced while maintaining the shape and shadow detail of the image in all three colors, this would be the best application of under color removal for the flexographic printing process. UCR is done at the input/scanning or color correction stage and is measured prior to applying a compensation curve. Contact the printer for guidance.

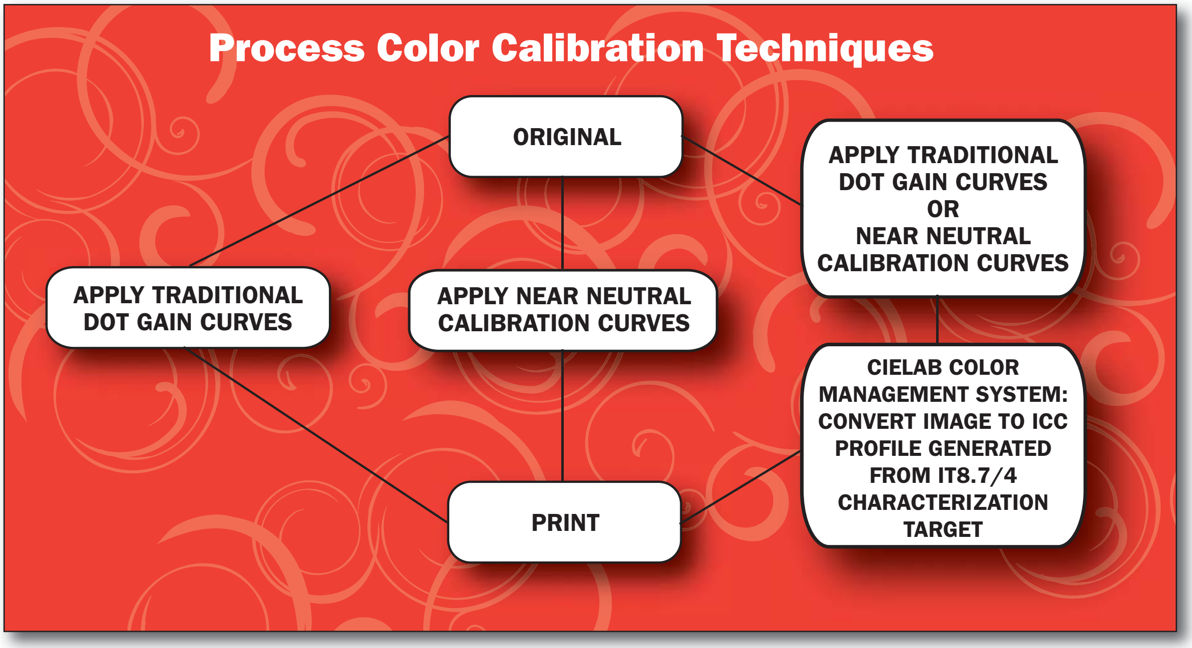
13.4 Gray Component Replacement (GCR)

Gray component replacement is more easily defined as an unwanted color (cyan in red or magenta in green) being replaced by black, in part or in whole, as the graying component. The use of GCR is the responsibility of the prepress provider and the printer. It is recommended that GCR be restricted to a single unwanted color under normal conditions in the flexographic process. Reviewing the job with the printer or customer prior to prepress will help determine the best approach. The prepress provider and the printer should reach a consensus on the amount (percent) of GCR used in an image. When the printer must print line black on the same station as the process black, GCR should not be used. It is better to have a short black for the separation (skeleton black) so that the printer has more latitude in setting impression.

14.0 PROCESS COLOR CALIBRATION

There are three basic methods used to optimize process color separations and achieve the best possible match. Regardless of the method used, the objective is the same – match the proof to the printed image. The three basic methods are:

1. Dot Gain Curves based on Tone Scales.
2. Tonal Curves based on Near Neutral Calibration.
3. CIELAB Color Management System.



14.1 Process Color Calibration Techniques

The following paragraphs provide a brief overview of the three main process color calibration techniques. Each technique is explained in more detail in Prepress Sections 14.2, 14.3 & 14.4.

1. **Dot Gain Curves based on Tone Scales (14.2)**

   This method applies dot gain curves to the image prior to platemaking. Tone scales are printed during the press fingerprint trial and measured to determine the dot gain experienced on press. The prepress provider places the dot gain values into the prepress workflow software and applies the resulting dot gain curves to the output file. Each color separation (CMYK) is treated independently. This method has been utilized by the industry for many years and is well understood. The shortcoming of this approach is that it does not consider gray balance, overprints, or differences in colorants & gamuts between the printing press and the proofing device.

2. **Tonal Curves based on Near Neutral Calibration (14.3)**

   Near neutral calibration is based on an optimized tonal curve, the Neutral Print Density Curve (NPDC), derived from 3/color overprints (CMY) instead of single color dot gain curves. Matching a common tonal curve derived from 3/color overprints corrects for dot gain, ink trap, and gray balance simultaneously. Therefore, NNC curves are used in place of single color dot gain curves. NNC does not correct for gamut or colorant differences. Some approaches to NNC, such as G7™, define the colorants using an international standard, such as ISO 12647-2. The primary advantage of NNC is improved color matches across presses and print methods.

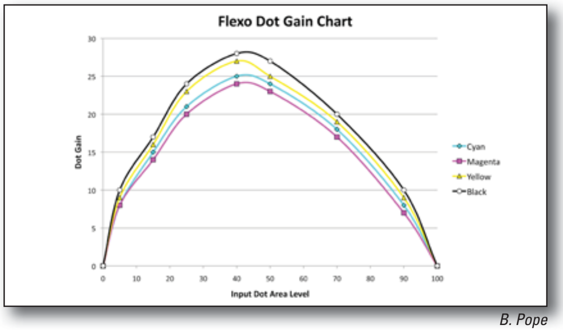
3. **CIELAB Color Management System, CMS (14.4)**

   The CIELAB CMS documents the colors that can be produced by a given printing system with an ICC profile. The ICC profile provides the information to determine what input is necessary to create a specific color on press. The CMS approach optimizes the ability to match proof-to-press and predict achievable results. This approach results in an ICC profile that represents how an output device (such as the press or proofer) renders color under a given set of conditions. The ICC profile is created by printing the IT8.7/4 target during the press characterization trial. Refer to Print Section 19.4 for more information. Each patch on the IT8.7/4 test target is measured and plotted in CIELAB color space to develop the ICC profile. The color management system is the most comprehensive of the three approaches; it addresses dot gain (TVI), colorant differences, and overprint characteristics.

14.2 Traditional Dot Gain Curves

A process color image consists of four separations printed on top of one another. In order to maximize the detail in the printed image, each separation (CMYK) must be optimized to achieve the full range of tones the printing process is capable of reproducing. Dot gain curves, derived from printed tone scales, represent the traditional method of optimizing each separation (CMYK).

The shortcoming of this approach is that it considers each separation (CMYK) independently. So while the dot gain experienced by each print deck is compensated for, gray balance, overprints, and color & gamut differences are not controlled. Along with traditional dot gain curves, the prepress provider may also use the traditional gray balance approach (identifying the best dot size of M & Y for a given cyan dot percentage) to achieve color balance within the image. Using the traditional method, it is more difficult and less efficient to accurately and consistently match a proof. Because the traditional approach does not consider and control for the actual color of the process inks (Lab/LCh), the results are usually inferior to the other two approaches, particularly when multiple print locations and/or presses are involved.



B. Pope

14.2: Dot Gain Curves: Dot gain curves are used to reduce the size of the dot in the file, and therefore on the plate, to compensate for the expected dot gain on press – as measured during the press fingerprint.

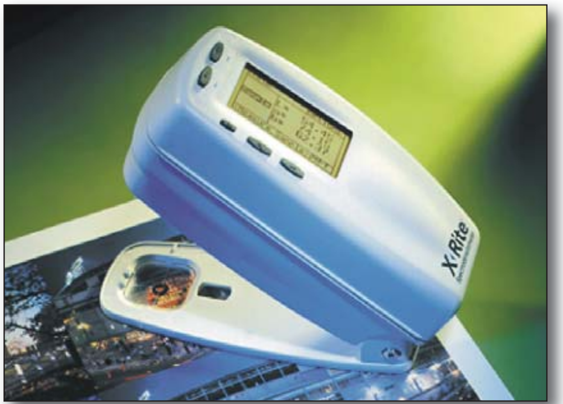
equations, and guidelines in CGATS.4 and CGATS.5. Some of these may be found in the Glossary of this document. Measurement conditions and characteristics measured should be reported in a certificate of analysis (CoA) to be included with the contract proof.

16.4.1 Densitometer Guidelines

Application: A reflection densitometer, or spectrodensitometer, is used to measure key print characteristics for process color images such as: density, dot area/dot gain, trap, print contrast and gray balance. These densitometric functions are critical for measuring and controlling the reproduction of continuous tone images. Using a densitometer improves the proofer's ability to consistently and accurately reproduce a continuous tone image. A densitometer is designed to be used only with the four traditional process inks (yellow, magenta, cyan and black). When using non-traditional colors for expanded gamut continuous tone images, the usefulness of the densitometric functions is limited because the filters and equations utilized by the instrument are specific to the traditional process colors.

Industry Standard: ANSI/CGATS.4-2006 *(2006 Graphic Technology – Graphic Arts Reflection Densitometry Measurements – Terminology, Equations, Image Elements, and Procedures)* is the standard used for the measurement of printed materials using a reflection densitometer. For additional information on densitometry, refer to "Introduction to Densitometry – Users Guide to Print Production Measurement Using Densitometry," published by IDEAlliance. IDEAlliance contact information is listed in the Appendix.

Measurement Variables: Key instrument variables must be properly set to produce meaningful measurements. These variables should be documented and communicated with all densitometric data.



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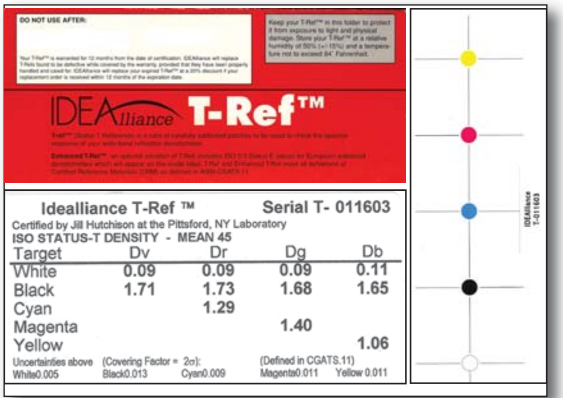
- **Densitometer/Spectrodensitometer:** manufacturer and model.
- **Spectral Response:** The density value obtained is a function of the spectral characteristics of both the ink being measured and the instrument spectral response setting. The values obtained with different response functions may be similar or significantly different, depending on the particular material being measured. Status T is the preferred spectral response in North America. It is defined to closely match the characteristics of graphic arts materials normally used in the United States, such as ink-on-paper printed materials, off-press proofs, and original art to be color separated. Status E is defined to closely match the characteristics of graphic arts materials normally used in Europe, such as ink-on-paper printed materials, off-press proofs, and original art.
- **Sample Backing:** Many flexographic substrates are translucent; consequently, the choice of backing material will greatly influence any color measurements. The best choice is to use a white backing material that is spectrally non-selective, diffuse-reflecting, and has a "L" value greater than 92.
- **Sampling Aperture:** While aperture sizes typically range from 2.0 – 6.0mm; 3.4mm is the standard aperture size. It is critical for each test element to be slightly larger than the instrument aperture for accurate measurement.
- **Calibration:** FIRST supports assigning one person responsible for daily calibration of all densitometers/spectrodensitometers in accordance with the manufacturer's recommended procedures. A reflective calibration standard



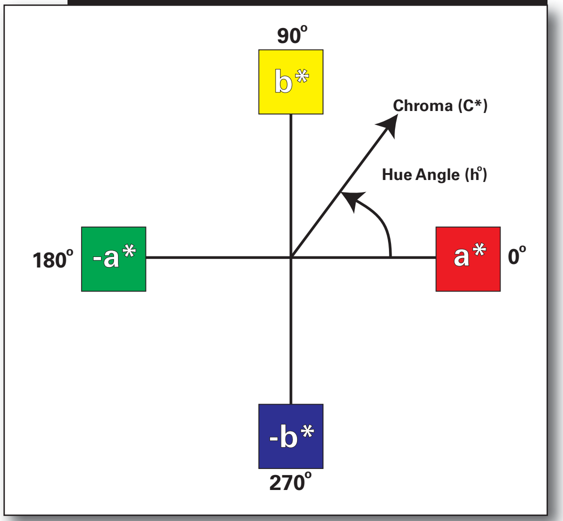
IDEAlliance

Colorimetric Parameters:

CIELAB L*a*b* and L*C*h° are the most common colorimetric parameters. L*a*b* describes the location of a color in CIELAB color space using the red/green and blue/yellow dimensions. L*C*h° is another method describing the location of a color in CIELAB color space, using the more native, or intuitive, language of lightness, chroma, and hue. Chroma and hue are mathematically derived from the *a and *b values.

- L = The lightness axis indicates how light or dark a color is. It moves from white (at the top) to black (at the bottom).
- a* = Describes the red/green dimension of a color. The more positive the a* value, the more red the color. The more negative the a* value, the more green the color.
- b* = Describes the yellow/blue dimension of a color. The more positive the b* value, the more yellow the color. The more negative the b* value, the more blue the color.
- C = Chroma describes the color saturation; how strong or weak a color is. The closer to the center of the circle, the more neutral the color. The closer to the edge of the circle, the more saturated the color.
- h° = The hue angle refers to the name of the color (red vs. blue) and identifies its position on the color wheel. Most hues have the greatest possible saturation at the mid-point of the lightness axis.

CIELAB COLOR SPACE COORDINATES



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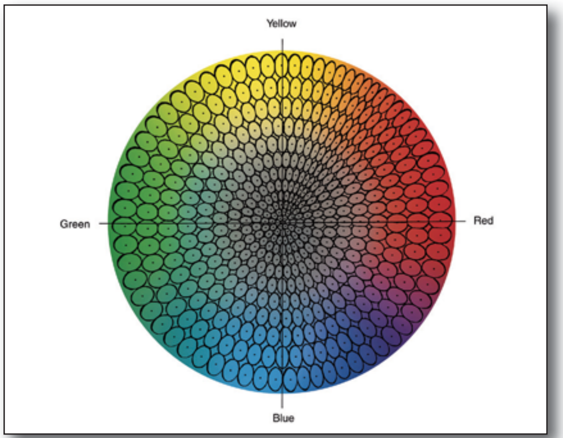

X-Rite

16.4.2a: Determining Acceptable Color Difference: The weighted color difference equations use slightly different mathematical formulas to calculate the shape of the acceptable color difference ellipse.

Color Tolerancing Method – Calculating DE:

Color tolerancing is used to determine if a "sample" color, compared to a "reference" color, is acceptable. The accuracy of the color match is typically expressed as Delta E (ΔE or DE). The DE value represents the overall color difference and is derived from one of several equations. All color difference equations compare the location of a "reference" color to the "sample" color in CIELAB color space; however, CIELAB color space is not uniform. For example, shifts in hue are typically more easily perceived than shifts in lightness or chroma.

Color difference equations are either weighted or unweighted.

Unweighted color difference equations, such as CIE 1976 (DE_{ab}), weight hue, chroma and lightness equally. Equal weighting does not correspond well with human perception of color differences; therefore, a sample may visually match the reference color but produce an unacceptable DE value or vice versa.

Weighted color difference equations, such as DE_{CMC}, DE_{CIE94}, and DE_{2000}, achieve better agreement with human perception by weighting hue, chroma, and lightness differently. The formula used to weight the three-color axis is slightly different for each weighted color difference equation.

The CMC tolerancing method includes three weighting factors set by the user, expressed as (l:c:cf), where: l=lightness, c=chroma, and cf=commercial factor, or DE. The CMC ratio l:c (lightness:chroma) determines the shape of the ellipsoid, which is typically set at 2:1 for most applications; however, an l:c ratio of 1:1 is becoming more common. The cf (commercial factor) determines the overall size of the ellipsoid and the threshold, or tolerance, of acceptable color difference. The cf determines the DE limit, for example, if the cf = 1.5, then the acceptable DE = 1.5 as well.

17.9 Printing Plate Measurement and Control

Table 17.9a

Printing Plate Measurement & Control	
Properties to Measure	*Measurement Device/Tool*
Durometer	Shore A Gauge
	Only for material < 0.250″ (6.35mm)
Thickness Uniformity	Plate Micrometer
Plate Relief	Plate Micrometer
Halftone Dot Size	Flexo Plate Analyzer, Microscope
Bulb Output	Radiometer
Line Width	Microscope

M. Mazur, E.I. du Pont de Nemours & Co.

17.9a: Plate Durometer: A Shore A gauge is used to measure plate hardness, or durometer.

Shore A Gauge

Measure the durometer, or hardness, of polymer materials, such as flexographic printing plates with a Shore A gauge. Test the calibration of the Shore A gauge using the test block supplied with the instrument. The test block is matched with the serial number of each instrument and is stamped with a durometer reading for calibration. When properly calibrated, the instrument should read within plus or minus one point of the number stamped on the test block.

When using the Shore A gauge, a minimum area of 2″ x 2″ (50 mm x 50 mm) is required to get an accurate reading. Multiple measurements should be taken. The ASTM standard for measuring Shore A requires a plate caliper of 0.250″ (6.4mm). The durometer for thinner plates may still be measured; be sure to indicate the plate thickness actually measured. Readings are only taken in the solid area of the plate. Do not take readings on process areas of the plate due to distortion of the plate material.

Plate Micrometer

Measure the thickness uniformity and relief of flexographic printing plates with a plate micrometer (either analog or digital readings). Calibrate the instrument using a precision machine block inserted between the surfaces. Accuracy of calibration should be within ±0.0005″ (0.013 mm) of the calibration block.

When measuring caliper and relief with the plate micrometer, the test area should be at least 1″ x 1″ (25 mm x 25 mm). Take multiple measurements across the plate to determine the uniformity of plate thickness. Digital plate micrometers equipped with a printer can output

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17.9b: Plate Micrometer: Plates should be inspected and measured with a micrometer. Gauge readings should be marked on the plates for use during plate mounting.

statistical data of the plate measurements. To confirm the plates comply with certification requirements, the printer should verify the data.

When measuring the plate uniformity both within a plate and from color-to-color, both solids and screened areas should be measured. Excessive variation may indicate inadequate drying. Refer to the specific plate material specifications, listed in Prepress Sections 17.3 – 17.8, for thickness uniformity guidelines.

Flexographic Plate Analyzer

The flexographic plate analyzer measures halftone dot size. A high-resolution video camera allows for precise measurement; it can read halftones regardless of the contrast, color, or graining of the image. Excellent correlation is possible with conventional densitometers when measuring film-to-plate. Stochastic or FM screen images can also be verified for quality. Multiple measurements should be taken to determine the repeatability of the measurements, especially with highlight dots.

Microscope

A microscope, or 100x magnifier with a scale, can be used to inspect images. Halftone dot size, rule widths, and plate relief can be measured.

Exposure Guide

- **Radiometers:** Exposure is the most important step in platemaking because it is the image formation step. Exposure bulbs degrade over time and should be monitored using a radiometer to ensure consistent image formation. Radiometers are available which can measure UVA bulbs (exposure and post exposure) as well as UVC bulbs (light finishing). When exposures are established, bulb output (irradiance) should be measured and documented. As bulb output declines, exposure times must be increased to ensure consistent energy is delivered to the plate. The adjustment to exposure can be calculated using the equation:

  Energy (millijoules/cm2) = Irradiance (milliwatts/cm2) x Time (seconds)

  For example: Main exposure was originally established to be 600 seconds at a bulb irradiance of 20 milliwatts/cm2. So the total energy required is 20 x 600 = 12,000mJ/cm2. One month later, the bulb irradiance was measured at 18 mW/cm2. To ensure the same energy is delivered to the plate, the exposure time needs to be increased to 667 seconds (12,000mJ/cm2 ÷ 18mW/cm2).

- **Control Targets:** During the main exposure process, the control target is imaged within each plate. The control target is used as the exposure guide; it contains positive line and halftone scales. The line screen value of the control target should correspond with the line screen value of the image.

M. Beuscher

17.9c: Flexo Plate Analyzer measures halftone dot size on the finished plate.

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17.9d: Microscope: Dot size, rule widths and plate relief can be measured on the finished plate using a microscope.