

# ***QUALITY CONTROL IN THE PRINTING INDUSTRY***



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## **INTRODUCTION**

Quality control is more and more, assuming a greater importance in the printing industry.

That is because of a lot of causes:

- **Competition**, incitement to the continuous improvement given by comparison with markets firmly built on the controlling techniques.
- **ISO 9000 Certification of Product or System**, for which measurements and statistics are necessary elements.
- **The highest degree of reached automation** in all stages of process that impose the rationalization and optimization of proceeding coherently with the nowadays available technology.
- **The introduction of realization highly stretched to increase the qualitative standard** (a good example are the stochastic screens) so it is necessary to monitor correctly and accurately the production cycle.
- **The difficult economic situation and the small economic grow** induce to presume that only the most attentive and prepared ones will resist.

To do this competence and perseverance in the valuation of printed are necessary.

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## ***VISUAL VALUATION OF PRINTED is very important.***

- 1 It takes into account of a great quantity of elements at the same time (register, color, distortion elements, ex.).
- 2 It is also extremely sensitive to minimum chromatic and tonal variation.
- 3 It values immediately the most important print characteristics: evident out register and frequent "uncleans" give an unacceptable reproduction.
- 4 The customer judges the print prevalently with visual standard.

*If so, what is the densitometer used for?*

The densitometer is very useful. **If you can measure** ink, densities, Dot Gain, Trapping, Print Contrast, **you can control them.**

## ***INSTRUMENTAL VALUATION using a densitometer***

- 1 Our eyes even when "good" are different; everyone sees the colors in its own way, they cannot be standardized or calibrated like the densitometer.
- 2 The eye is influenced by a bright source present in the observation place (more hot, more cold): this is the phenomenon of metamerism. The densitometer has a standard light built in and it is not effected by this problem.
- 3 We know if a print is "too much yellow", but we don't succeed in quantifying it numerically. Densitometry gives us *values* to standardize our production, to uncover when there are some problems or where they come from (if by print or photolithography), to dispose irrefutable subjects when the customer is not totally satisfied of the final result.
- 4 The man has not its own *memory of color* as the densitometer: it is possible, instead of recording information, to file and use it again after a long time, if it is useful (let's think the reprinting).

### **Summarizing:**

it is not enough to value a print in a visual way only or utilizing exclusively densitometric techniques.

A good judgment of the level of print quality can be only *the result of matching these two experiences.*

## ***PRINT CONTROL STRIPS***

Since a finished printed image generally consists of the overprint of the four halftone screens, it is very difficult to isolate each of the various components affecting the reproduction of the original image.

To overcome this problem, a series of test elements can be printed along with the image, and each element can be designed to highlight a particular aspect of the printing process. While some of these test targets can be evaluated by eye, others require the use of a densitometer.

The usual form of these test elements is a strip across the edge of the press sheet, although in boxboard and label work these elements may be interspersed with the images. These test strips, called **print control strips** or **color bars**, are available commercially from FOGRA, BRUNNER, etc. and consist of strips of film containing the various test elements for each of the four colors. In some cases six color versions are available when special colors might be used.

The usual densitometric targets in a color bar are: Solid Ink Density, Dot Area/Gain of the quarter, half and three-quarter tints, Contrast and the Trapping of ink overprints.

## ***POLARIZATION FILTER***

A densitometer with polarization filter gives less difference between a wet and a dried-back printed sheet: in fact the polarization filter removes the surface reflections due to the wet film of ink just applied to paper.

## **THE 5 PARAMETERS OF DENSITOMETRY VALUATION**

### **1 - Density**

***Absolute density** is the measured density of the ink sample including the substrate or base, while **relative density** is the density of the ink sample minus the density of the substrate.*

### **2 - Chromatic Balance (gray balance)**

*It typifies the color balance of the job for the combination of press, paper and ink being used.*

### **3 - Dot Gain**

*It monitors the way the dot is reproduced. As the image progresses through the reproduction process from film to plate, plate to blanket and finally blanket to paper, the size of the dot changes.*

### **4 - Print Contrast**

*It is a measure of the ability of the printing process to hold shadow detail.*

### **5 - Trapping**

*It is a measure of how well the inks are adhering to each other.*

## 1-DENSITY

### *Description*



*Full (Solid)*



*Screen (Tint)*

It is the capacity of a printed color to absorb light (opacity) and therefore not to reflect it, expressed in a logarithm way (at basis 10) to conform it at the discerning rule of the human eye.



*The specification* The standardization of solid. Density values.

The average among the present rules on market (FIPP, BVD/FOGRA, ex.):

$$1,45 \pm 0,10 \text{ C-M-Y}$$

$$1,90 \pm 0,20 \text{ B}$$

for paper and coated cardboard.

### *The advice*

The greater assurance of tint density measure: - small variation - more visual sensitivity.

*DR 101*  
*DR 848*

a) The visualization of 4 colors at the same time on the display is a big advantage.

D	C 1.46	M 1.44
	Y 1.3	B 1.73

b) Two memories (REF) to store standard information (e.g.: REF1 density of solids and REF2 the tint density) in order to proceed directly by comparison easily translatable to input for the printing unit.

D-R1	C .06	M .04
	Y .12	B .04



## 2-CHROMATIC BALANCE (gray balance)

*Description* It is the balance test among Cyan, Magenta and Yellow placed upon a patch only. In fact if the ratios are correct, the good color balance should give a neutral gray visual control deprived of a predominance.

<u>GAFT</u>	<u>BRUNNER</u>
40% Cyan	50% Cyan
30% Yellow	41% Yellow
30% Magenta	41 % Magenta

*The specification* Density of C-M-Y equals, or:  
Y = at maximum + 0,05  
M = base value  
C = at minimum – 0,05

*The advice* Visual judgment: Brunner (e.g.) lays the patch flanked to a black at 50%. Densitometric judgment: it can be the position where to effect a control of fast proof, executed with a measurement only while the printing unit runs and without wasting of time.

*DR 101*  
*DR 848* a) The three colors appear at the same time on the display and the operator has not to select them one by one.

GB	C .47	M .52
	Y .54	B .53

b) Two memories (REF) can be used to store: the over indicated specification (REF1); the values of the sheet "OK print" (REF2).

It is important to point out that with a measurement only it is possible to control many parameters and to obtain immediately possible discordances ascribed to values of specification or of the sheet "OK print".

GB-R1	C .03	M .03
	Y .04	B .03

c) It is important to offer this mode of measurement separated from that of density.

### 3-DOT GAIN

*Description*



*Screened Area (Dr)*



*Solid Area (Ds)*

The apparent Dot Area according to Murray- Davies:  
 $- Dt$

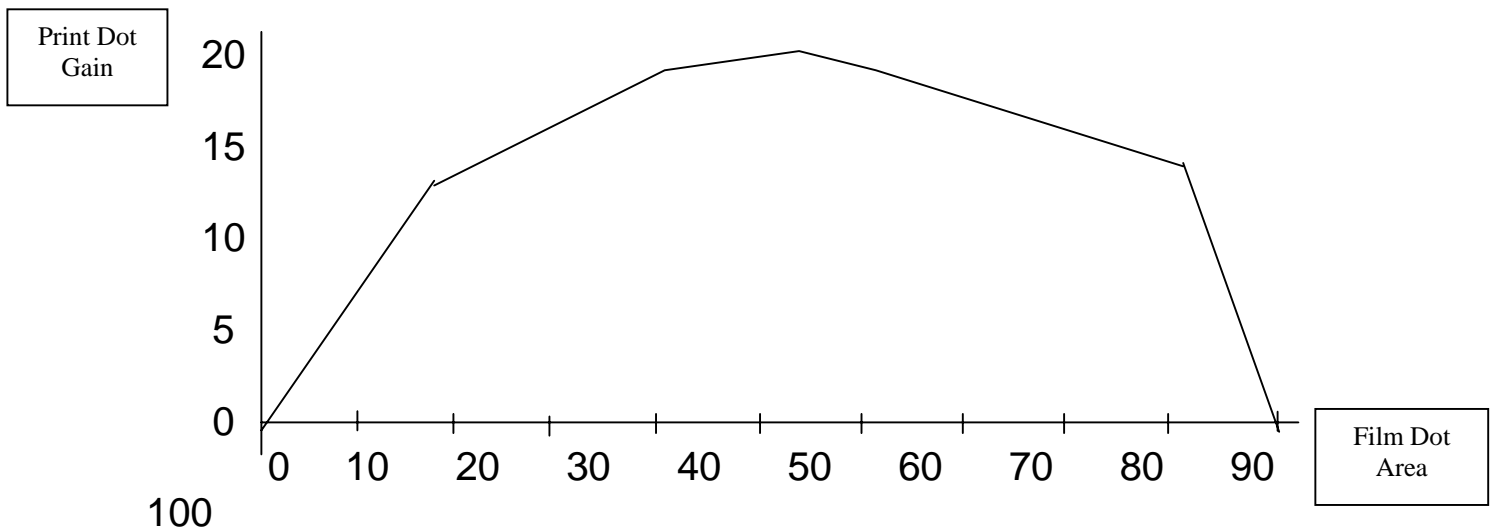
$$\text{Apparent Dot Area \%} = \frac{1 - 10^{-Dt}}{1 - 10^{-Ds}} \times 100$$

Where:  $Dt$  = tint density  
 $Ds$  = solid density

Dot gain according to Murray-Davies:

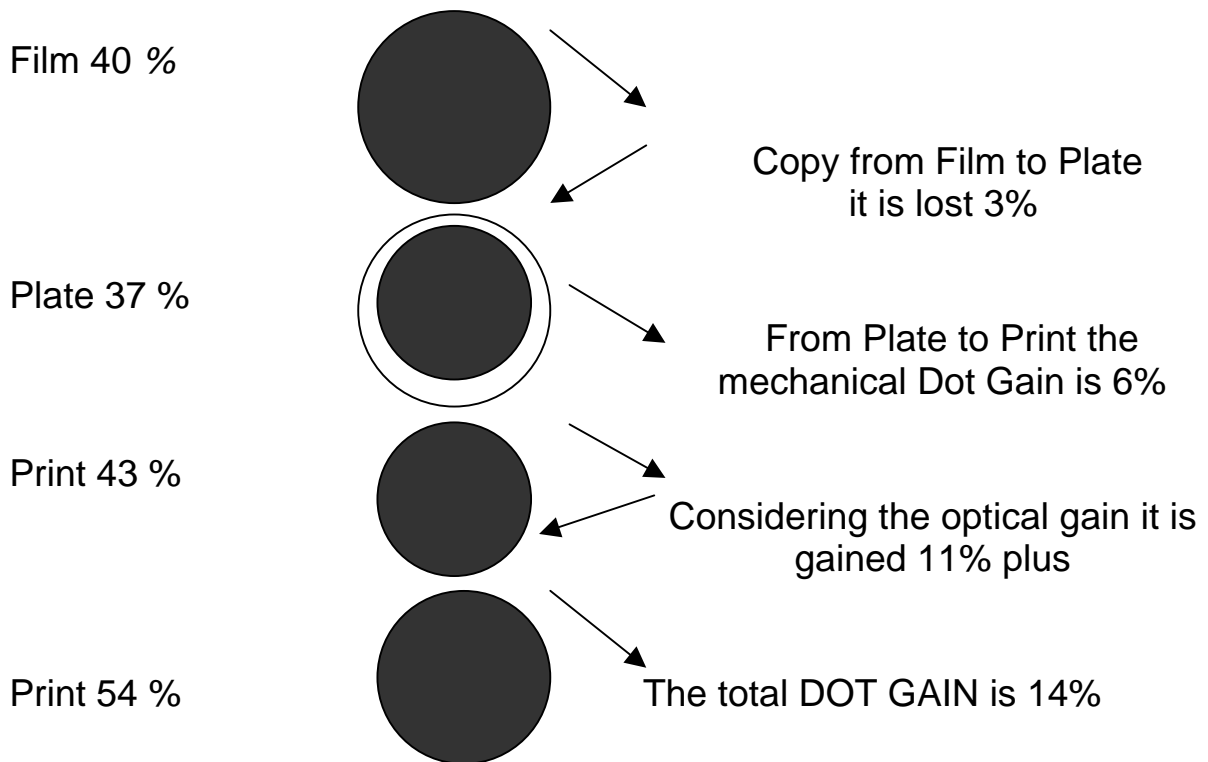
$$\text{DOT GAIN} = \text{Apparent Dot Area} - \% \text{ Film}$$

Indicative characteristic curve % Film



The Dot Gain measured by the densitometer includes both mechanical Dot Gain grow of the physical halftone dot and an optical gain (how the

dot appears to the human eye, due to the refraction of the light on the substrate):



*The specification*

As guideline only, the following are typical values for Dot Gain:

- 15 ± 2 for C-M-Y
- 18 ± 2 for B

for paper and coated cardboards. It isn't very important always to achieve a minimum or lower dot gain, but to assure that it remains steady and constant among different works and above all inside the same impressions.

*The advice*

Plot the characteristic curve of each print element in order to have a technical map for each machine, knowing what it is possible to expect as qualitative yield and having information as input for pre-press as a direction on the selecting curve.

DR 101  
DR 848

a) There is a remarkable possibility to obtain the three dot gain in comparison to 25%, 50%, 75% (Brunner) starting from a measurement only of common solid and having all information on the display; this process restores immediately the characteristic curve.

%-R1	Cyan	1.37
------	------	------

9%	15%	10%
----	-----	-----

b) It is a great convenience to profit the two memories in order to store the parameters of two different philosophies of measurement. It is possible to treat fast any control strip without replacing reference information in the densitometer (e.g.: test print with Fogra's scale and firm system based on Brunner).

## 4- PRINT CONTRAST (K)

*Description*



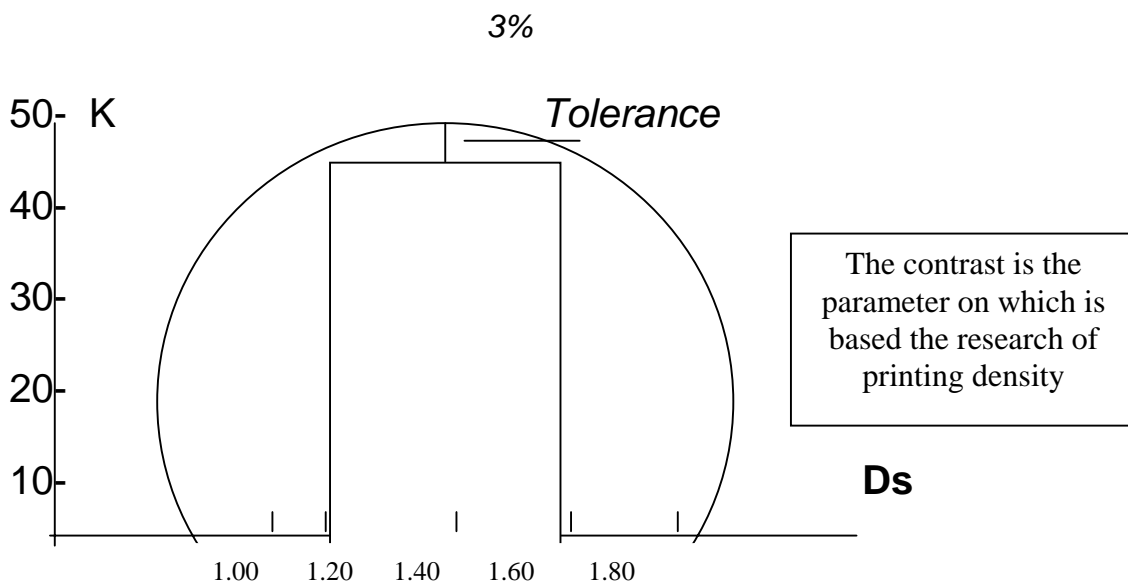
Screened Area ( $D_{75}$ )  
75% - 80%



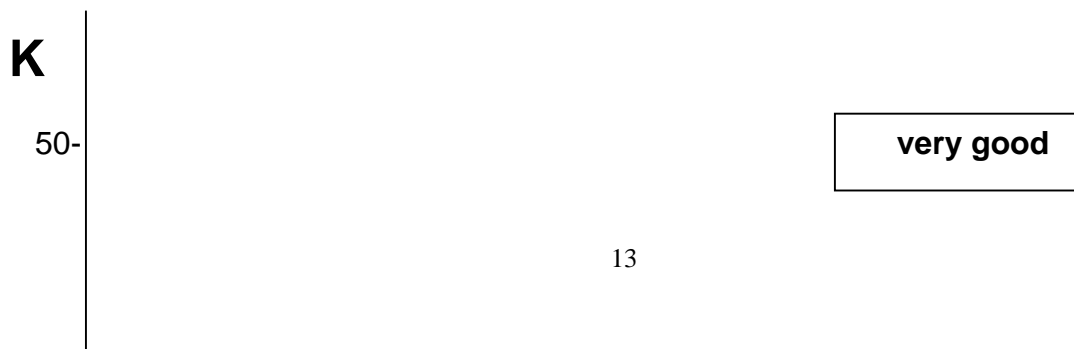
Solid Area ( $D_s$ )

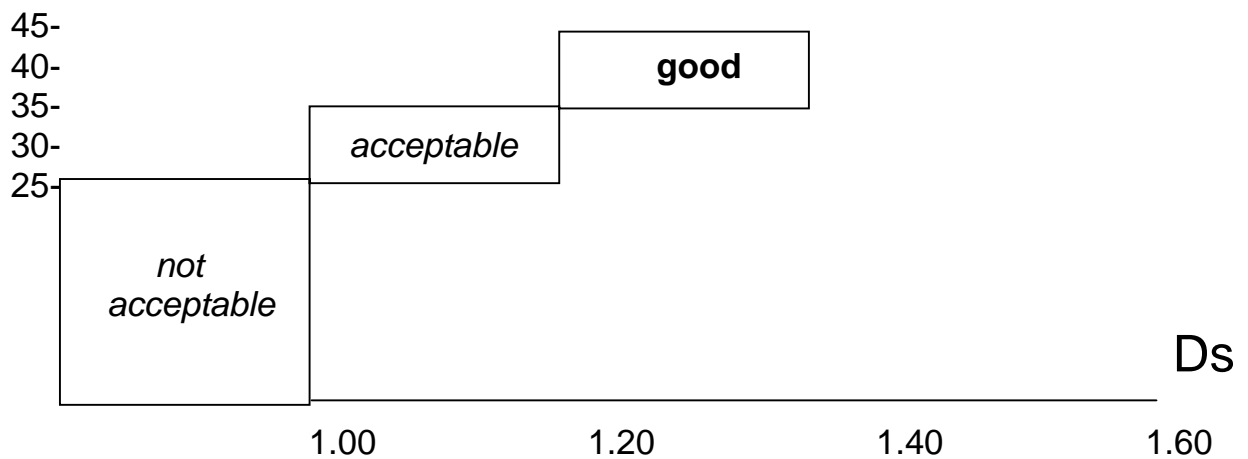
Shinner e Renzer' s experience

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



The print contrast is inversely proportional to the gain. The increasing of contrast increases also the print quality.





*The specification* The reference is the plot just reported.

*The advice*

To the most elevated contrast values correspond the best inking of that printing group. The contrast is starting point to extend the standardization to the other parameters: it is from the paper with the best contrast that we take the standard information about density, dot gain and best trapping for each printing element. It is much better that every firm finds his own values, instead of starting from the international standard.

*DR848*

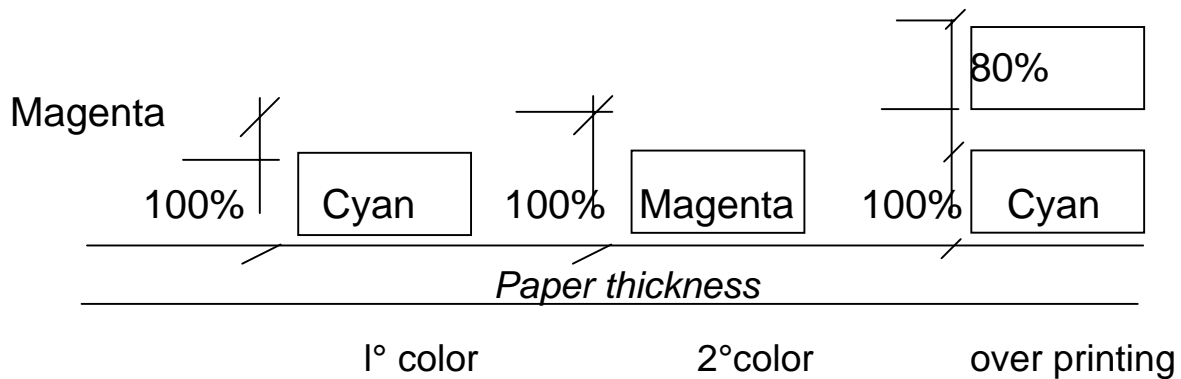
a) The densitometer is "intelligent": the operator measure first the solid and then the screen or vice versa, *DR848* always puts in order information automatically and gives the same result.

b) The display shows the value of the two densities and furthermore the calculated contrast: you have not to select density mode to register value.

%-R1	CYAN	50
1 C	1.38	2 C .69

## 5-TRAPPING

### *Description*



It is the ability of the first ink down to accept the next ink and of the second printed ink to be overprinted to the first down.

Clearly it is better in the case of an overprint "humid over dry" instead of "humid over humid".

The usual printing sequence is: Cyan-Magenta-Yellow with Black printed either first or last.

Green:      Ability of Yellow to overprint on Cyan.  
                  Ability of Cyan to accept the Yellow.

Red:         Ability of Yellow to overprint on Magenta.  
                  Ability of Magenta to accept the Yellow.

Blue:        Ability of Magenta to overprint on Cyan.  
                  Ability of Cyan to accept the Magenta.

The Preucil's Equation

$$\% \text{ Apparent Trap} = \frac{(DOP - D1)}{D2} \times 100$$

Where:

DOP= density of the 2-colors overprint

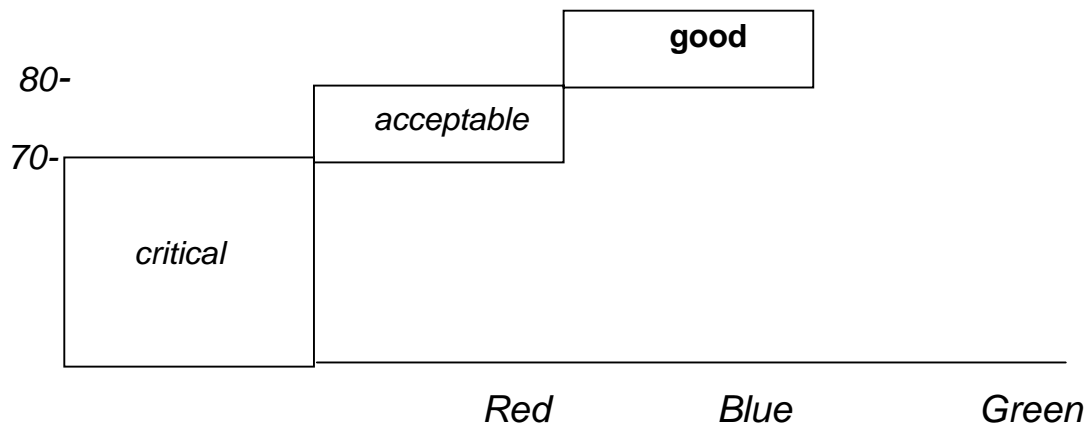
D1 = density of first down ink

D2 = density of second down ink.

N.B. The filter used to take these readings is always that of the second down color.

— Trap  
 90—

excellent



*The specification* For a print sequence Cyan-Magenta-Yellow good trapping values should be:

Red 70%      Green 80%      Blue 75%.

*The advice* The print sequence Cyan-Magenta-Yellow is the best because, even at lower values of trapping, it gives pleasant reds, greens and blues. When working with screened colors and solid in full area, using a multicolor press, it is preferred to print the screens among the first groups and the solids among the last in order to improve ink adhering to each other.

*DR 848*

a) It makes the process easier showing step by step which patch to measure and informing constantly the operator on what he has to do.

b) The densitometer does not need to be selected on the filter corresponding to the second printed color to effect a right measurement but it does the operation automatically.

T	TRAP	C+Y
	78	

To effect affordable valuation in pressroom it is necessary to have



## **THE WHOLE COLOR REPRODUCTION PROCESS UNDER CONTROL**

First of all it is necessary to standardize the top in order not to nullify all efforts that are done at the bottom, that is in the printing.

Color measurement and control stages in the graphic art workflow

Client → Graphic Design → Prepress → Printing → Client  
are:

**\*PRINT SHAPE**

**\*PROOF SHEET**

**\*FINAL FILM**

## **PRINT SHAPE**

<i>Description</i>	It reproduces tonal values of film introducing a more or less light dot loss, depending on exposition which it has been submitted to.
<i>The specification</i>	Minimum dot reproduced: 2%. Maximum dot reproduced: 99%. Micro circles resolution: 12 Micron (10-15). Continue tone: Fourth step lightly veiled. Dot loss: 2,5%+/-1 pointed out at 40% or 50%. (All that using an Ugra Pcw scale).
<i>The advice</i>	It is not necessary to pose the Ugra's scale over all the plates, it is enough to do it 2/3 times at a day (it is always necessary when we are modifying any variable), the control of each shape will be treated through micro lines field existing in any scale of print.
<i>DR 101</i> <i>DR 848</i>	They can measure also on the offset printing plates but with relative reliability because of graphisms-bottom and of superficial irregularities given by graining. CO.FO.ME.GRA. manufactures a dedicated densitometer to control offset plates. This new densitometer DFP402 measures film dot area in transmission and plate dot area in reflection on offset plates regardless of color, contrast or graining. Two decimals display precision with high reliability.

## **PROOF SHEET**

### *Description*

It reproduces the final chromatic result we have obtained. We speak of contractual test when it has been signed ("Ok print") by the customer as acceptance and indication of what he wants.

It is possible to divide them in **analogical** and **digital**. The analogical ones are printed reproduction by press, chemical tests, (Cromalin-Matchprint). The digital ones are of different kind: ink jet, sublimation thermic, electrostatic toner, colored emulsion and they can be with or without generation of dot. But only machine proof sheet or proof press are totally reliable in measuring.

### *The specification*

The same values, the same analyzed parameter for print are valid also for the proof sheet.

### *The advice*

Treat the starting first on the ground of own standard and after comparison with a test.

To operate therefore shifts to test direction, but without leaving too far from specifications to pursue it, otherwise that could damage the possibility to obtain a constant print without tonal fluctuation.

### *DR 101*

a) Density value, balance, dot gain of trusted test *DR 848* be registered in memories (REF) of the densitometer, allowing an immediate control of the possible discordance.

b) Having memorized inside Fogra and Brunner's references, the comparison with any other test adopted from your firm, results simple and fast without the need of memorizing every time different reference information in order to make the measurements.

## **THE FINAL FILM**

*Description* The final films are for to the pressman, the originals to be reproduced.

*The specification*

- a) The films for printing have to be the same used for the proof sheet.
- b) The bottom of the film has to have a density less than 0,05 and a highest density over 3,00.
- c) The percentage of the coverage on the linear scale has to correspond exactly to the declared one.
- d) Screen angulations: 30 degrees among Cyan, Magenta and Black, 15 degrees for the Yellow in comparison to one of the other color.

*The advice*

Ask for the pre-press to use a linear scale on the job and control periodically density and percentage of reproduction on the film. The percentage control is also useful to establish the wear of the control scales and to decide if a replacement is needed.

*DR848*

It should now be clear that we have to control the whole reproduction process films, plates and print. The DR 848 densitometer is the only one in the market measuring color in reflection and in transmission on your light table.

## TYPICAL VALUES IN OFFSET PRESS

### “DR 101” and “DR 848” DENSITOMETERS WITH NARROW BAND DIN FILTERS AND POLARIZATION FILTER

COLOUR	TYPES OF PAPER	SOLID DENSITY	DOT GAIN <i>Brunner Bar</i>		DOT GAIN <i>Fogra Bar</i>	
			50%	75%	40%	80%
CYAN	HAND USE	1.20 ± 0.05	16 ± 4	16 ± 3	20 ± 4	15 ± 3
	OPAQUE COATED	1.35 ± 0.05	12 ± 3	12 ± 3	16 ± 3	11 ± 2
	GLOSSY COATED	1.45 ± 0.05	10 ± 2	10 ± 3	14 ± 3	9 ± 2
MAGENTA	HAND USE	1.15 ± 0.05	20 ± 4	16 ± 3	20 ± 4	15 ± 3
	OPAQUE COATED	1.30 ± 0.05	12 ± 3	12 ± 3	16 ± 3	11 ± 2
	GLOSSY COATED	1.40 ± 0.05	10 ± 2	10 ± 3	14 ± 3	9 ± 2
YELLOW	HAND USE	1.10 ± 0.05	16 ± 4	16 ± 3	20 ± 4	15 ± 3
	OPAQUE COATED	1.25 ± 0.05	12 ± 3	12 ± 3	16 ± 3	11 ± 2
	GLOSSY COATED	1.35 ± 0.05	10 ± 2	10 ± 3	14 ± 3	9 ± 2
BLACK	HAND USE	1.60 ± 0.10	17 ± 5	16 ± 3	20 ± 4	15 ± 3
	OPAQUE COATED	1.75 ± 0.10	13 ± 3	13 ± 3	18 ± 3	12 ± 2
	GLOSSY COATED	1.80 ± 0.10	12 ± 2	11 ± 3	16 ± 3	10 ± 2

#### TRAPPING

*Is an indication of ability, or inability of a printed ink to accept the next ink printed compared to how well paper accept that ink*

VALUE	1 OR 2 COLOURS PRESSES	4 COLOURS PRESSES
95% ± 100%	VERY GOOD	UNREACHABLE
85% ± 95%	GOOD	VERY GOOD
75% ± 85%	STANDARD	GOOD
70% ± 75%	ACCEPTABLE	STANDARD
65% ± 70%	POOR	ACCEPTABLE
< of 65%	NOT ACCEPTABLE	POOR

#### PRINT CONTRAST

*It's a measure of the ability of the printing process to hold shadow detail*

75%	READ	80%
50% ± 60%	VERY GOOD	46% ± 54%
45% ± 50%	GOOD	43% ± 46%
40% ± 45%	EXCELLENT	39% ± 43%
35% ± 40%	STANDARD	33% ± 39%
25% ± 35%	POOR	23% ± 33%
< di 25%	NOT ACCEPTABLE	< di 23%

## TRANSMISSION DENSITOMETRY

**The Equation:**      Density =  $\text{Log}_{10} \frac{1}{T}$

Where T = Transmittance

Transmission density is a function of the amount of light which passes through the film.

Black and white transmission densitometers are used for film inspection, and scanner and image setter calibration and linearity. The basic measurements are Density and Dot Area.

### **Why measure Density?**

Measure D-Min of the film's clear area to assure that there is no fogging. D-Min is typically .03 D, and not more than .05 D for most films.

Measure D-Max of the exposed (black area) to assure proper exposure and processing.

Recommended D-Max is typically 3.8, and 4.0 D and higher for some laser films. Excessive D-Max may reduce resolution, and low D-Max may cause toning in the non-image area on the printing plate.

### **Apparent Dot Area**

#### **The Murray/Davies Dot Area Equation:**

$$\text{Apparent Dot} = \frac{1 - 10^{-(Dt)}}{1 - 10^{-(Ds)}} \times 100$$

Where Dt = Density of film tint minus density of film base  
Ds = Density of solid, or D-Max, minus density of film base.

## Why measure Dot Area

### **Image setter calibration /film verification:**

Most Post Script-based image setting systems can be calibrated to ensure consistent film output. Calibration is necessary to achieve not only the proper maximum density levels, but also to ensure accurate and consistent tone reproduction, for consistency among each film of a colour separation or for vignettes, tints, duotones and single-colour halftone images. Image setter calibration has two basis steps. Setting the exposure and linearity.

### **Image setter Exposure:**

Establish the proper image setter exposure by generating an exposure sweep or density test. Evaluate positive and reversed type, horizontal and vertical lines visually. Ensure that the maximum density of the film meets or exceeds the film manufacturer's specifications. Once you have selected and exposure level, record it for review later, and set the exposure level. Plan to re-evaluate this setting if you change film types, processor chemistry, if you have your image setting equipment serviced, or if you see variation in daily film density values.

### **Image setter Linearity:**

Use the Post Script transfer function to align your film output. Some image setting systems include a software application that generates a standard 11-step or 21-step alignment test image – if your system doesn't include this, a few third parties market such software. Measure the dot area of the test image, and record the values in your calibration software. Apply the calibration and viola, your tint percentages should be automatically adjusted for exposure-or processor-related anomalies – in other words, your tints will be imaged accurately. Plan to repeat this process whenever change film types, processor chemistry, if you have your image setting equipment serviced, or if you see variation in daily dot area values.

### **Film verification:**

Transmission densitometers should be used to check films prior to plate making, to ensure proper maximum density and dot area levels. This is especially true if the films were not verified upon image setter output or if the films were duped, contacted or composited to create the final film.

During film inspection verify that screens or film tints are correct and have not changed during duplication. Is an intended 50% tint on image setter output in fact 50%?

Today software programs are available to automate image setter calibration and alignment. Modern densitometers can be interfaced directly by RS-232 interface to the Macintosh™ or IBM® PC, eliminating time consuming, and error-prone manual entry of density and dot area values/data.

## **GLOSSARY**

**ANSI, American National Standards Institute, Inc.** is the U.S. standards body which verifies requirements for due process consensus, and other criteria for approval have been met by standards developers.

**Apparent Dot Area:** The percent dot area, as measured and calculated with a graphic arts densitometer, using the Murray-Davies equation.

**Apparent Dot Gain:** In graphic arts, the difference between Apparent Dot Area of the films as measured with a transmission densitometer, and the Apparent Dot Area of the proof or printed sheet as measured with a reflection densitometer.

**Backing Material:** The material placed directly under or behind a sample when measured. ANSI/ISO 5/4 - ANSI PH2.17 specifies a black backing be used to reduce measurement variability, especially when paper is printed on both sides.

**Calibration:** To check, adjust, or systematically standardize the graduations of a device densitometer

**CIE, Commission International de l'Eclairage:** Translated as the International Commission on Illumination, the main international organization concerned with colour and colour measurement.

**Colour Separation:** The conversation of the red, green, and blue color information used in a computer into cyan, magenta, yellow, and black channels that are used to make printing plates.

**Colour Temperature:** A measurement of the color of light radiated by an object while it is being heated. The measurement is express in terms of absolute scale, or degrees Kelvin. Lower Kelvin temperatures such as 2400° K are red; higher temperatures such as 9300° K are blue. Neutral temperature is gray, at 6504°K.

**Colorimeter:** A photo-electric device that measures reflectance, has an instrument response known as the standard observer, as defined by CIE, and calculates and displays calorimetric data such as CIE  $L^*a^*b^*$ , and CIE  $l^*c^*h^*$ .

**Contrast:** The level of variation between light and dark areas in an image.

**D50:** The CIE Standard Illumining that represents a colour temperature of 5000°K. This is the colour temperature that is most widely used in graphic arts industry viewing booths.

**Densitometer:** A photo-electric device that measures transmitted or reflected light to calculate and display density values. The density values are used to



*adjust exposures for photographic applications and ink levels when printing. (See Reflection Densitometer and Transmission Densitometer).*

**Density:** *The ability of a material to absorb light-the darker it is, the higher the density.*

**Four-Colour Process:** *Depositing combinations of the subtractive primaries cyan, magenta, yellow, and black on paper and achieve. These colorants are deposited as dots of different size, shapes, and angles to create the illusion of different colours.*

**ISO:** *International Organization for Standardization. ISO is the International standards body.*

**Metameris, Metameric Pair:** *The phenomenon where two colours appear to match under on light source, yet do not match under a different light source. Two such colours are called a metameric pair.*

**Overprint:** *On a press sheet colour bar, overprints are colour patches where two process inks have been printed, one atop the other. Checking the density of these patches allows press operators determine trap value. The term Overprint also applies to any object printed on top of other colours.*

**Process Colours:** *The standard printing ink set for process printing. Graphic Arts process colours are:*

**Cyan:** *Absorbs red light and transmits green and blue.*

**Magenta:** *Absorbs green light and transmits blue and red.*

**Yellow:** *Absorbs blue light and transmits red and green.*

**Black:** *Absorbs blue, red and green light. Used for type, and to add weight to 4-color images.*

**Process Control:** *Maintaining the performance of a process at its capability level. Process control involves a range of activities such as sampling the process product charting its performance, determining causes of any excessive variation and taking corrective actions.*

**Reflection Densitometer:** *An instrument that measures the amount of incident light that is reflected from the surface of a substrate, such as ink on paper.*

**Saturation (aka Chrome):** *The attribute of colour perception that expresses the degree of departure from the grey of the same lightness.*

**Standard:** *An established, approved reference against which instrument measurements of samples are evaluated.*

**Status E (DIN):** *A densitometer response which is the accepted standard in Europe for colour reflection densitometers.*

**Status T:** *Wide band colour reflection densitometer response which is the accepted standard in the United States for colour reflection densitometers.*

**Tolerance:** *The amount of acceptable difference between a know correct standard (usually the customer's specifications) and a set of measured samples.*

**Transmission Densitometer:** *An instrument that measures the amount of light that is transmitted through film from a known light source. Graphic arts transmission densitometers are programmed to calculated Density and Dot Area of half-tone film.*

**Viewing Booth:** *A enclosed area with controlled lighting that is used in graphic arts studios, service bureaus, and printing companies as a stable environment for evaluating proofs and press sheets. Viewing booths are generally illuminated using graphic arts industry-standard **D50** lighting and are surfaced in neutral grey colours.*