Dot Spread, Dot Gain and Contrast in Color Printing

TECHKON APPLICATION NOTE 5

1 Introduction and Scope

This Application Note comprises recommended values for solid density, dot gain and contrast in offset printing. Also the calculation of printing contrast (C) from dot spread (DP) or dot gain (DG) is explained.

Modern color reflection densitometers perform this calculation automatically so that the user does not need to calculate the values DP, DG and C.

This Application Note has two objectives:

- The basis of the calculations is presented in order to explain how modern densitometers work.

- To show how, using the formulas for fixed target and tolerance values of dot gain DG, the printing contrast (C) can be calculated.

Target and tolerances for dot gain DG have been published by, for example, Fogra and BVD. Many print houses have defined their own standards for dot gain, which are mostly more demanding than the published standards. For such DG values the corresponding C values can be calculated. Chapter 6 shows values for solid density, dot gain and printing contrast, which can be recommended for todays requirements in offset printing.

2 Basis of the Calculation

2.1 When measuring printed sheets, the dot spread (DP) is calculated using the Murray-Davies formula:

$$DP = \frac{1-10^{-DD}}{1-10^{-SD}} \cdot 100\ (\%) \qquad F1$$

where SD is solid density
and DD is dot density

2.2 Dot gain (DG) in the print is related to the screen percentage value of the film (SF). When directly exposing printing plates, the dot gain must be related to screen percentage value SF of the RIP file.

$$DG = DP - SF\ (\%) \qquad F2$$

2.3 The printing contrast C is calculated using

$$C = \frac{SD - DD}{SD} \qquad F3$$

Dot density DD is preferably measured in the control patches with film percentage values of 75 % or 80 %. The difference between this value of DD and the solid density (SD) determines the printing quality in practice.

3 The Impotance of Printing Contrast

As the dot density approaches the solid density, the shadow tones fill in, and the printing contrast C decreases. As the blanket soils gradually during printing, both contrast and print quality go down. By monitoring the contrast, one can see when the blankets of the printing units need to be washed. For this purpose a lower limit for acceptable prinsting contrast should be laid down as criterion for washing blankets.

There is another purpose for which printing contrast is significant: it is a measure of the quality of the printing press itself and of its adjustments. A well adjusted printing press works with a low dot gain and a high printing contrast. Both characteristics are measured with a color reflection densitometer, and are important guidelines for the adjustment and routine maintenance of printing units. Operational changes, such as the replacement of blankets or switch to another type of ink, should be checked by measuring dot gain and

printing contrast. The same applies if the paper grades are changed or various paper grades are used.

4 Calculation with a Color Reflection Densitometer

TECHKON color reflection densitometers R 410, R 410e and SD 620 calculate DP, DG and C automatically once solid density (SD) and dot density (DD) have been measured. TECHKON print control strips TCS 300, 325 and 400 and EPS print control strip TCS Digital have measuring patches which are appropriate for multi-color printing.

TECHKON black/white densitometer RT 120 can calculate dot spread (DP) on black once SD and DD have been measured.

5 Calculation of Target Values and Tolerances

The calculation of printing contrast values from target dot gain values is done in the following steps:

5.1 Solid density values SD must be determined. Figures based on own experience may be used or values may be taken from TECHKON Application Note 2 „Density of Normal Inking in Offset Printing“. For Class 1 paper the Application Note recommends, for example, the following values:

Cyan	SD	=	1.60
Magenta	SD	=	1.55
Yellow	SD	=	1.50
Black	SD	=	1.90

5.2 Murray-Davies formula *(F1 above)* is used to calculate the dot density DD:

$$DD = -\log\left[1-(1-10^{-SD}) \bullet \frac{DP}{100}\right] \qquad F4$$

From dot spread values DD, the corresponding dot density DD can thus be calculated.

5.3 From SD and DD, the printing contrast C can be calculated using formula F3.

Example 1:
SD = 1.55
DG = 9% (DP = 89 %)

Using these values in F4 gives:
DD = 0.87

The contrast (C) is then calculated according F3 using these values for SD and DD:
C = 0.44

Example 2:
SD = 1.55
DG = 9 % ± 2 %

Using both the lower and the upper limits of DG (i.e. DP = 91 % and 87 %) in F4 gives:
$DD_{91\%}$ *= 0.94*
$DD_{87\%}$ *= 0.81*

The corresponding limit values for contrast are, using F3:
$C_{91\%}$ *= 0.39*
$C_{87\%}$ *= 0.48*

Examples 1 and 2 give for DG = 9 % ± 2 % a range for printing contrast of:
C = 0.44 +0.04/-0.05

6 Guidelines and Tolerances

The table *(page 3)* shows typical guidelines for the solid density (SD), dot gain (DG) and printing contrast C which meet the quality standards of modern printing houses. The printing contrast values are calculated on the basis of solid density and dot gain at 80 % as described above.

Standards for Offset Printing

Positiv			DG			DG			C				
		SD	40%	Tol. +	Tol. -	80%	Tol. +	Tol. -	80%	C min	C max	Tol. +	Tol. -
Paperc lass1	Cyan	1,60	14	3	3	8	2	2	0,47	0,43	0,51	0,03	0,04
	Magenta	1,55	14	3	3	8	2	2	0,46	0,42	0,49	0,04	0,04
	Yellow	1,50	14	3	3	8	2	2	0,45	0,41	0,48	0,04	0,04
	Black	1,90	16	3	3	10	2	2	0,50	0,45	0,54	0,04	0,04
Paperc lass2	Cyan	1,55	15	3	3	10	2	2	0,42	0,37	0,46	0,04	0,05
	Magenta	1,50	15	3	3	10	2	2	0,41	0,36	0,45	0,04	0,05
	Yellow	1,40	15	3	3	10	2	2	0,38	0,33	0,42	0,04	0,05
	Black	1,80	17	3	3	12	2	2	0,43	0,37	0,48	0,05	0,06
Paperc lass3	Cyan	1,20	16	3	3	12	2	2	0,28	0,23	0,33	0,05	0,05
	Magenta	1,20	16	3	3	12	2	2	0,28	0,23	0,33	0,05	0,05
	Yellow	1,10	16	3	3	12	2	2	0,26	0,21	0,30	0,04	0,05
	Black	1,40	18	3	3	15	2	2	0,25	0,17	0,31	0,06	0,08

Negativ			DG			DG			C				
		SD	40%	Tol. +	Tol. -	80%	Tol. +	Tol. -	80%	C min	C max	Tol. +	Tol. -
Paperc lass1	Cyan	1,60	18	3	3	12	2	2	0,38	0,33	0,43	0,05	0,06
	Magenta	1,55	18	3	3	12	2	2	0,37	0,31	0,42	0,05	0,06
	Yellow	1,50	18	3	3	12	2	2	0,36	0,30	0,41	0,05	0,06
	Black	1,90	20	3	3	14	2	2	0,40	0,32	0,45	0,06	0,07
Paperc lass2	Cyan	1,55	20	3	3	14	2	2	0,31	0,24	0,37	0,06	0,07
	Magenta	1,50	20	3	3	14	2	2	0,30	0,23	0,36	0,06	0,07
	Yellow	1,40	20	3	3	14	2	2	0,28	0,21	0,33	0,06	0,07
	Black	1,80	22	3	3	16	2	2	0,30	0,19	0,37	0,07	0,11
Paperc lass3	Cyan	1,20	22	3	3	16	2	2	0,17	0,09	0,23	0,06	0,07
	Magenta	1,20	22	3	3	16	2	2	0,17	0,09	0,23	0,06	0,07
	Yellow	1,10	22	3	3	16	2	2	0,15	0,08	0,21	0,06	0,07
	Black	1,40	25	3	3	18	2	2	0,12	0,00	0,21	0,09	0,12

Specification of the Paper Classes

Paper class 1	all gloss-coated and half matt-coated papers with basis weights of 70 g/m² or more*
Paper class 2	all coated papers below 70 g/m²*
Paper class 3	all uncoated papers, including supercalendered and pigmented papers

* Matt-coated papers with basis weights of 70 g/m² or more are ranked as class 1 or class 2 depending on the printing process

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