NORTH AMERICAN PRINT SURVEY

by

Alan R. Muirhead, Michael Burgstein, and Raymond H. Fahr*

Abstract:
An extensive two year survey has provided average values of ink color properties, solid ink densities, and midtone dot gain for major industry segments. Differences between segments are discussed in view of proposed specifications for printing performance.

The printing industry in North America is made up of many segments, such as proof and production, sheetfed and web, with characteristic differences in printing performance in each segment. Over the past two years, Du Pont has measured more than seven hundred printed sheets as part of a printing analysis service offered to its customers. The results of these analyses allow us to describe in detail the performance characteristics of major industry segments. This paper will concentrate on three areas: ink color properties, solid ink density, and dot gain. A major theme will be the relationship among the segments and the impact that industry specifications may have on performance.

Measurement techniques

Measurements were based on the Cromalin® Offset Com Guide / System Brunner test form together with the Brunner Print Control Strip. Figure 1 shows a layout with two test forms; smaller sheets used only one form, and large sheets could run the form four-up. The test form contains critical pictorial elements to aid visual assessment of color quality. Detailed measurements were taken on the System Scale, the Cromalin® test strip and the Print Control Strip. All elements measured had a 150 line screen ruling.

Densities were read with a Macbeth RD-918 densitometer with SPI narrow band filters, interfaced directly into a Hewlett Packard 9816 desktop computer. Effective dot area and dot gain were calculated using the Murray-Davies equation and thus include both physical and optical gain.

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*E. I. Du Pont de Nemours & Co., Inc., PhotoSystems & Electronic Products Department, Chestnut Run, Wilmington, DE 19898

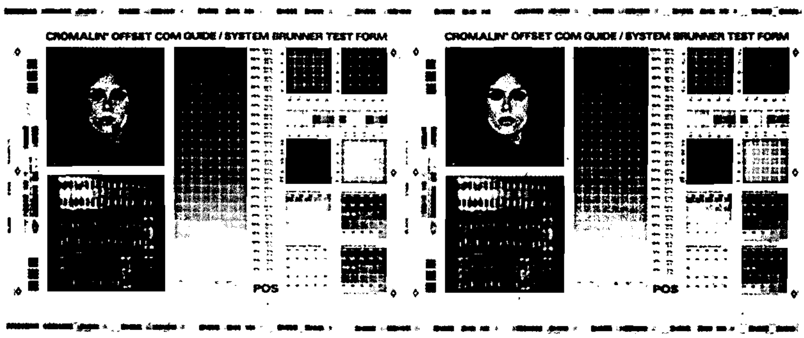

Figure 1: Print Survey Test Form (two up)

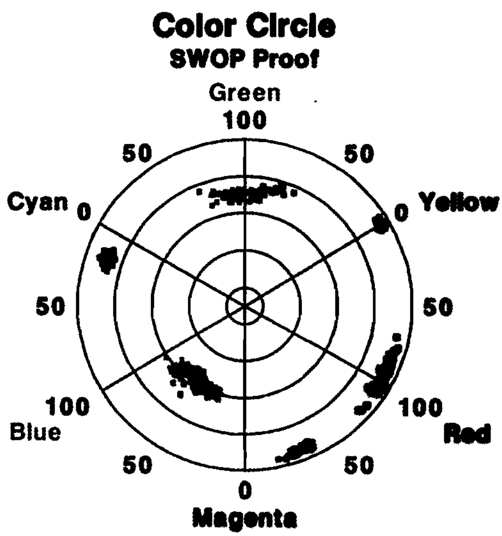

Figure 2: Ink Color Properties: SWOP Proofs

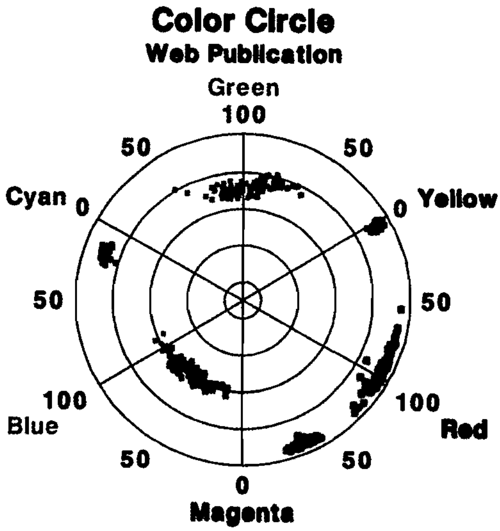

Figure 3: Ink Color Properties: Web Publication

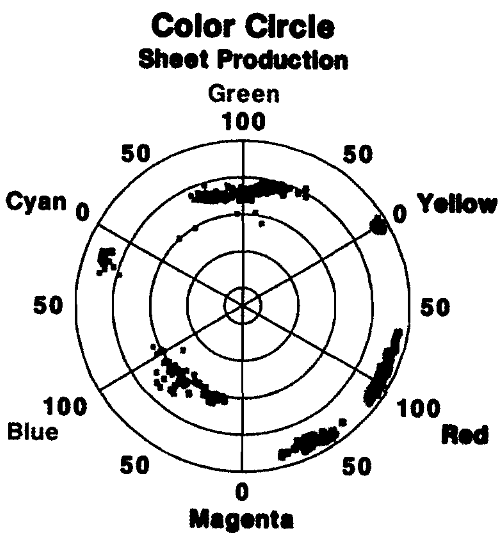

Figure 4: Ink Color Properties: Sheetfed Production

All information on printing conditions and the type of market an individual printer served were supplied by the printer. In particular, the printer would declare if he was printing proofs according to Specifications for Web Offset Publication (SWOP).

	NEG	POS
SHEET		
PROOF	125	70
SWOP	88	54
PRODUCTION	154	32
WEB		
COMMERCIAL	23	27
PUBLICATION	72	37

Table I: Types of Printing Analyzed

Table I shows the breakdown by industry segment of the number of sheets analyzed in the data base. The results for the Web Publication segment were largely obtained in cooperation with the Graphic Communications Association (GCA). Du Pont has actively participated in the GCA Spectrum research effort, which was described in the paper by Wilson, Leyda, and Brehm, presented at this meeting.

Ink Color Properties

Earlier surveys, particularly by Graphic Arts Technical Foundation (GATF), have shown the range in hue and grayness of both the inks used in four-color process printing and of the primary overprints (red, green, blue) which result. Our data may be compared to the GATF results, but care should be used because of the different densitometer filters employed.

Figure 2 shows the distribution of cyan, magenta, and yellow inks among all those samples described by the printer as being proofs made according to SWOP specifications, with SWOP inks. Yellow and cyan are tightly clustered, with magenta showing more variability. The overprints are much more widely distributed, due to the effects of differing solid ink densities, ink transparency, and trapping. These results reemphasize that the SWOP specifications do not uniquely define the colors of solid areas. As will be seen, the SWOP specification does lead to less scatter than in other industry segments.

Figure 3 shows the results for Web Publication. This segment prints under production conditions the materials which had been proofed under SWOP conditions. Note that the inks themselves match closely the color properties of the SWOP proofing inks. However, the overprints for Web Publication show much more color variation. Lower solid ink densities and less efficient trapping on high speed web presses contribute to the differences in the overprints.

In comparison, Figure 4 shows the color data for Sheetfed Production printing. This segment is not so influenced by the SWOP standards. Both cyan and magenta have a wider color distribution than the inks used for SWOP. In the overprints, blue and green show wide variation, with the red not much different from the SWOP proof results.

	(YMC)K	(CMY)K
SHEET		
PROOF	25%	62%
PRODUCTION	6%	84%
WEB		
COMMERCIAL	—	100%
PUBLICATION	3%	97%

Table II: Sequence

The sequence of ink laydown may also contribute to differences between proof and production. Table II shows that twenty five percent of the sheets printed according to a shop's proofing conditions used a sequence in which yellow was printed first, magenta second, and cyan third of the three primary colors, with black anywhere in the sequence. Production printing almost exclusively used the opposite color sequence, with cyan first, then magenta and yellow. Southworth and others have argued that the cyan - magenta - yellow sequence compensates for trapping problems and color impurities in typical process inks, and these data demonstrate that most printers have now adopted the cyan - magenta - yellow sequence.

Solid Ink Density

Solid ink density was measured across the sheet on the Brunner Print Control Strip. The standard deviation of solid ink density within a sheet differed slightly from segment to segment, ranging from 0.066 for proofs to 0.088 for web publication.

	Y	M	C	K
SHEET				
PROOF	1.28	1.39	1.25	1.49
PRODUCTION	1.25	1.33	1.20	1.49
WEB				
COMMERCIAL	1.17	1.28	1.21	1.52
PUBLICATION	1.15	1.32	1.16	1.37

Table III: Solid Ink Density Averages by Segment

Table III and Figure 5 give the solid ink density averages for each segment. As expected,

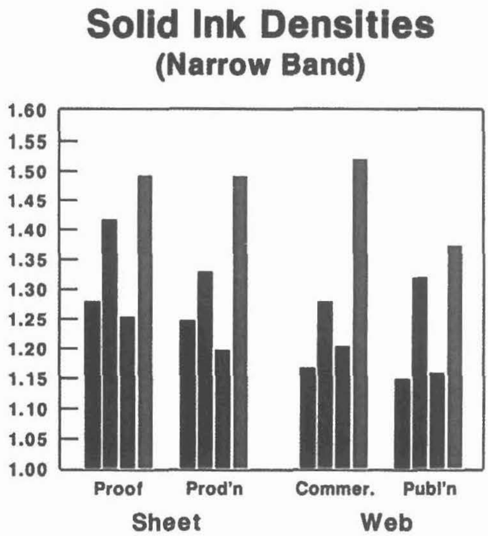

Figure 5: Solid Ink Densities, Y - M - C - K, by Segment

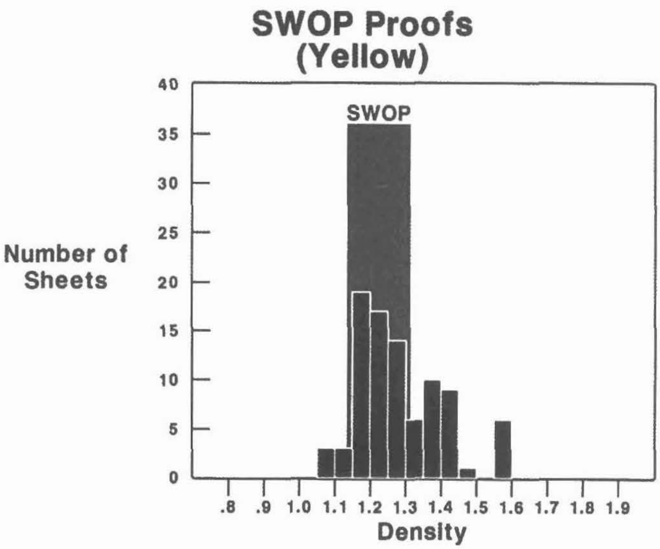

Figure 6: Distribution of SWOP Proof Solid Ink Densities: Yellow (SWOP range from measurement of IPA high-low swatches)

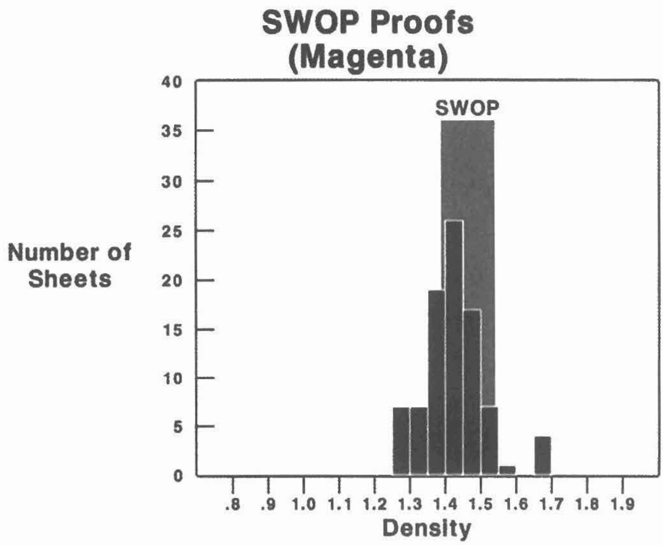

Figure 7: Distribution of SWOP Proof Solid Ink Densities: Magenta
(SWOP range from measurement of IPA high-low swatches)

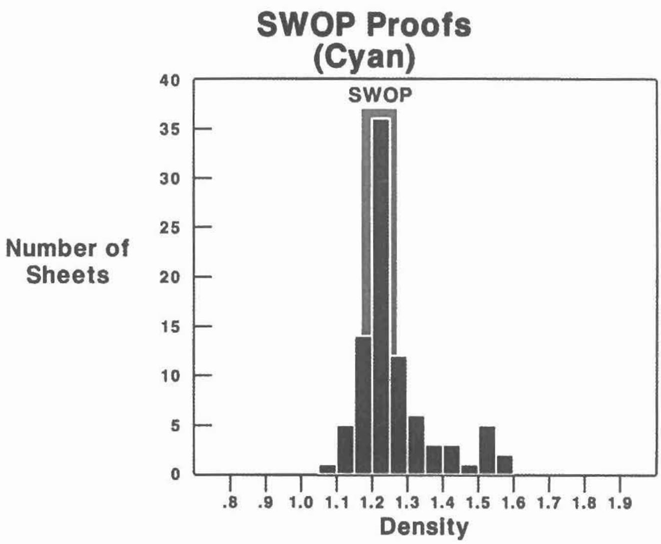

Figure 8: Distribution of SWOP Proof Solid Ink Densities: Cyan
(SWOP range from measurement of IPA high-low swatches)

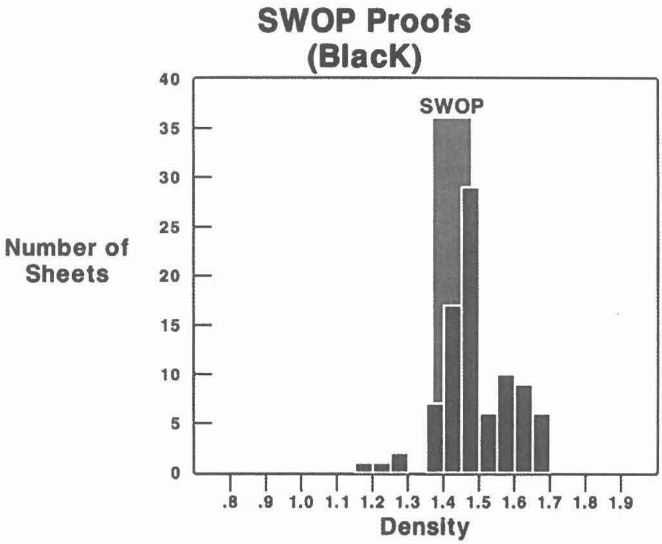

Figure 9: Distribution of SWOP Proof Solid Ink Densities: Black (SWOP range from measurement of IPA high-low swatches)

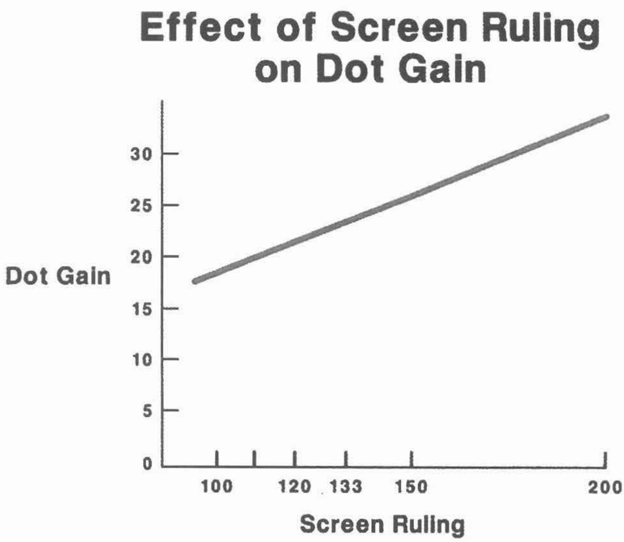

Figure 10: Dependence of Dot Gain on Screen Ruling (for 26% dot gain at 150 line screen)

densities are higher in sheetfed printing, especially in proofing, and are lower for web printing. The standard deviation between printers is approximately 0.10, so there is considerable overlap between the segments. The web publication data may be skewed slightly high compared to actual production, since these include GCA trials in which production presses were asked to print to the density specifications for SWOP proofing.

It is interesting to compare the solid ink densities on those proofs which were supposed to be made according to SWOP specifications with the International Prepress Association high-low density swatches. Figures 6 through 9 show the distribution of solid ink densities for SWOP proofs, overlayed by a band representing the range of several high-low swatches measured on the same densitometer. Solid ink densities tended to be within the high-low range, although the 0.103 standard deviation for the SWOP segment implies wider variation than the high-low swatches allow. Deviations from the high-low range were mostly toward increased density.

Dot Gain

Dot gain is now recognized as one of the most significant factors affecting printing quality. A goal of our print survey is to characterize dot gain performance of the various industry segments.

The dot gain results reported here are derived from test targets employing a 150 line per inch elliptical screen ruling. Dot gain measurements vary proportionally with screen ruling, decreasing as the ruling becomes more coarse. Figure 10 shows the theoretical relationship between rulings for a dot gain of twenty six percent measured on a 150 line screen. The same printed result has a dot gain of twenty one percent on a 120 line screen, as is used in the GCA/GATF Proof Comparator reported on in the paper by Wilson, Leyda, and Brehm. Screen ruling needs to be defined when discussing dot gain measurements.

Negative Printing

The full dot gain curve for all press proofs using negative-working printing plates is presented in Figure 11. The central line represents the average of all the sheets analyzed, the inner band indicates plus and minus one standard deviation, and the outer band shows the full range of all data. The flattening of the top band is caused by truncation in the computer plotting routines at thirty seven percent gain. The typical shape of the dot gain curve is clearly evident, with the maximum in dot gain occuring near the midtone. Dot gain for the fifty percent dot is 18.6 percent. Restricting the sample to only SWOP proofs (Figure 12) gives essentially the same average and standard deviation with a slightly narrower overall range. Sheetfed production (Figure 13) is at a slightly higher dot gain level, with an average of 20.2 percent gain above the fifty percent dot.

Web printing is at a significantly higher dot gain level. Commercial printing (Figure 14) averages 24.7 percent gain at midtone, and publication (Figure 15) averages 26.8 percent. A very few extreme examples in publication contribute to the wide range.

The results for negative printing are summarized in Figure 16 and Table IV. The 8 percent difference in dot gain between proofing and web publication has been under study by several groups, notably GCA and SWOP. GCA has determined a "normal operating window" for web

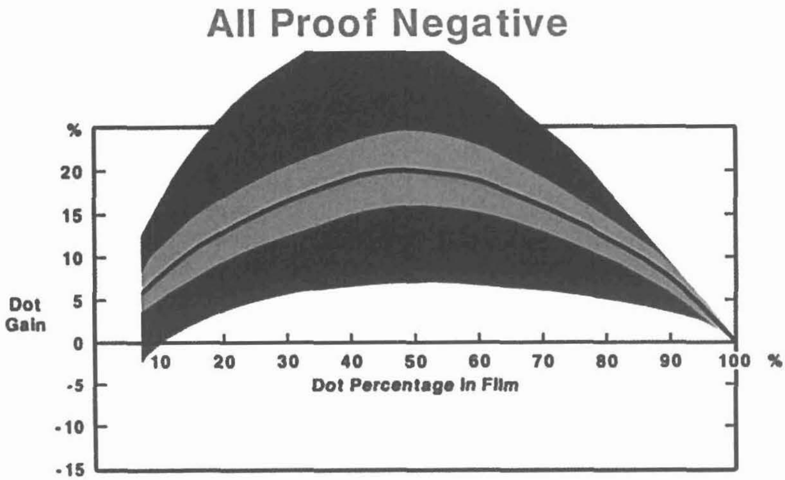

Figure 11: Dot Gain Curves: All Negative Proofs
(average [line], plus and minus one standard deviation [center band], full data range [outer band])

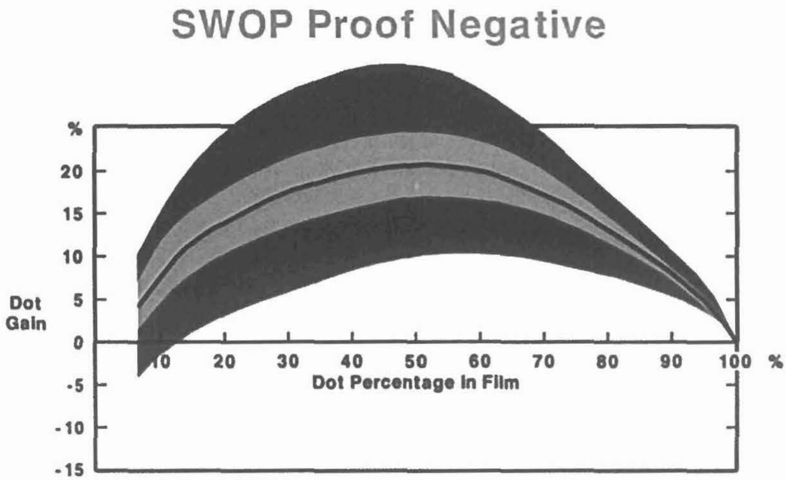

Figure 12: Dot Gain Curves
SWOP Negative Proofs

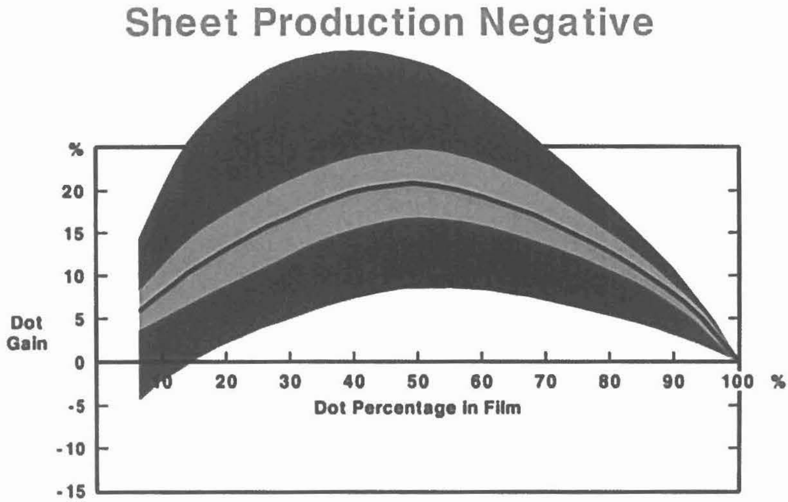

Figure 13: Dot Gain Curves
Negative Sheetfed Production

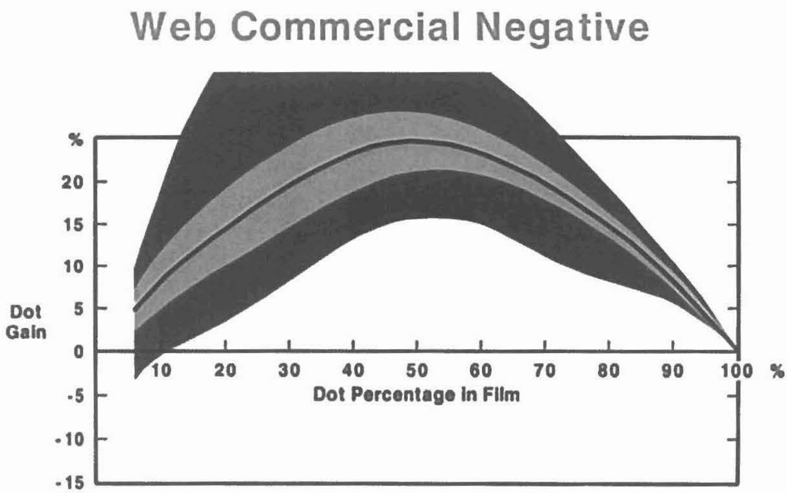

Figure 14: Dot Gain Curves
Negative Comercial

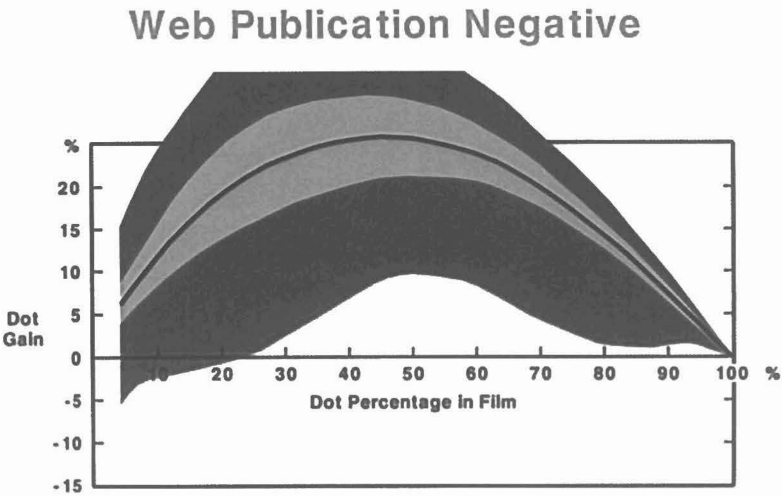

Figure 15: Dot Gain Curves
Negative Web Publication

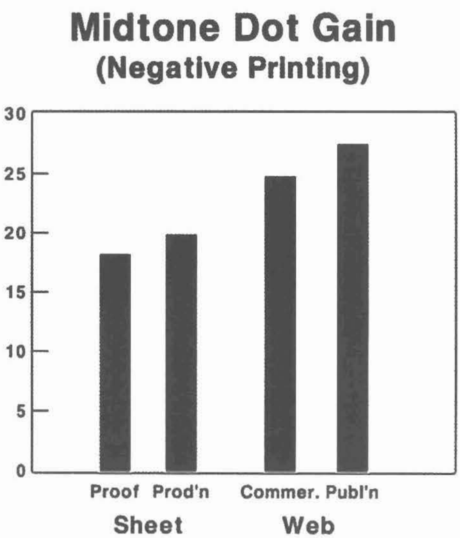

Figure 16: Midtone Dot Gain by Segment, Negative Printing

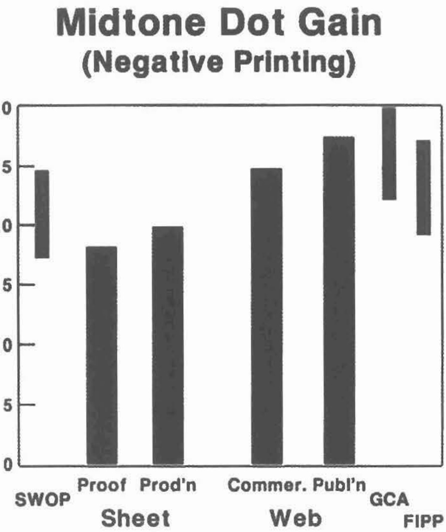

Figure 17: Midtone Dot Gain (Negative) with Proposed Specifications

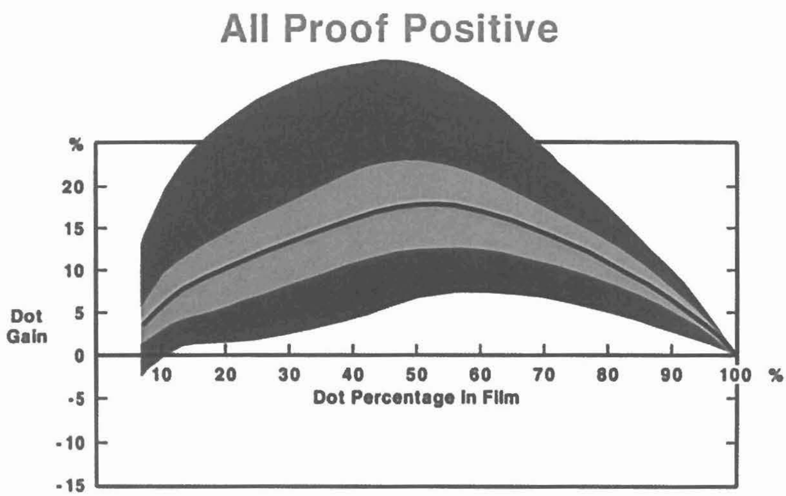

Figure 18: Dot Gain Curves
All Positive Proofs

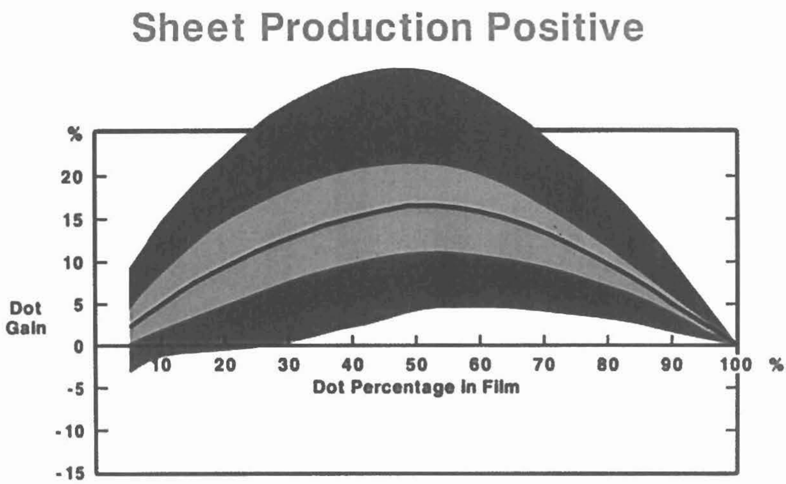

Figure 19: Dot Gain Curves
Positive Sheetfed Production

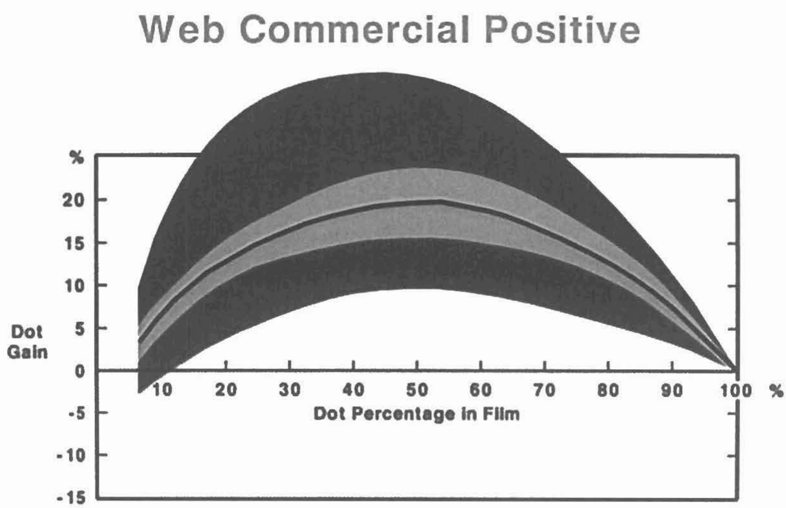

Figure 20: Dot Gain Curves
Positive Web Comercial

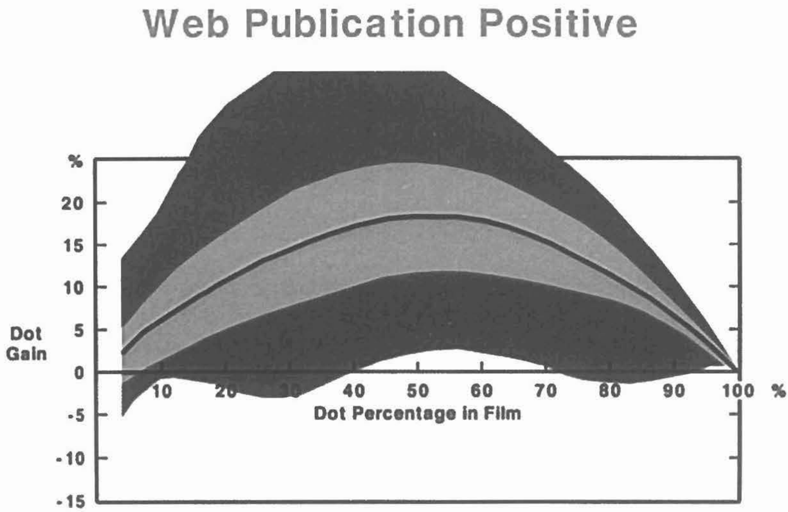

Figure 21: Dot Gain Curves
Positive Web Publication

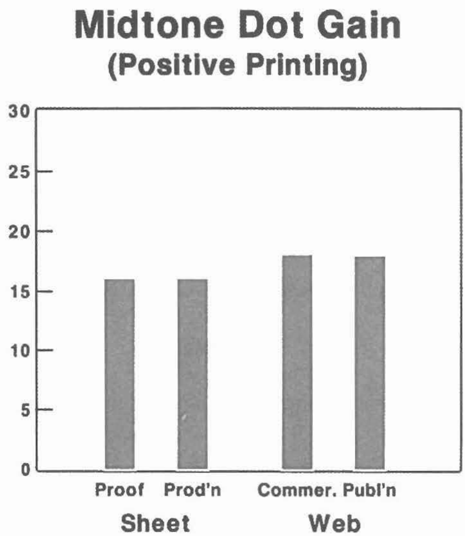

Figure 22: Midtone Dot Gain by Segment, Positive Printing

publication presses of 22 - 30 percent dot gain (150 line), based on the Spectrum trials over the past four years. The SWOP committee is considering a draft specification for proofing of dot gain equivalent to 17 - 25 percent on a 150 line screen. In Figure 17 these two ranges are superimposed on the findings from the survey, together with a proposed European specification from FIPP, the International Federation of the Periodical Press. The considerable overlap among the various proposals suggests that consistency in dot gain from proof through production is a realistic long term goal. Standard deviation of midtone dot gain found in the survey is four to five percent, indicating that most printers could fall within the plus or minus four percent limits which are under discussion.

Positive Printing

Positive printing exhibits less dot gain than negative printing, according to the findings of our survey. Positive proofing (Figure 18) has average midtone gain of 17.2 percent, and positive sheetfed production averages at the same level (Figure 19). Positive web printing (Figures 20 and 21) has midtone gain of approximately 19 percent. Note in web publication the extreme sharpening resulting in dot size reduction on a few sheets. Figure 22 summarizes these results.

	NEG	POS
SHEET		
ALL PROOFS	18.6	17.2
SWOP PROOFS	19.0	16.6
PRODUCTION	20.2	17.2
WEB		
COMMERCIAL	24.7	19.3
PUBLICATION	26.8	18.6

Table IV: Midtone Dot Gain Averages by Segment

Positive and negative printing are compared in Table IV and Figure 23. The difference in dot gain arises from the plate characteristics, since positive plates sharpen and negative plates gain with exposure. To print optimally from either type of plate, dot gain on press should be known in order to establish the tone reproduction curves needed to make separations.

Summary

The data presented here characterize significant differences between various segments of the North American printing industry. Some of the differences, such as ink color properties, may be a matter of choice for the individual printer and his customer. Other differences, such as solid ink density, are an essential part of the printing process: given today's technology, it is unlikely that high-speed web presses can come up to the inking levels of the sheetfed. Other differences, such as dot gain, can be modified to produce good quality consistency across all segments. Efforts by GCA and SWOP to bring the industry to more uniform printing performance will serve to increase quality and customer confidence in printing.

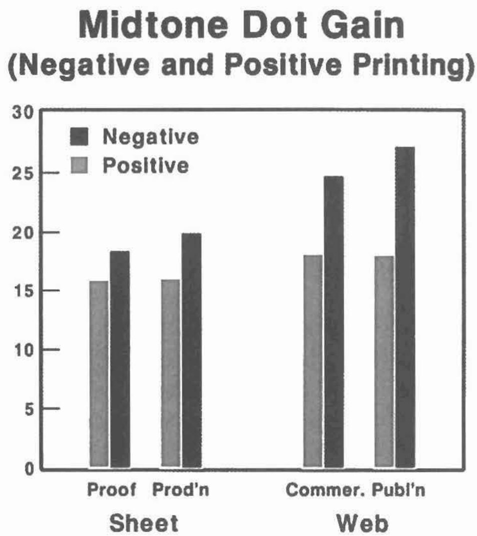

Figure 23: Midtone Dot Gain, Positive and Negative Printing

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