TESTING METHODS FOR LITHO OFFSET PLATES AND THEIR COMPATIBILITY WITH THE PROCESS

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Abstract: Lack of relevant testing methods for litho offset plates complicates the choice of plate for a given process. In this study more than a dozen well-known plate brands and a few new makes were tested for mechanical, physico-chemical, optical and printability properties in laboratory conditions and on pilot scale using some new techniques.

Based on the results, a test routine, including running life and lithographic properties, is introduced for the plate control.

INTRODUCTION

Image transfer usually means the ability of a material surface to render the intensity variation of different frequencies.

Optical methods for measuring the image transfer in screening, in film output and in printing are dominant. Methods for measuring the image transfer properties in litho offset plates have not become established because the image transfer in plates may be studied from many different points of view. The coated and uncoated parts of a plate have differences in optical, mechanical, surface-chemical and dielectrical properties.

The requirements of compatibility of the measuring methods with the offset plates grows when filmless reproduction is used. Testing methods for litho offset plates are used by plate manufacturers mainly, and only few of them are official standards. It is our task to present general testing methods available to the printer.

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A number of commercial litho offset plates have been tested and a test routine is now proposed for plate control. The study is based on development work carried out in the Technical Research Centre of Finland and partly in Helsinki University of Technology (Taulos 1983).

EXPERIMENTAL

Presensitized aluminium-based commercial litho offset plates were tested in laboratory conditions and on pilot scale using some new techniques. The number of different plates was 15, i.e. 8 negative and 7 positive plates. The nominal printing lives of the plates ranged from 40 000 to 200 000 impressions. The tested plate types were Fuji FNM-2 and FPM-N, Kalle P7S and N3S, Howson Algraphy Marathon AQ, Marathon Super and Alympic Gold, Nordisk Tidningsplåt NTP Oden, Polychrome DSN, GP, GAN and GAP, Sakura SLP and SWN, and UPA-1.

The plates were developed by hand with their respective chemicals. Since different methods were used to test some of the plates, this paper is a summary of two different tests. The testing methods were grouped as follows:

A. Mechanical properties

Thickness (mm) means the total thickness of a plate measured as an average value. The accuracy of the Bacher instrument was 0.01 mm.

Tensile strength (N/mm^2) means the drawing force needed to break a 20 cm wide sample plate according to the standard SFS 3173. The force range of the Wolpert instrument was 1 kN.

Elongation (%) is obtained during the tensile strength test. Elongation gives in percentage the increase of length caused by drawing in a sample plate.

Surface hardness (HVI) means Vicker's hardness measured by a Zwick Z 323 instrument according to the standard SFS 3214. The hardness value has been tabulated according to the size of the hole that the measuring nib makes on the plate surface when the force is 9.81 N (1 kp) and the loading time 10 to 15 s.

B. Physico-chemical properties

Surface roughness (μm) means the average deviation of the real profile from the middle line of the surface. The result is reported as an R_a-value or an s-value defined by the following equations

$$R_a = 1/L \cdot \int_0^L |y| \, dx \qquad (1)$$

$$s = \sqrt{1/L \cdot \int_0^L y^2 dx} \qquad (2)$$

Figure 1 expresses the principle of the middle line, which is the least square line of the y_i-values.

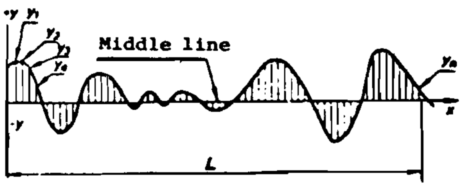

Figure 1. The middle line of a surface profile. L is the length of a measuring sequence.

The accuracy of the Taylor Hobson Surtronic 3 instrument for measuring R_a-values is 10 percent.

S-values were measured with the Mechanical Profilometer in the following conditions:

- diameter of the measuring nib 5 μm
- filtering, high pass 0.3 Hz
  low pass 20 Hz
- driving speed 0.606 mm/s

The accuracy of the Mechanical Profilometer is better than 10 percent.

Surface energy (mN/m) means the critical surface tension of a plate measured with the contact angle method (Anon., 1966). The model liquids used in the method are the same as those described by Kaelble (1975). The surface energy with dispersion and polar components can be calculated by a computer from the coated and uncoated surfaces of a plate (Karttunen, 1979).

The accuracy of the method is 5 mN/m.

C. Optical properties

Spectral sensitivity (nm) means the wavelength area in which the light-sensitive plate coating reacts to the absorbed radiation energy. The measurements are made with the Hilger-Watts D 330 grating monochromator (Manninen, 1974).

The accuracy of the method is 5 nm.

Resolution means the power of rendering small circular line fields from the UGRA test scale to a plate coating (Anon., 1976). The lamp in the Nu Arc VFC 32/25 copying frame was Litolux 2000 W. The smallest rendering line width obtained by the optimum exposure is reported.

Contrast means the value $K = (D_{100} - D_{75})/D_{100}$, where D_{100} and D_{75} are the densities of the compact (100 percent) tone and the screened (75 percent) tone. In web-fed printing the contrast values have exceptionally been calculated from an unscreened halftone field (D_H) of the printed UGRA test scale (Anon., 1976).

Contrast transfer function (CTF) means the intensity variation measured from a line-screened test figure with the Joyce Loebl microdensitometer. The line widths of the test figure were 200, 150, 125, 100, 75, 50 and 25 µm/mm, i.e. expressed in frequencies 2.5, 3.3, 4, 5, 6.7, 10 and 20 cycles/mm.

If the image transfer process from the original to the printing is assumed to be linear, for a sinusoidal or cosine type intensity variation the CTF can be expressed as a function of frequency k

$$CTF(k) = C_{output}/C_{input} \qquad (3)$$

where $C_{output} = (I_{max} - I_{min})$ is the intensity contrast of a frequency and C_{input} is the intensity contrast measured by the smallest frequency (2.5 cycles/mm). The CTF-values of the process can be combined by multiplication. CTF and MTF (modulation transfer function) are analogical (Hakkarainen, 1973).

Tone rendering indicates how perfectly the dots are copied from the test film to the plate coating or from the plate to the paper. Tone rendering is usually measured in terms of density or in dot sizes. In this study the tones have been measured from the UGRA test scale with the Nikon Shadowgraph instrument and the Joyce Loebl microdensitometer, and from printings with the Cosar SOS 40 densitometer; screen rulings were 60 l/cm and 120 l/cm.

D. Printing properties

Running life means the greatest number of acceptable impressions a correctly made plate can give. Mostly the evaluation of the running life is based on the subjective comparison of print samples. An abrasion method has been developed for determining the running life of plates. In this method 1 mm wide parallel lines are copied on to the plate. After developing, a series of abrasions are made on the plate surface by the Ink Abrasion Tester with an abrasion suspension containing silicate. The number of abrasions in one series is e.g. 0, 500, 1000, 1500, 2000, 3000 to 6000. In web-fed printing the plates are placed side by side onto a plate cylinder and printing is performed normally. After printing the print samples are measured at the abrasion points with the Elrepho instrument. As a result, graphs can be drawn showing the lightness as a function of the abrasion quantity. The maximum value expresses a change in the ink transfer, and it is a good measure of running life.

Ink/water balance is here defined as the ink and water feed levels giving the highest contrast. The correlation between the contrast and the ink or water feed was investigated in printings.

In web-fed printing the press was Goss Community, the paper was SC-offset 60 g/m^2, the ink was black Roto Rotalith 31000, the fountain solution was GRA-water, pH 6, the blanket was Reeves Vulkan 714, and 105 000 impressions were made.

In sheet-fed printing the press was Nebiolo Invicta 25S, the paper was coated Silvablade 80 g/m^2, the ink was black Winter Iroset Europa, the fountain solution was 1.5 percent Polychrome 77, the blanket was Reeves Vulkan 714, and the number of impressions was 1 000.

RESULTS

The plates were coded so that N refers to a negative plate and P stands for a positive plate.

A. Mechanical properties (Table 1)

Tensile strength of the tested plates was in the range of 129 to 182 N/mm^2. According to the measurements the platemaker seems to use the same type of aluminium in all his plates.

Elongation of the tested plates was in the range of 1.0 to 2.8 percent. According to the measurements the tensile strength is inversely proportional to elongation.

Surface hardness of the tested plates was in the range of 43.0 to 54.5 HV1. High hardness values (>51.0 HV1) seem to correlate quite well with small nominal running lives, which is an unexpected result.

B. Physico-chemical properties (Tables 2 and 3)

Surface roughness depends on the graining method. A high R_a-value (or s-value) represents great roughness, which in printing means the ability of the plate to accept great quantities of ink and water. The correlation between roughness and contrast, or maximum density was found in the density measurements of the print.

The s-values measured with the Mechanical Profilometer were different from the R_a-values of the same plates.

Surface energy was almost the same in all the plates. The coated surface of plate 7N was an exception: the surface energy was close to the value measured from the uncoated surface. There were only small differences between the dispersion components of the plates, but the differences between the polar components were rather great, especially in coated surfaces. A high value in the surface energy means easy wetting of a plate. A great difference in the polar components means good selectivity of a plate.

No correlation between surface energy and contrast or maximum density was found in the density measurements of the print.

C. Optical properties (Tables 4...7)

Spectral sensitivity of all the plates was found to be in the range of 250 to 480 nm. None of the plates is suitable for copying by the Ar-laser (wavelength 488 nm). The maximum sensitivity of all the plates was about 400 nm. Obviously the differences in the exposure times required depend on the quality and quantity of the sensitizer.

Resolution has been measured by microscopic methods from the UGRA scale's circular fields copied on to a plate. Using the optimum exposure step 5 (0.75 D) and step 6 (0.90 D) of the UGRA scale have been copied to the compact in the negative and positive plates. Resolution was low in plates 3N, 5N and 9N.

Tone rendering from the UGRA scale to the plates has been given in dot sizes. With a screen ruling of 60 l/cm there were only small differences between the plates. The greatest fog of a dot on the UGRA scale was found to be in the light tones.

Contrast transfer function of the process ($CTF_{process}$) consists of original (ctf), plate (CTF_{plate}) and press (CTF_{press}) components. According to the measurements the greatest differences in the CTF were generated in frequencies ≧ 5 cycles/mm especially in printing and platemaking. E.g. CTF_{plate} means the coating thickness on the image and non-image plate surfaces expressed in percentages of the maximum coating thickness in each frequency.

D. Printing properties (Tables 8...10)

Running life measured by the abrasion test depends on the difference of the polar components in the plates. Figure 2 gives the curves of a plate from different impressions. Figure 3 shows the difference of the polar components vs. the number of abrasions and the evaluated running life. In the abrasion test the number 1 equals 100 impressions.

Ink/water balance was studied in terms of the variation in contrast. In sheet-fed printing the ink feed was changed and the water feed was constant; and vice versa in web-fed printing.

The contrast variation of the print in relation to the average was rather small when the water feed was changed slowly. A rapid and big change in the water feed strongly affected

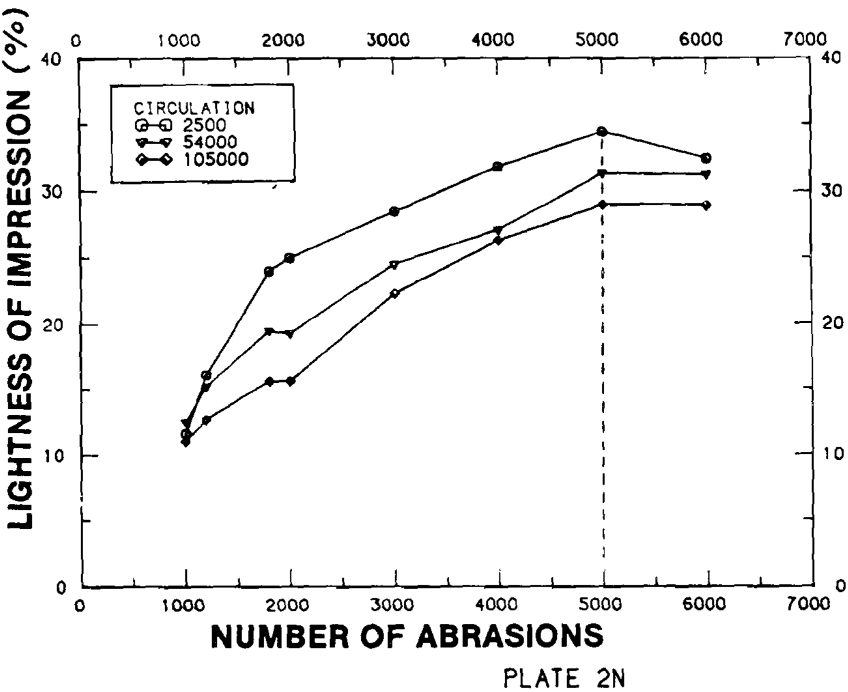

Figure 2. Lightness of impression vs. the number of abrasions.

the contrast in web-fed printing.

The correlation coefficients contrast vs. impression are rather big in plates which have short running lives. The correlation coefficients contrast vs. water feed are rather big in plates which have long running lives.

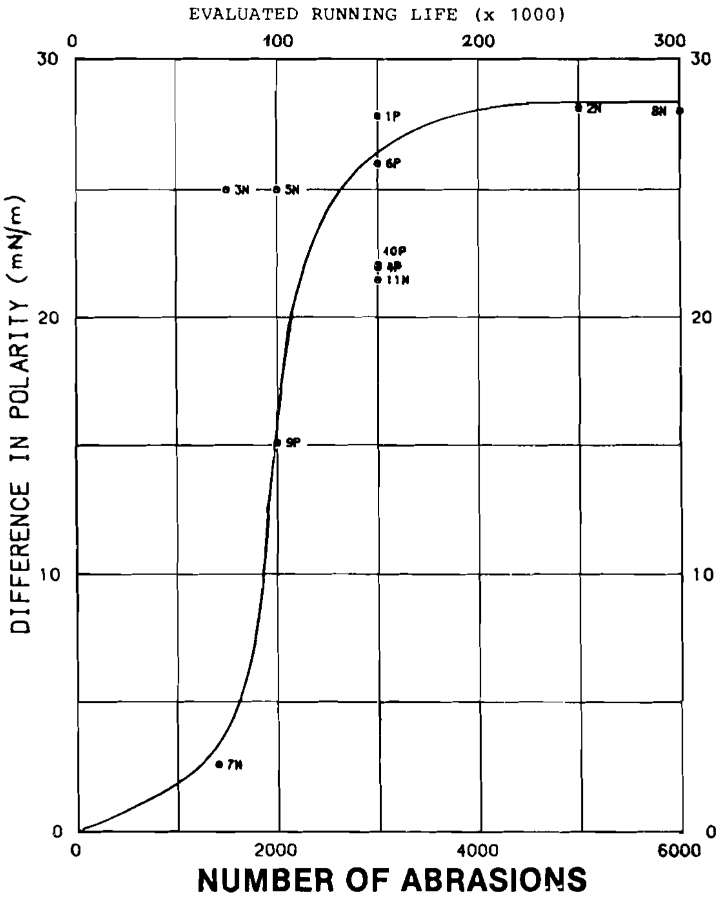

Figure 3. Evaluation of running life.

DISCUSSION

Unscreened surfaces

An unscreened test scale with steps also gives the tone steps to the print. This can be explained by the combined effect of roughness and coating thickness. Kaelble (1971) has shown that a decrease in the coating thickness on a plate increases the roughness of the surface and the wetting, too. Therefore the coated plate surface receives more water, and the ability of the surface to receive ink, and the density of the print, decrease. It is obvious that very thin coatings make a discontinuous compact surface on the plate. However, the overall effect of roughness on the wetting remains small (Manninen 1975).

This study shows that due to the small difference of the polar components $\Delta\gamma^p$ between coated and uncoated surfaces the plate is very sensitive to density variations in the print depending on the variation of thickness in the coating.

It has been observed (Noble et al., 1981) that the roughness of a plate decreases with increasing abrasion. This means a decrease in the wetting of a coated plate surface. But abrasion tests are not the same in plate making because reduction of the plate coating by abrasion differs from the reduction caused by the light energy in the plate copy.

Plates 7N, 9P and 14N with great differences in roughness in the coated and uncoated surfaces gave high maximum densities (D_{100}) in the compact tone. Plates 2N and 11N with small differences in roughness gave rather high non-image (D_o) tones. This phenomenon may depend on the relation of the ink/water emulsion in different surfaces.

The printing properties of the tested litho offset plates seem to depend on the combined effect of coated and uncoated surfaces, and not only on the comparison of compact (or non-image) surfaces.

<u>Screened surfaces</u>

In printing the deviations of dot sizes resulting from the plate roughness are greater in the light tones than in the halftones (Pearson et al., 1981).

The plate properties of screened surfaces can be formulated by the unscreened properties.

The $CTF_{process}$-values in a frequency of 20 cycles/mm are good for plates 9P and 11N which have average CTF_{plate} - and $\Delta\gamma^p$-values. (Not high or low as in plates 2N and 7N).

Plates 7N, 9P and 13P with small $\Delta\gamma^p$-values have the maximum absolute contrast $\Delta D = D_{100} - D_{75}$ with a lower compact density (D_{100}) than the other plates which were tested. Plate 2N with the greatest $\Delta\gamma^p$-value has the maximum ΔD with a greater compact density (D_{100}) than the other plates.

Taulos (1983) has measured the total difference of screened tones on the UGRA test scale

$$dD = \sum_{i=1}^{12} \left[D_i(120) - D_i(60) \right] \qquad (4)$$

where $D_i(120)$ is the density of step i with a screen ruling of 120 1/cm
$D_i(60)$ is the density of step i with a screen ruling of 60 1/cm.

Plates 7N, 9P and 13P with small $\Delta\gamma^p$-values also have small dD-values in sheet-fed printing.

Both in sheet-fed and web-fed printing plates 7N and 9P have quite a good contrast stability when water and ink feeds are changed.

In web-fed printing several positive plates have very low contrast levels with small water feeds. Water sensitivity of the plates can also be evaluated by changing the water feed and by measuring the contrast.

Methods of plate control

According to the measuring results the following methods are suited and relevant to litho offset plate control:

- mechanical profilometer to measure the roughness
- contact angle projector with model liquids to measure the surface energy
- microdensitometer to measure the CTF and the coating thickness using a line-screened test figure as an original
- densitometer for tone rendering and to measure the contrast using a screened test scale with unscreened non-image and compact tones
- ink abrasion tester with an abrasion suspension to measure the wear of plates; after pulling a proof the print is measured with a microdensitometer or an Elrepho instrument.

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TABLE 1.

MECHANICAL STRENGTH

Plate	Thickness (mm)	Nominal running life (x 1000)	Tensile strength (N/mm^2)	Elongation (%)	Surface hardness (HV1)
1P	0.30	>150	159	2.0	45.9 ± 0.9
2N	0.30	>100	162	1.8	51.2 ± 4.0
3N	0.30	>100	156	2.4	51.9 ± 1.5
4P	0.30	>200	154	2.0	50.4 ± 2.6
5N	0.30	>100	168	2.0	54.5 ± 4.0
6P	0.24	>100	182	1.0	53.9 ± 2.6
7N	0.30	>120	135	2.4	44.0 ± 1.5
8N	0.24	>150	141	2.0	49.5 ± 2.5
9P	0.30	>150	129	2.8	43.0 ± 0.6
10P	0.27	>150	156	2.0	45.0 ± 0.1
11N	0.25	>150	165	2.0	46.3 ± 3.0
12P	0.30	>100			
13P	0.25	>60			
14N	0.25	>40			
15N	0.30	>80			

Method: Bacher instrument; Wolpert instrument, Standard SFS 3173 and DIN 50114; Vicker's hardness, Standard SFS 3214, Zwick Z 323 instrument

TABLE 2.

SURFACE ROUGHNESS

Plate	Coated surface R_a-value (µm)	Uncoated surface R_a-value (µm)	Coated surface s-value (µm)	Uncoated surface s-value (µm)
1P	0.25	0.45		
2N	0.28	0.30	0.23	0.26
3N	0.40	0.66		
4P	0.34	0.80		
5N	0.38	0.56		
6P	0.34	0.55		
7N	0.65	0.67	0.58	0.70
8N	0.42	0.57		
9P	0.47	0.81	0.40	0.64
10P	0.09	0.25	0.19	0.23
11N	0.28	0.34	0.28	0.30
12P	0.22	0.21		
13P			0.17	0.29
14N			0.55	0.75
15N	0.45	0.54		

Method: Taylor-Hobson Surtronic 3 — Mechanical Profilometer (Taulos 1983)

TABLE 3.

SURFACE ENERGY

Plate	Surface energy (mN/m)		Dispersion component (mN/m)		Polar component (mN/m)		Difference of polar components (mN/m)
	Coated	Uncoated	Coated	Uncoated	Coated	Uncoated	
1P	33.7	62.2	30.1	30.8	3.6	31.4	27.8
2N	39.7	60.8	37.4	30.5	2.3	30.4	28.1
3N	37.6	61.9	31.6	30.8	6.1	31.1	25.0
4P	38.5	60.1	31.4	30.9	7.2	29.2	22.0
5N	35.8	57.1	30.9	27.6	4.5	29.5	25.0
6P	34.2	61.4	29.6	30.8	4.6	30.6	26.0
7N	55.0	58.0	30.4	30.9	24.6	27.2	2.6
8N	38.4	60.2	36.7	30.7	1.6	29.6	28.0
9P	43.6	61.3	28.2	30.8	15.4	30.5	15.1
10P	40.3	61.6	31.7	30.7	8.7	30.8	22.1
11N	42.6	61.9	32.9	30.7	9.7	31.2	21.5
12P	43.1	56.4	32.9	30.9	10.2	25.5	15.3
13P	42.3	60.0	33.1	30.9	9.1	29.1	20.0
14N	40.0	59.8	34.8	29.6	5.2	30.2	25.0
15N	51.7	64.7	39.7	28.7	12.0	36.0	24.0

Method: SCAN P18:66, Lorentzen-Wettre contact angle projector

TABLE 4.

OPTICAL PROPERTIES

Plate	Exposure time (s)	Resolution (µm)	Spectral sensitivity (nm)	Spectral max. sensitivity (nm)
1P	40	6	260-460	400
2N	60	8	250-480	390
3N	75	12	270-480	390
4P	60	8	270-470	400
5N	120	17	270-470	390
6P	30	6	260-470	400
7N	42	8	260-480	400
8N	30	8	250-460	390
9P	36	17	270-460	400
10P	46	6	260-480	410
11N	120	8	280-480	390
12P	-	6	-	-
13P	42	-	-	400
14N	84	-	-	400
15N	120	8	290-480	400

Method:	Litolux 2000 W	UGRA test scale, circular fields	Hilger-Watts D 330 grating monochromator

TABLE 5.

TONE RENDERING FROM FILM TO PLATE

							Method:
UGRA (60 l/cm)	%	8.1	24.3	55.2	86.2	96.1	Nikon Shadowgraph
Fog	µm	x	8	7	7	6	Joyce Loebl micro-densitometer
1P	%	8.1	23.9	55.5	86.5	96.4	Nikon Shadowgraph
2N	"	92.0	76.1	44.6	14.0	3.9	"
3N	"	92.6	76.3	45.0	14.4	3.5	"
4P	"	7.8	24.2	55.3	86.4	96.6	"
5N	"	92.9	76.6	44.8	14.1	3.8	"
6P	"	8.2	23.5	55.5	85.6	95.7	"
7N	"	92.2	76.4	45.9	14.5	4.3	"
8N	"	92.4	76.1	44.5	13.8	3.8	"
9P	"	8.2	24.1	55.7	85.9	96.0	"
10P	"	8.2	24.0	54.9	86.1	96.1	"
11N	"	92.3	76.9	45.7	14.4	4.1	"
12P	Not measured						
13P	"	8.2	24.3	55.6	85.5	96.2	"
14N	"	92.1	76.3	45.2	14.2	4.0	"
15N	Not measured						

Fog means the area of a dot profile between densities 0.3 and 1.3

$x = D_{max} < 1.3$

TABLE 6.

CONTRAST TRANSFER FUNCTIONS (Taulos 1983)

$$CTF_{total} = ctf \times CTF_{plate}$$

Frequency (cycles/ mm)	CTF_{total} (%) 13P	10P	11N	14N	2N	7N	9P
2.5	100	100	100	100	100	100	100
3.3	100	100	98	100	100	100	100
4	101	103	98	100	103	100	101
5	99	100	80	100	109	100	101
6.7	99	100	80	88	103	98	100
10	99	84	80	77	100	98	96
20	77	66	60	51	89	39	66

$$ctf = CTF_{original} \times CTF_{measuring\ device}$$

Frequency (cycles/ mm)	ctf (%) Positive	Negative
2.5	100	100
3.3	100	100
4	100	100
5	100	100
6.7	100	100
10	100	100
20	93	91

$$CTF_{plate} = CTF_{total} / ctf$$

Frequency (cycles/ mm)	CTF_{plate} (%) 13P	10P	11N	14N	2N	7N	9P
2.5	100	100	100	100	100	100	100
3.3	100	100	98	100	100	100	100
4	101	103	98	100	103	100	101
5	99	100	80	100	109	100	101
6.7	99	100	80	88	103	98	101
10	99	84	80	77	100	98	96
20	83	71	66	56	98	43	71

TABLE 7.

CONTRAST TRANSFER FUNCTIONS (Taulos 1983)

$$CTF_{process} = ctf \times CTF_{plate} \times CTF_{press}$$
$$= CTF_{total} \times CTF_{press}$$

Silvablade,
Ink feed level I

Frequency (cycles/mm)	$CTF_{process}$ 13P	10P	11N	14N	2N	7N	9P
2.5	100	100	100	100	100	100	100
3.3	100	100	100	100	94	96	100
4	94	98	100	100	92	96	97
5	94	92	100	94	92	88	86
6.7	92	67	85	71	71	73	83
10	47	11	38	46	26	47	60
20	12	0	23	13	9	20	20

$$CTF_{plate + press} = CTF_{process} \quad ctf$$

Silvablade,
Ink feed level I

Frequency (cycles/mm)	$CTF_{plate + press}$ (%) 13P	10P	11N	14N	2N	7N	9P
2.5	100	100	100	100	100	100	100
3.3	100	100	100	100	94	96	100
4	94	98	100	100	92	96	97
5	94	92	100	94	92	88	86
6.7	92	67	85	71	71	73	83
10	47	11	38	46	26	47	60
20	13	0	25	14	10	22	22

TABLE 8.

DENSITIES IN PRINTING

Plate	Sheet-fed (Taulos 1983)								Web-fed									
	I_i		II_i		III_i				I_w		II_w		III_w		I_w		I_w	
	D_{75}	D_{100}	D_{75}	D_{100}	D_{75}	D_{100}	D_o	Max D_{100}	D_H	D_{100}	D_H	D_{100}	D_H	D_{100}	D_H	D_{100}	D_H	D_{100}
1P									0.33	0.82	0.31	0.57	0.78	0.83	0.41	0.87	0.52	0.84
2N	1.07	1.50	1.10	1.52	0.84	1.25	0.13	1.59	0.22	0.79	0.21	0.67	0.61	0.83	0.32	0.84	0.35	0.85
3N									0.35	0.81	0.24	0.66	0.39	0.83	0.24	0.80	0.22	0.71
4P									0.40	0.85	0.30	0.57	0.64	0.73	0.43	0.90	0.40	0.83
5N									0.55	0.90	0.19	0.80	0.25	0.92	0.49	0.90	break	
6P									0.63	0.85	0.32	0.44	0.78	0.83	0.48	0.67	0.50	0.65
7N	0.92	1.39	1.02	1.52	0.85	1.26	0.08	1.67	0.21	0.80	0.16	0.71	0.25	0.77	0.13	0.79	0.03	0.15
8N									0.21	0.83	0.13	0.71	0.37	0.83	0.26	0.83	0.41	0.84
9P	0.81	1.16	1.28	1.52	0.94	1.25	0.07	1.63	0.33	0.85	0.24	0.49	0.37	0.85	0.31	0.87	0.36	0.93
10P	1.11	1.46	1.25	1.53	0.89	1.26	0.07	1.53	0.48	0.76	0.32	0.45	0.60	0.65	0.57	0.72	0.46	0.68
11N	1.09	1.46	1.25	1.51	0.93	1.26	0.16	1.51	0.42	0.87	0.27	0.49	0.20	0.75	0.17	0.60	break	
12P							Not measured											
13P	0.88	1.34	-	-	0.84	1.25	0.08	1.34										
14N	0.97	1.42	1.13	1.52	0.85	1.25	0.09	1.61										
15N							Not measured											
Circulation	1 000		1 000		1 000				2 500		12 000		44 500		54 000		105 000	

D_o = density of an unscreened step (UGRA 0.15 D)

D_{75} = density of a 75 percent tone

D_{100} = density of a 100 percent compact tone

D_H = density of a halftone on the UGRA scale

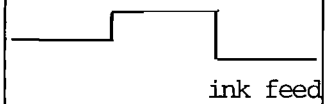
TABLE 9.

PRINTING PROPERTIES

Contrast at different ink/water feed levels I, II and III

Plate	Number of abrasions	Evaluated running life (x 1000)	Sheet-fed (Taulos 1983) I_i	II_i	III_i	Web-fed I_w	II_w	III_w	I_w	I_w
1P	3000	155				0.60	0.46	0.06	0.53	0.38
2N	5000	250	0.29	0.28	0.33	0.72	0.69	0.27	0.62	0.59
3N	1500	115				0.57	0.64	0.53	0.70	0.69
4P	3000	120				0.53	0.47	0.12	0.52	0.52
5N	2000	120				0.61	0.76	0.73	0.46	break
6P	3000	145				0.26	0.27	0.06	0.28	0.23
7N	1400	70	0.34	0.33	0.33	0.74	0.77	0.68	0.84	0.80
8N	6000	300				0.75	0.82	0.55	0.69	0.51
9P	2000	100	0.30	0.16	0.25	0.61	0.51	0.56	0.64	0.61
10P	3000	120	0.24	0.18	0.29	0.37	0.29	0.08	0.21	0.32
11N	3000	115	0.25	0.17	0.26	0.52	0.45	0.72	0.72	break
12P		Not measured								
13P			0.34	-	0.33					
14N			0.32	0.26	0.33					
15N		Not measured								

Method: Ink Abrasion tester with an abrasion suspension



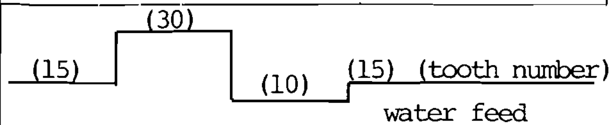


TABLE 10.

CORRELATION COEFFICIENTS OF CONTRAST IN WEB-FED PRINTING

Plate	Water feed	Impression
1P	0.421	-0.077
2N	0.474	-0.001
3N	0.070	0.740
4P	0.336	0.387
5N	0.051	0.591
6P	0.525	0.368
7N	0.154	0.727
8N	0.561	-0.594
9P	-0.172	0.480
10P	0.319	-0.221
11N	-0.274	0.953