REFERENCES

1. Stephenson, A. Are UV Flexo inks really that easy to use. *Flexo & Gravure International*: **4(12)**(1997)**:** 6-11.

2. Meyer, K. H. Flexo Printing Technology. 4th ed.; Coating Fachbucher:St.Gallen. 2000; pp.1-16.

3. Dykes, Y. Flexography: Principles and Practices. 5th ed.; Foundation of Flexographic Technical Association, 1999; pp.33-36.

4. Kershner, P. UV curing, coating and drying explained. *Flexo* **24(3)**(1999): 84-88

5. Bean, J. A. and Cortese, J. UV curing health and safety. *Flexo* **25(7)**(2000): 36-39.

6. Niederstad, D. Solid flexo printing with UV inks – a challenge for printing plates. *Flexo & Gravure International* : **4(12)**(2000): 16-18.

7. Lagerstedt, P. and Kolseth, P. Influence of surface energertics on ink transfer in flexo printing. Advances in printing science and technology. Volume23.; Bristol, J.A. ED., Pentech press, London. 1995: pp 270-297.

8. Meyer, K. H. and Leber, S. "The printing plate as a quality characteristic in the reproduction of the printed image in flexographic printing." A short report on a research project carried out by the DFTA-Technology-Centre at the technical college of printing, Stuttgart, December 1996

9. Meyer, K. H. and Leber, S. "Printing inks and their influence on print quality in relation to printing motive and printing material" A short report A short report on a research project carried out by the DFTA-Technology-Centre at the technical college of printing, Stuttgart, December 2000

10. De Grace, J. H. and Margin, P.J. A mechanistic approach to ink transfer Part I: Effect of substrate properties and press condition. Advances in printing science and technology. Volume21.;Bristol,J.A. ED., Pentech press, London. 1993: pp 312-326.

11. BASF Drucksysteme GmbH. Work manual Flexographic plates; pp.14-16.

12. Dykes, Y. Flexography: Principles and Practices. 5th ed.; Foundation of Flexographic Technical Association, Inc. 1999; pp 6-9.

13. Finna, D. and Jansen, V. Thin-plate technology: The success is the system. *Flexo &Gravure International* **4(12)**(1998) :18-24.

14. Hargreaves, I. Ultra-violet and electron-beam curing systems. In R. H. Leach and R. J. Pierce (eds.), Printing Ink Manual. 5th ed.; Blueprint: London. 1993; pp 661-669.

15. Cusdin, G.B. What plate thickness really works best? *Flexo* **22(3)**(1997) : 90-94.

16. Tabbernor, G. A. Rheology of printing inks. In R. H. Leach and R. J. Pierce (eds.), Printing Ink Manual. 5th ed.; Blueprint: London. 1993; pp 766-775.

APPENDICES

APPENDIX A

STABILITY OF EACH PLATE, INK, AND SUBSTRATE COMBINATION (DYNAMIC SWELLING TEST)

FAH 114 Plate

Table A-1 Printed dots produced in a long-term test using FAH 114 plate, radical ink, and paper

FAH 114 + Radical ink + Paper		
% Dot on film	Printed dot (%) At the beginning	Printed dot (%) After 35,000 impressions
0	0	0
9	45.5	47.3
19	60.9	65
29	67.8	71
39	77.4	82.1
49	88.2	87.6
59	95.4	95.7
70	94.5	95.3
81	96.3	97.7
90	100	100
96	100	100
100	100	100

Table A-2 Printed dots produced in a long-term test using FAH 114 plate, cationic ink, and paper

FAH 114 + Cationic ink + Paper		
% Dot on film	Printed dot (%) At the beginning	Printed dot (%) After 35,000 impressions
0	0	0
9	39.9	49.9
19	56.2	65.7
29	68.8	77.4
39	74.5	87.1
49	83.7	92.4
59	92.1	96.9
70	93.1	98.1
81	94.8	99
90	97.1	99.7
96	98.8	100
100	100	100

Table A-3 Printed dots produced in a long-term test using FAH 114 plate, radical ink, and HGW

FAH 114 + Radical ink + HGW		
% Dot on film	Printed dot (%) At the beginning	Printed dot (%) After 35,000 impressions
0	0	0
9	37.1	44
19	65.7	63.3
29	57.9	66.8
39	69.9	77
49	78.9	83.9
59	89.5	92.5
70	91.4	93.2
81	95.2	96.6
90	99.7	99.7
96	99.7	99.7
100	100	100

Table A-4 Printed dots produced in a long-term test using FAH 114 plate, cationic ink, and HGW

FAH 114 + Cationic ink + HGW		
% Dot on film	Printed dot (%) At the beginning	Printed dot (%) After 35,000 impressions
0	0	0
9	36.9	43.8
19	53.2	63
29	60.8	70.6
39	69.7	84
49	80.9	89.9
59	88.8	94.4
70	92.6	96.8
81	95	98.6
90	98	99.1
96	98.5	98.7
100	100	100

Table A-5 Printed dots produced in a long-term test using FAH 114 plate, radical ink, and PE

FAH 114 + Radical ink + PE		
% Dot on film	Printed dot (%) At the beginning	Printed dot (%) After 35,000 impressions
0	0	0
9	43.9	52.1
19	64.1	73.3
29	71.5	77.6
39	78	84.7
49	88.1	90.6
59	95	93.5
70	95.4	94.3
81	96.4	97.3
90	100	99.1
96	100	99.9
100	100	100

Table A-6 Printed dots produced in a long-term test using FAH 114 plate, cationic ink, and PE

FAH 114 + Cationic ink + PE		
% Dot on film	Printed dot (%) At the beginning	Printed dot (%) After 35,000 impressions
0	0	0
9	46.7	54.9
19	64.2	72.7
29	75.2	80.6
39	80.5	90.7
49	90.6	94.5
59	95.6	97.3
70	97.9	97.6
81	98.1	98.8
90	99.4	99.2
96	99.7	98.5
100	100	100

FAH 170 Plate

Table A-7 Printed dots produced in a long-term test using FAH 170 plate, radical ink, and paper

FAH 170 + Radical ink + Paper		
% Dot on film	Printed dot (%) At the beginning	Printed dot (%) After 35,000 impressions
0	0	0
9	44.6	45.5
19	56	61.2
29	61	66.5
39	76	84
49	84.1	91.3
59	91.4	93.8
70	93.7	97
81	95.3	97.6
90	100	99.2
96	99.4	99
100	100	100

Table A-8 Printed dots produced in a long-term test using FAH 170 plate, cationic ink, and paper

FAH 170 + Cationic ink + Paper		
% Dot on film	Printed dot (%) At the beginning	Printed dot (%) After 35,000 impressions
0	0	0
9	33.1	39.8
19	51	62.1
29	62.7	76
39	71.2	86.6
49	84.2	93.2
59	90.2	97.2
70	93.6	98.5
81	96.2	99.7
90	98.7	99.4
96	99.4	99.4
100	100	100

Table A-9 Printed dots produced in a long-term test using FAH 170 plate, radical ink, and HGW

FAH 170 + Radical ink + HGW		
% Dot on film	Printed dot (%) At the beginning	Printed dot (%) After 35,000 impressions
0	0	0
9	35.3	35.4
19	50.7	56.7
29	54.2	62.9
39	68.8	82.1
49	76	88.6
59	86	94.7
70	90.6	96.5
81	95.2	99.2
90	98.6	100
96	98.7	100
100	100	100

Table A-10 Printed dots produced in a long-term test using FAH 170 plate, cationic ink, and HGW

FAH 170 + Cationic ink + HGW		
% Dot on film	Printed dot (%) At the beginning	Printed dot (%) After 35,000 impressions
0	0	0
9	32.2	33.8
19	45.7	53.2
29	58.8	72.1
39	62.8	80.4
49	76.9	91.8
59	85.4	95.7
70	91.5	97.1
81	96.1	98.5
90	98.1	99.7
96	98.7	99.7
100	100	100

Table A-11 Printed dots produced in a long-term test using FAH 170 plate, cationic ink, and HGW

FAH 170 + Radical ink + PE		
% Dot on film	Printed dot (%) At the beginning	Printed dot (%) After 35,000 impressions
0	0	0
9	48.6	60.4
19	71.4	79.1
29	80.9	89.4
39	89.9	96.6
49	94.7	97.6
59	96.6	95.7
70	98.2	95.5
81	98.5	99
90	99.7	99.1
96	99.5	99.9
100	100	100

Table A-12 Printed dots produced in a long-term test using FAH 170 plate, cationic ink, and PE

FAH 170 + Cationic ink + PE		
% Dot on film	Printed dot (%) At the beginning	Printed dot (%) After 35,000 impressions
0	0	0
9	40.7	49.7
19	63	70.7
29	74.9	88.4
39	81.9	93.6
49	92.2	98.9
59	97.2	98.3
70	98.7	94.8
81	100	95.9
90	100	98.5
96	100	99.8
100	100	100

ACE 114 Plate

Table A-13 Printed dots produced in a long-term test using ACE 114 plate, radical ink, and paper

ACE 114 + Radical ink + Paper		
% Dot on film	Printed dot (%) At the beginning	Printed dot (%) After 35,000 impressions
0	0	0
9	37.1	37.6
19	51.5	55.3
29	60.9	67.7
39	70.9	77.4
49	81.4	89.2
59	86.3	92.9
70	90.5	94.4
81	95	96.9
90	99	99
96	100	99.7
100	100	100

Table A-14 Printed dots produced in a long-term test using ACE 114 plate, cationic ink, and paper

ACE 114 + Cationic ink + Paper		
% Dot on film	Printed dot (%) At the beginning	Printed dot (%) After 35,000 impressions
0	0	0
9	33.1	40.5
19	48.1	57.1
29	57.8	70.9
39	70.2	78.2
49	74	88.2
59	83.5	95
70	89.1	95.8
81	90.7	96.7
90	96.2	99
96	100	99.3
100	100	100

Table A-15 Printed dots produced in a long-term test using ACE 114 plate, radical ink, and HGW

ACE 114 + Radical ink + HGW		
% Dot on film	Printed dot (%) At the beginning	Printed dot (%) After 35,000 impressions
0	0	0
9	33.5	33.4
19	46.6	47.7
29	58.3	65.6
39	65.9	68.9
49	78.7	81
59	82.9	88.8
70	89.9	93
81	94.9	95.4
90	98.2	98.7
96	99.7	99.4
100	100	100

Table A-16 Printed dots produced in a long-term test using ACE 114 plate, cationic ink, and HGW

ACE 114 + Cationic ink + HGW		
% Dot on film	Printed dot (%) At the beginning	Printed dot (%) After 35,000 impressions
0	0	0
9	29.3	37.4
19	45.2	52.6
29	55.5	66.2
39	65	77.7
49	77.1	85.3
59	83.1	92.1
70	91.4	95.1
81	92.1	96.6
90	95.3	98.6
96	98.2	99.2
100	100	100

Table A-17 Printed dots produced in a long-term test using ACE 114 plate, radical ink, and PE

ACE 114 + Radical ink + PE		
% Dot on film	Printed dot (%) At the beginning	Printed dot (%) After 35,000 impressions
0	0	0
9	39.5	45.8
19	53.7	54.1
29	65.6	68.8
39	74.7	77.8
49	84.3	87.6
59	90.4	92.2
70	95	95.1
81	96.4	96.6
90	99.5	99
96	100	99.3
100	100	100

Table A-18 Printed dots produced in a long-term test using ACE 114 plate, cationic ink, and PE

ACE 114 + Cationic ink + PE		
% Dot on film	Printed dot (%) At the beginning	Printed dot (%) After 35,000 impressions
0	0	0
9	41.1	43.5
19	57.1	59.6
29	70.1	73.1
39	83.8	86.1
49	89	90.2
59	91.4	95.2
70	95.5	97.6
81	96.8	97.4
90	97.7	98.3
96	99.8	99
100	100	100

ACE 170 Plate

Table A-19 Printed dots produced in a long-term test using ACE 170 plate, radical ink, and paper

ACE 170 + Radical ink + Paper		
% Dot on film	Printed dot (%) At the beginning	Printed dot (%) After 35,000 impressions
0	0	0
9	38.2	56.7
19	52.1	82.1
29	63.5	89.5
39	70.8	95.1
49	78.6	97.7
59	84.3	100
70	89.1	100
81	89.6	99.1
90	97.1	100
96	98.1	100
100	100	100

Table A-20 Printed dots produced in a long-term test using ACE 170 plate, cationic ink, and paper

ACE 170 + Cationic ink + Paper		
% Dot on film	Printed dot (%) At the beginning	Printed dot (%) After 35,000 impressions
0	0	0
9	33.5	40.7
19	49	59.8
29	59.1	74.1
39	68.4	82.4
49	76.7	85.9
59	83.9	90
70	88.1	95.5
81	89.5	95
90	98	98.1
96	98.2	98.6
100	100	100

Table A-21 Printed dots produced in a long-term test using ACE 170 plate, radical ink, and HGW

ACE 170 + Radical ink + HGW		
% Dot on film	Printed dot (%) At the beginning	Printed dot (%) After 35,000 impressions
0	0	0
9	33.8	48
19	52.1	79.9
29	57.7	89.9
39	65.6	90.6
49	73.6	92.5
59	82	93.2
70	88.6	92.7
81	91.8	96.7
90	97.6	98.4
96	98.9	98.5
100	100	100

Table A-22 Printed dots produced in a long-term test using ACE 170 plate, cationic ink, and HGW

ACE 170 + Cationic ink + HGW		
% Dot on film	Printed dot (%) At the beginning	Printed dot (%) After 35,000 impressions
0	0	0
9	30.6	33
19	43.1	49.6
29	55.8	65.4
39	66.8	74.7
49	78.6	81.4
59	87.5	88.5
70	91.4	93
81	93.4	95.3
90	97.6	98.6
96	100	99.8
100	100	100

Table A-23 Printed dots produced in a long-term test using ACE 170 plate, radical ink, and PE

ACE 170 + Radical ink + PE		
% Dot on film	Printed dot (%) At the beginning	Printed dot (%) After 35,000 impressions
0	0	0
9	42	65
19	55.5	92.3
29	70.6	91.9
39	75.3	92.6
49	84.8	90.1
59	90.2	88.3
70	93.3	88.6
81	95.3	94.5
90	98.9	96.3
96	99.6	97.3
100	100	100

Table A-24 Printed dots produced in a long-term test using ACE 170 plate, cationic ink, and PE

ACE 170 + Cationic ink + PE		
% Dot on film	Printed dot (%) At the beginning	Printed dot (%) After 35,000 impressions
0	0	0
9	59.5	48.9
19	60.5	69
29	67.2	79.7
39	77.1	82
49	87.2	84.6
59	91.9	91.1
70	96.6	92.1
81	96.6	96.5
90	99.3	98.9
96	100	98.9
100	100	100

Sprint 114 Plate

Table A-25 Printed dots produced in a long-term test using Sprint 114 plate, radical ink, and paper

Sprint 114 + Radical ink + Paper		
% Dot on film	Printed dot (%) At the beginning	Printed dot (%) After 35,000 impressions
0	0	0
9	46.8	46.2
19	53.7	58.6
29	65.4	66.6
39	72.1	76.8
49	79.2	85.4
59	86.2	90.9
70	94.4	93.7
81	93.2	96.1
90	96.7	98.5
96	97.9	99.4
100	100	100

Table A-26 Printed dots produced in a long-term test using Sprint 114 plate, cationic ink, and paper

Sprint 114 + Cationic ink + Paper		
% Dot on film	Printed dot (%) At the beginning	Printed dot (%) After 35,000 impressions
0	0	0
9	44.3	65
19	56.8	72.2
29	67.1	74.9
39	75.4	81.4
49	81.4	88.5
59	90.7	91.7
70	96.4	95.4
81	99.7	96.9
90	98.3	98.4
96	99.7	100
100	100	100

Table A-27 Printed dots produced in a long-term test using Sprint 114 plate, radical ink, and HGW

Sprint 114 + Radical ink + HGW		
% Dot on film	Printed dot (%) At the beginning	Printed dot (%) After 35,000 impressions
0	0	0
9	47.5	40.6
19	39.4	43.4
29	52.4	53.3
39	56.8	63.3
49	67.1	72
59	78.6	83.6
70	91.9	89.3
81	91.9	95
90	96.4	97.6
96	98.4	99
100	100	100

Table A-28 Printed dots produced in a long-term test using Sprint 114 plate, cationic ink, and HGW

Sprint 114 + Cationic ink + HGW		
% Dot on film	Printed dot (%) At the beginning	Printed dot (%) After 35,000 impressions
0	0	0
9	37	54.8
19	53.2	63.3
29	58.8	67.8
39	71.4	79.9
49	78.7	84.6
59	84.9	90
70	93.4	94.9
81	97.3	98.8
90	99.4	99.4
96	97.9	99.6
100	100	100

Table A-29 Printed dots produced in a long-term test using Sprint 114 plate, radical ink, and PE

Sprint 114 + Radical ink + PE		
% Dot on film	Printed dot (%) At the beginning	Printed dot (%) After 35,000 impressions
0	0	0
9	58.6	50.4
19	51	59.9
29	65.1	64.4
39	66.8	76.3
49	77.7	83.6
59	85.3	88.7
70	92.9	92.5
81	95.8	96.1
90	97	98.6
96	97.9	99.1
100	100	100

Table A-30 Printed dots produced in a long-term test using Sprint 114 plate, cationic ink, and PE

Sprint 114 + Cationic ink + PE		
% Dot on film	Printed dot (%) At the beginning	Printed dot (%) After 35,000 impressions
0	0	0
9	50.6	66.7
19	63.1	73.3
29	67.8	84.9
39	77.8	84.9
49	84.7	91.5
59	87.9	94.5
70	96.9	97.5
81	97.4	98.6
90	99.1	99.9
96	99.2	100
100	100	100

Sprint 170 Plate

Table A-31 Printed dots produced in a long-term test using Sprint 170 plate, radical ink, and paper

Sprint 170 + Radical ink + Paper		
% Dot on film	Printed dot (%) At the beginning	Printed dot (%) After 35,000 impressions
0	0	0
9	34.2	39.7
19	42.5	50.5
29	52.7	59.6
39	61.3	67.4
49	70.6	74.9
59	78.1	81.9
70	81	85.7
81	89.7	89.7
90	96.2	95.8
96	98.4	97.6
100	100	100

Table A-32 Printed dots produced in a long-term test using Sprint 170 plate, cationic ink, and paper

Sprint 170 + Cationic ink + Paper		
% Dot on film	Printed dot (%) At the beginning	Printed dot (%) After 35,000 impressions
0	0	0
9	44.2	62.3
19	56.1	74.1
29	66	79.3
39	74.3	84.6
49	77.9	89.1
59	82.7	92.4
70	84.2	92.4
81	89.4	94.4
90	92.7	97.8
96	96.1	99.3
100	100	100

Table A-33 Printed dots produced in a long-term test using Sprint 170 plate, radical ink, and HGW

Sprint 170 + Radical ink + HGW		
% Dot on film	Printed dot (%) At the beginning	Printed dot (%) After 35,000 impressions
0	0	0
9	30.1	31.7
19	31.7	36.4
29	40.9	46.3
39	51.4	53.6
49	62	62.8
59	75.9	77
70	84.7	83.2
81	88.4	89.9
90	94.8	95.4
96	99	98
100	100	100

Table A-34 Printed dots produced in a long-term test using Sprint 170 plate, cationic ink, and HGW

Sprint 170 + Cationic ink + HGW		
% Dot on film	Printed dot (%) At the beginning	Printed dot (%) After 35,000 impressions
0	0	0
9	32.2	60
19	44.3	70.7
29	54.5	78.3
39	62.9	81.7
49	69.1	86
59	76.3	90.1
70	85.9	92.6
81	87.9	94.1
90	93.8	97.2
96	97.4	98.4
100	100	100

Table A-35 Printed dots produced in a long-term test using Sprint 170 plate, radical ink, and PE

Sprint 170 + Radical ink + PE		
% Dot on film	Printed dot (%) At the beginning	Printed dot (%) After 35,000 impressions
0	0	0
9	41.6	45.7
19	43	54
29	51.6	60.2
39	60	62.9
49	70.6	71.5
59	81.5	83
70	89.3	89
81	94.2	94.3
90	97	97.9
96	99.2	99.1
100	100	100

Table A-36 Printed dots produced in a long-term test using Sprint 170 plate, cationic ink, and PE

Sprint 170 + Cationic ink + PE		
% Dot on film	Printed dot (%) At the beginning	Printed dot (%) After 35,000 impressions
0	0	0
9	58.5	83.2
19	66.4	84.2
29	75.9	88.7
39	80.3	86.4
49	82.6	90.5
59	86.4	91.7
70	92.1	93.9
81	93.8	95.7
90	96.3	97.7
96	98.4	97.8
100	100	100

APPENDIX B

STABILITY OF EACH PLATE/ INK COMBINATION

(STATIC SWELLING TEST)

- **Solid area**

Table B-1 Thickness of the plate samples measured before and after the swelling tests

Sample number	Thickness (before the test) micron	Thickness (after the test) micron
1	1153	1223
2	1153	1263
3	1706	1800
4	1709	1832
5	1143	1123
6	1139	1222
7	1156	1207
8	1156	1217
9	1720	1774
10	1732	1780
11	1591	1581
12	1582	1682

Table B-2 Hardness of the plate samples measured before and after the swelling tests

Sample number	Hardness (before the test) Shore A	Hardness (after the test) Shore A
1	78.8	71.7
2	79.2	70.1
3	72.2	62.9
4	72.1	62.2
5	76.2	78.1
6	75.8	76.0
7	77.0	72.2
8	76.9	72.1
9	71.8	64.5
10	71.7	64.5
11	72.4	71.6
12	73.0	65.6

Table B-3 Weight of the plate samples measured before and after the swelling test

Sample number	Weight (before the test) (g)	Weight (after the test) (g)
1	1.9490	2.0824
2	1.9468	2.1643
3	2.7703	2.9442
4	2.7752	2.9985
5	2.3627	2.3416
6	2.3589	2.5483
7	1.9575	2.0410
8	1.9518	2.0637
9	2.7887	2.8990
10	2.7976	2.9121
11	2.9591	2.9554
12	2.9548	3.1316

- **Screen area**

Table B-5 Thickness of the plate samples measured before and after the swelling tests

Sample number	Thickness (before the test) micron	Thickness (after the test) micron
1	1135	1215
2	1148	1276
3	1705	1792
4	1704	1837
5	1098	1153
6	1099	1286
7	1165	1229
8	1173	1232
9	1718	1771
10	1717	1785
11	1588	1632
12	1581	1766

APPENDIX C

PRELIMINARY STUDY

The preliminary of the thesis was conducted at the department of Imaging and Printing Technology, Chulalongkorn University.

Plate Thickness (Micrometers)

Table C-1 Thickness of the plates measured by a thickness gauge

Ink applying time (hours)	Solvent-washable plate	Water-washable plate
0	1179	1176
4	1194	1176
8	1206	1176
12	1218	1179
16	1225	1183
20	1228	1187

Plate Hardness (Shore A)

Table C-2 Hardness of the plates measured by a durometer

Ink applying time (hours)	Solvent-washable plate	Water-washable plate
0	75.5	72
4	73.5	72.5
8	72.5	72
12	72	73
16	71.5	72
20	71	72

Discussion

The test

Unlike the printing condition, this test is carried out without the effects of printing impression, high temperature during print run, and printing speed. These effects would increase the penetration of the ink into the photpolymer plate. Therefore, the printing result would be more influenced by the presence of ink penetration.

About the mechanical forces in the printing nip, some properties related to an elastic modulus are not well analyzed since the instrument for measuring the resilience of the photopolymer is not available.

The results

Physical properties:

As shown in Table 6, the thickness of the plate increases with an increasing in ink applying time. This is because the penetration of the ink into the photopolymer surface leads the swelling to occur. Table 7 shows another result of the ink penetration, softening, which reduces the photopolymer plate's hardness. This reduction also increases when the ink applying time is increased.

Both water-washable and solvent-washable plates are influenced by the presence of ink penetration. The water-washable plate has more stability in both thickness and hardness than the solvent-washable plate, which can be determined as a better print quality and less print variations

VITA

Mr. Supachai Theravithayangkura was born on March 31, 1978 in Bangkok, Thailand. He received his B.Sc. degree in Photographic Science and Printing Technology from the Faculty on Science, Chulalongkorn University in 1999, and he has been a graduate student in the Imaging Technology Program, Graduate school, Chulalongkorn University since November 1999.