CHAPTER III

EXPERIMENTAL

3.1 Materials

3.1.1 Printing plates

5 photopolymer plates with same thickness (1.70 mm)

a) nyloflex® FAH 170

b) nyloflex® ACE 170

c) nyloflex® FAH DII170

d) nyloflex® ACE DII170

e) DuPont® DPU 67

3.1.2 UV Flexo ink : BASF® Ultraking FLS Process Cyan VW 42501

3.1.3 Printing substrates : Jac BRILLANT WEISS 30080 Gussgestr

3.1.4 Tesaprint ® 52382 (0.38 cm)

3.1.5 Ethanol

3.1.6 Hydrosolv

3.2 Apparatus

3.2.1 Thickness gauge

3.2.2 Hardness gauge : Hätermeßgerät ® von Bareiss

3.2.3 Densitometer : TECHKON® R 410

3.2.4 VIP® flex 334 vipflex Flexo Eye V.5.09

3.2.5 Exposure Unit and Aftertreatment : Combi FIV

3.2.6 Wascher Unit :Combi FV

3.2.7 Printing press : Nilpeter® , Model

3.2.8 Anilox roll : 400/3.0 l/cm.

3.2.9 Computer to Plates imaging : Hell ® F 1200

3.2.10 Film imaging : AGFA® SelectSet Avantra 25E

3.2.11 Contact angle meter : FACE® Model CA-A

3.2.12 Microscope : Olympus® BH-2

3.3 Procedure (14)

3.3.1 Evaluation of plate making parameters.

A test was made for each plate type in order to determine the suitable processing time to be used in the making the plate.

3.3.1.1 Wash out test

3.3.1.1.1 Four printing plate pieces which had not been pre-exposed through the plate back were cut to a size of 12 x 17 cm (4.7x7 inches).

3.3.1.1.2 A covering lamina had placed on each raw plate piece, and then full area had exposed in the exposure unit for 10 minutes.

3.3.1.1.3 Now the plate pieces had washed out at different flow speeds in the continuous flow washer. The first plate piece washed out at 240 mm/min., the second plate piece 200 mm/min., the third at 160 mm/min., and the fourth at 120 mm/min.

3.3.1.1.4 The plate pieces are dried for approx. 15 minutes (this drying time is only applicable for the test.

3.3.1.1.5 After drying, the thickness is measured at the washed-out spots.

The wash-out depth was the difference to the standard depth. But we have chosen the plate, which have thickness 1700 μm so the desired relief depth is 900 μm, the wash-out time at which a relief depth of 1000 μm has been achieved is used. But in this case the relief depth factor which acceptable will be 850 ± 50 μm

The figure 3-1 demonstrates the connection between the relief depth and the wash-out time. The measured values are the difference between the previously determined plate thickness and the remaining thickness of the washed-out plate pieces.

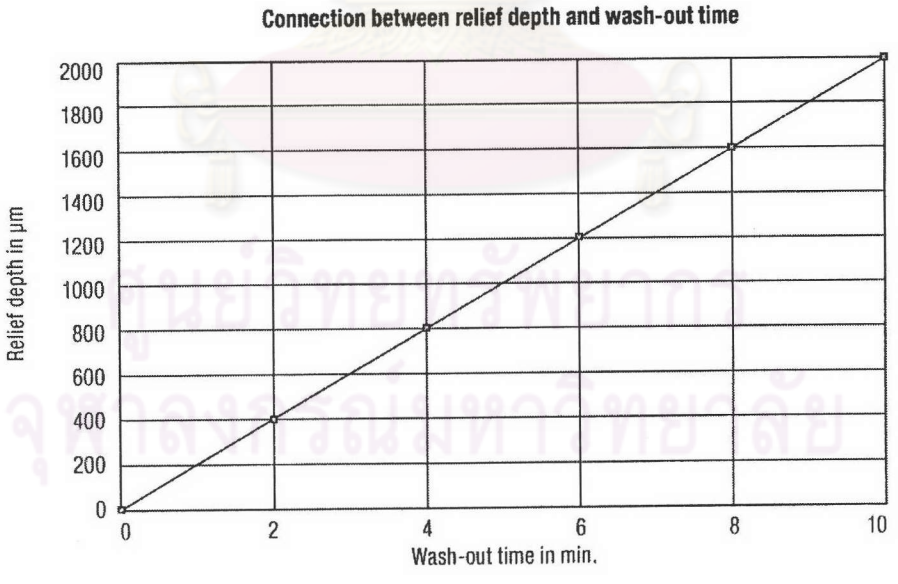

Figure 3-1 Display for wash-out process.

3.3.1.2 Continuous flow washer

With the use of continuous washers, printing plate is first punched with a punch and then hanged into the transport rail which pulls the plates one after the other through the wash-out, cleaning and pre-drying unit. The necessary wash-out time follow from the brush contact pressure, the type and condition of the solvent and the flow speed. The printing plate leaves the device pre-dried and with a clean black. A separate cleaning step is no longer necessary.

While room temperature is sufficient for washing-out solvent is heated up to an operating temperature of 30° C ± 1°C. This level must be maintained in every type of washer.

3.3.1.3 Plate-back pre-exposure test

3.3.1.3.1 At first, a plate is cut to a size of 20 x 48 cm and then placed with the relief layer down onto the vacuum plate of the exposure unit. The front side and back side can easily be identified by testing at a corner of the plate which film can be detached. This is always exclusively the film of the front side. For the time being, this protective layer remains on the plate. A vacuum is not required in the pre-exposure test.

If the vacuum plate is not equipped such that it is free from reflections, a reflection-free background should be ensured during pre-and main exposure.

3.3.1.3.2 Prior to the beginning of the exposure, the plate piece is covered with an opaque lamina which has the size of the test areas of the test

negative. The first area remains covered all the time, the stepped exposure begins with the second area figure 3-2.

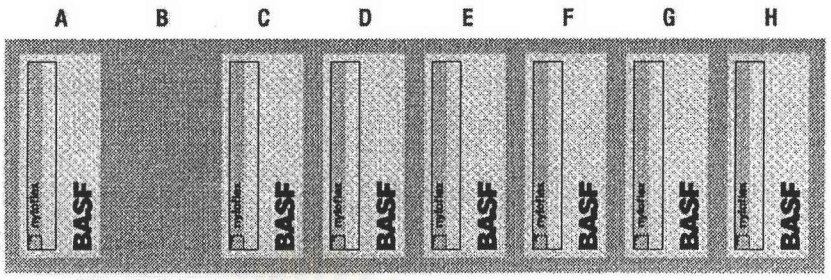

Figure 3-2 Pre-exposure test technique.

3.3.1.3.3 The second step is exposed 10 seconds, then the cover plate is shifted from position C to position B so that the third area is uncovered. This one is exposed for 20 seconds. Then the cover plate is shifted from position D to position C, and an exposures in 10-second steps. Normally, 8 steps are exposed figure 3-3 Depending on the plate type (plate thickness), these time will vary.

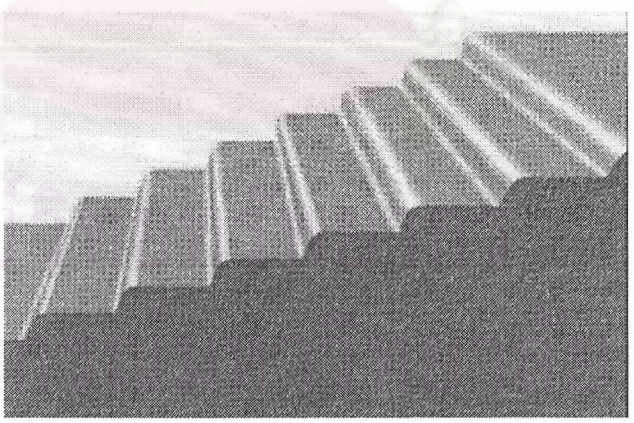

Figure 3-3 Profile of the test plate with different pre-exposure times.

The exposed printing plate is now washed out depending on the desired relief depth in accordance with the time determined in the wash-out test. For the

measurement of the different steps, the printing plates must then be dried for approx. 15 minutes.

The reason for the recommended extra in order to achieve a 200 μm deeper relief depth is as follows between the lower part of the layer which has been polymerized through the plate-back pre-exposure and the upper part which has not been polymerized, there is a transition phase in which the material is partly polymerized. This partly polymerized material should be washed out as far as possible in a thoroughly polymerized zone.

The extension of the wash-out time is necessary because this material will detach more slowly.

The selection of the relief depth should be made according to the following criteria

- Halftone or line
- Substrate, and
- Machine condition

The plate-back pre-exposure test must be made individually for every new plate batch.

3.3.1.4 Main exposure test

3.3.1.4.1 For the main exposure test, raw printing plate is cut to a size of 20 x 48 cm.

3.3.1.4.2 The full area of the raw plate is exposed with the previously determines pre-exposure time through the plate back.

3.3.1.4.3 The raw plate is turned (relief layer up), and the protective film is removed. The print test negative is placed on the printing with the matted layer side down. The edges of the printing plate are covered with profiled strips of film in order to guarantee a perfect vacuum and to prevent the vacuum film is rolled over the plate with a uniform pull. In order to remove air trappings fast, it is recommendable to rub the vacuum film with a rubber roller or an anti-static cloth. Trapped dust particles will show, and it is absolutely necessary to remove them from transparent negative areas in order to avoid exposure faults.

3.3.1.4.4 As the plate-back exposure, the correct main exposure time is determined by means of a stepped exposure test figure 3-4.

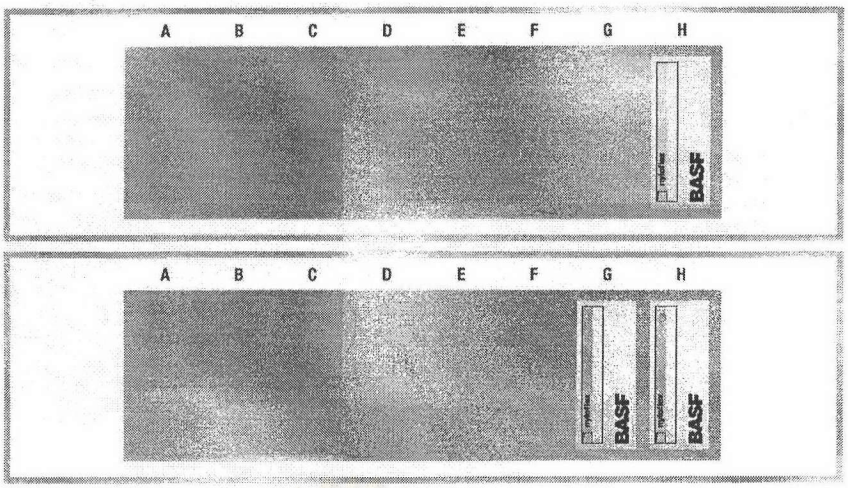

Figure 3-4 Main exposure test technique.

3.3.1.4.5 The exposure printing plate is washed out and dried. The correct exposure time can be seen from the different development stages of the relief details. Steps which have been developed too shortly show too strongly washed-out halftone areas and wavy line.

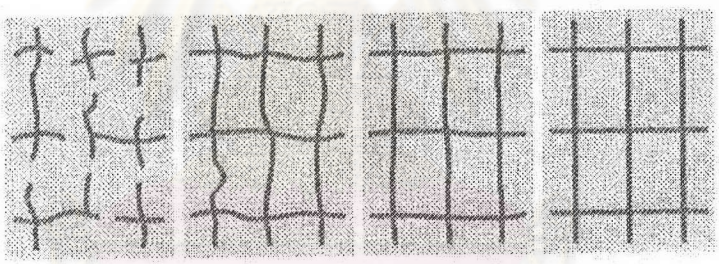

Figure 3-5 Effect of different exposure time on a line grid.

3.3.1.5 Upper and lower exposure limits

For the printing plates in thicknesses from 0.76-3.18 mm., the following limits apply:

The lower exposure limit is the time with which

- Isolated dots with a diameter of 200 μm ,
- A line grid with 55μm lines, and

- A halftone with a 2 % tone value are well anchored with an up to 0.7 mm relief depth.

The upper exposure limit is the time with which the intermediate depth of a reverse dot with a 400 µm diameter is at least 70 µm. this is the case, if the relief depth between the thick lines of the solid area obviously decreases in figure 3-6.

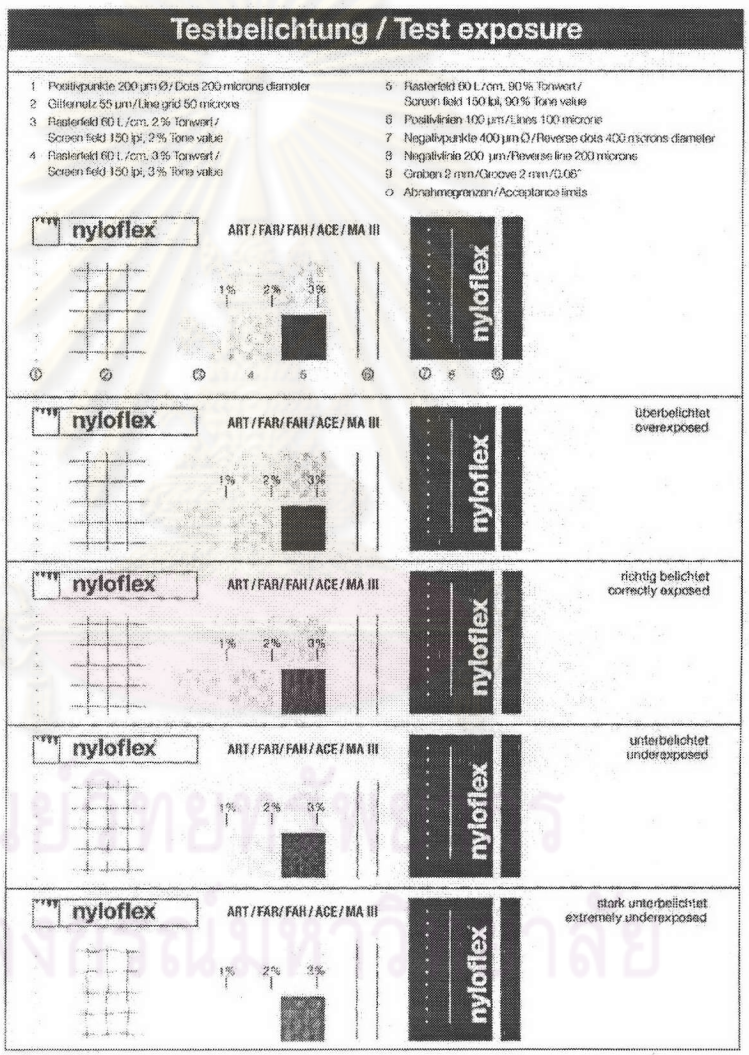

Figure 3-6 Evaluation of upper and lower exposure limits.

3.3.1.6 Drying

The washed-out printing plate is placed in a drying cabinet equipped with a hot air blower. The recommended drying time for a 170 mm. thick plate is 2 hours at a temperature of 65°C as given in the table 3-1.

Plate type/Thickness	**nylosolv®**
ART/FAR/FAH/ACE/FE 0.76 to 1.14 mm/0.030-0.045"	2h / 65 °C(149 °F)
ART/FAR/FAH/ACE 1.70 to 3.18 mm./0.067-0.125"	2-3 h / 65 °C (149 °F)

Table 3-1 Recommended drying time. **(14)**

3.3.1.7 Post exposure

The post exposure can be made before or together with the light aftertreatment. For the post exposure, the front side of the monolayer plate is exposed to UV light in the aftertreatment device or exposure unit without vacuum film. The post exposure and the main exposure should be select at the same times . This way, we will guarantee that the plate is well and thoroughly polymerized and is optimal with regard to its hardness, compressibility, solvent and crack resistance. Recommendation : post exposure time 10-15 minutes. **(15)**

3.3.1.8 UVC light after treatment

The exposure of the printing plate to short-wave UVC light makes the plate surface non-sticky again. In this process, the printing plate remains glossy so that the result of the UVC light aftertreatment cannot be checked visually. It can only be felt.

The stickiness is determined by pressing the ball of the hand onto it, proceeding in 3-minute steps and checking the stickiness after each step. The optimal time must not be exceeded substantially, since in this case there would be the risk that cracks will from, above all in the partly polymerized area. For the same reason, no printing plate should be exposed to the aftertreatment immediately out of the drying cabinet while it is still warm; the printing plate should first cool down.

During the UVC light aftertreatment, special care should be taken that the required drying time are observed. A premature light aftertreatment may fix remaining swellings in the plate, and the result will be thickness deviations in the finished plate. The length of the light aftertreatment with UVC light differs depending on the device and the plate type.

Too long exposure time will make the plate surface brittle. Cracks may appear. Cracks also occur, if the UVA / UVC light aftertreatments are made at the same time and the temperature in the light aftertreatment device rises too much. Care must be taken that the temperature in the light aftertreatment device remains constant. If this is not the case, the result may be changed in the times determined.

3.3.2 Print quality test

3.3.2.1 Preparation of plate quality test

The above steps are the plate preparation for quality testing. Each measurement of the relief value from each plate type has to nearly to each other because of the relief dept will effective on angle of screen.

3.3.2.2 Printing plate for quality test

It is quite difficult to compare the quality of each plate type after printing because of the different printing condition. Especially the effective of plate impression to substrate will effect the printing quality. We cannot use the same impression for every type of plate because the printing result will not complete and cannot evaluate print performance. So firstly this experiment will adjust plate impression just to touch the substrate with full print area.

3.3.2.3 Definition printing quality test

Evaluate the print result by using the roundness factor of gain. The diameter from top to bottom and from left to right should be ± 10 μm. All print results which has gain property according to this range can evaluate with other print result.

3.3.3 Ink Transfer test

3.3.3.1 Sample preparation

Cut the plate to a rectangular shape size of 10 x 15cm. The size of the test area should be 8x 9 cm.. There will be a total of 5 different plates with ten plates per sample. Then die cut the substrate to 10x15 cm. and remove to check weight.

3.3.3.2 Printing sample

Install the new anilox roll 400/3.0 l/cm and put the new substrate into the press. Test and set up the plate to plate cylinder then run the press at a speed of 10 rpm for approximately 10 minutes then stop. Remove the substrate to the before exposure unit both after and before printing the weight total of 10 samples

Remove the used plate from the plate cylinder and measure the weight of the plate. Use the value from the measurement to calculate the amount of ink transfer in every element. Then change and set the new type plate to the cylinder and repeat the above procedure.

3.3.1.3 Calculation of ink transfer coefficient to the difference position.

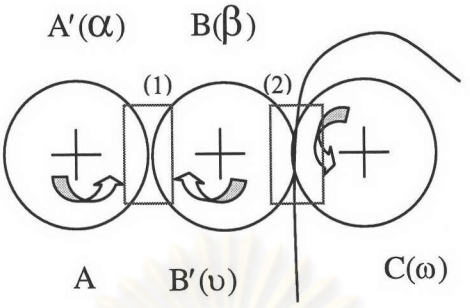

Figure 3-7 Schematic boundaries of ink transfer representation.

Two boundaries of ink transfer nip are established as shown in figure 3-7 to obtain equations :

1st Boundary

$$(A+B') = \beta(A+B') + \alpha(A+B') \quad (1)$$

$$\beta+\alpha = 1 \quad (2)$$

2nd Boundary

$$\beta(A+B') = \upsilon\beta(A+B') + \omega\beta(A+B') \quad (3)$$

$$\omega+\upsilon = 1 \quad (4)$$

From equation (3),the quantity of ink on plate and substrate of the printing are defined as :

$$B' = \upsilon\beta(A+B') \quad (5)$$

$$C = \omega\beta(A+B') \quad (6)$$

Thus , ink transfer coefficient will be obtained

From equation (6),

$$\beta = C / \omega(A+B') \quad (7)$$

From equation (5), (7)

$$\upsilon = B'\omega / C \quad (8)$$

From equation (4), (8)

$$\omega = 1 / (1+(B'/C)) \quad (9)$$

From equation (4), (9)

$$\upsilon = 1- (1 / (1+(B'/C))) \quad (10)$$

Note that ; from equation (7), (9)

$$\beta = C (1+(B'/C))/ (A+B') \quad (11)$$

From equation (2), (11)

$$\alpha = 1- C (1+(B'/C))/ (A+B') \quad (12)$$

Where :

A	Ink quantity on anilox roll before transferred to the plate
A′	Ink quantity on anilox roll after transferred to the plate
B	Ink quantity on plate before transferred to substrate
B′	Ink quantity on the plate after transferred to substrate
C	Ink quantity on substrate after printing.
α	Ink transfer coefficient of anilox roll after transferred to plate
β	Ink transfer coefficient of plate before transferred to substrate
υ	Ink transfer coefficient of plate after transferred to substrate
ω	Ink transfer coefficient of substrate