

Newsinks and fountain solution

1995

Newsinks and fountain solution. (1995). In Newsprint and Newsink Economy and Quality in the Face of Rising Prices : Workshop, Hong Kong, 13-14 June 1995. Singapore: Asian Media Information & Communication Centre.

<https://hdl.handle.net/10356/86727>

**Newsinks
&
Fountain Solution**

Session 5:

Newsinks

Composition and properties
Testing and handling
New developments

Fountain solution

Basics
Recommendation
Handling

The role of ink

- Form a coherent layer on the paper.
 - Account to about 1 to 2% of the total newspaper weight
 - Ink in non-image area --> bad quality
 - Laboratory method can help but will never replace a trial on the press.
 - Newsinks are often manufactured to suit the needs of a particular newspaper. Parameters used: location, needs of advertisers, press, general quality level. It will fix the price.
-



The composition of a printing ink

Composed of three distinct parts:

- a pigment
- a vehicle
- additives.

Pigment

- Colouring agent. Dispersed in a very fine grained form.
- For black ink: carbon black (incomplete burning of hydrocarbons).
- In the production process, pigments go through a surface treatment.

Vehicle

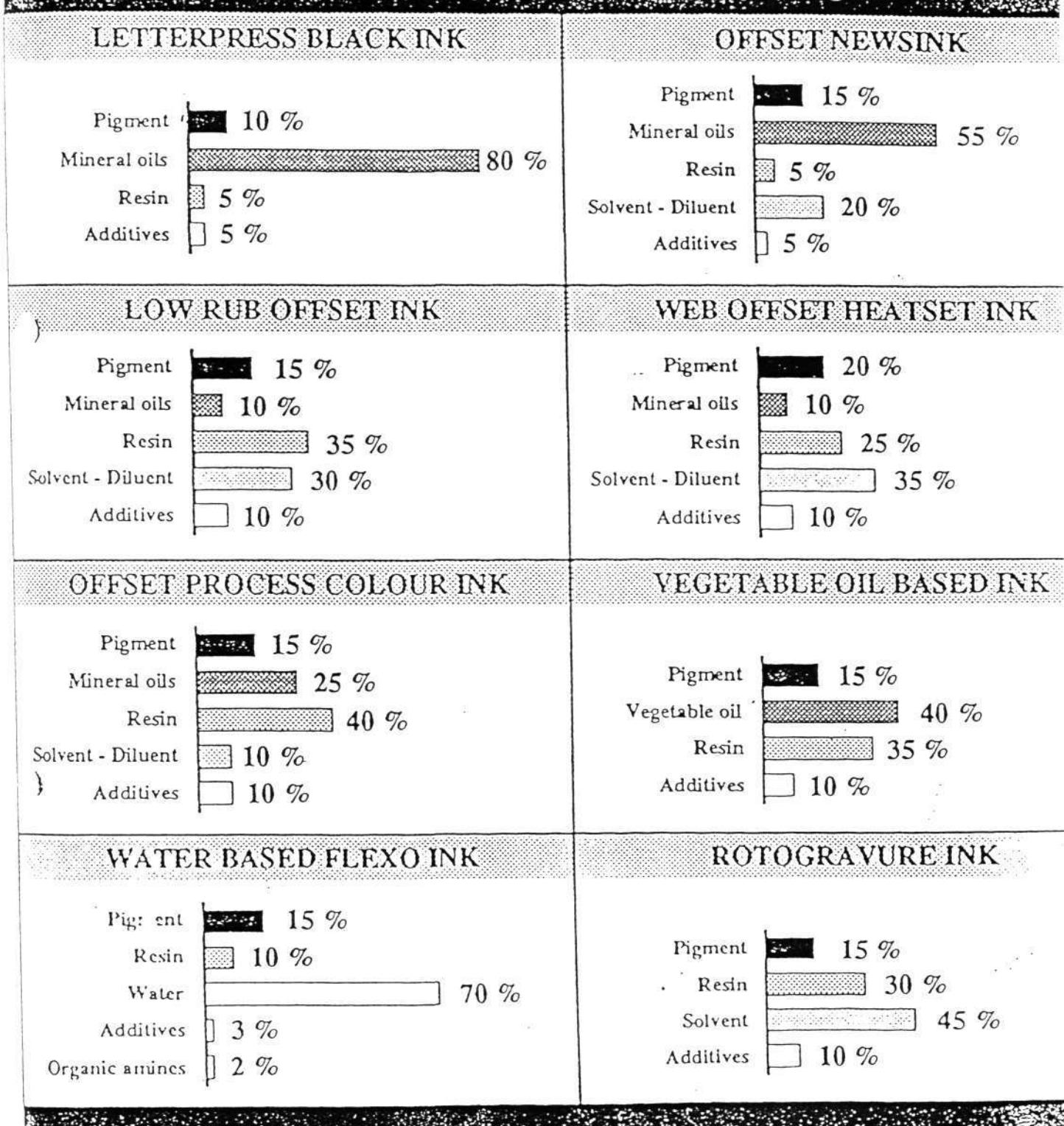
- Transportation of the pigment and to give the ink its final aspect after drying.
- The vehicle is composed of a hard resin, a solvent and a diluent

Additives

- May be used to adjust flow, set-off characteristics, print-through, ink transfer...



Approximative composition of different printing inks



Ink	Temp. °C	General behaviour of the ink	Relaxation period s	Viscosity Stable viscosity level	Viscosity Fixed shear rate, 250 s ⁻¹	Yield value	Phase lag	Thixotropy	Rec. time s
G	23	Almost Newtonian	~0.8	15 Pas at 30 s ⁻¹ 2 Pas at 200 s ⁻¹	15 Pas * 2 Pas *	No	75°-80°	No	Immediate
	40	Newtonian				No	80°-83°		
R	23	Distinct Pseudoplastic	~0.5	4 Pas at 230 s ⁻¹ 2 Pas at 220 s ⁻¹	3.5 Pas 1.5 Pas	~15 Pa <10 Pa	35°-65° 25°-55°	Strong	~200
	40	Distinct Pseudoplastic							
S	23	Weak pseudoplastic	~10	5 Pas at 370 s ⁻¹ 2.5 Pas at 370 s ⁻¹	5.5 Pas 3 Pas	No	62°-66°	Weak ~3 s ⁻¹	~60
	40	Almost Newtonian				No	60°-66°		
H1	23	Almost Newtonian	~0.5	10 Pas at 230 s ⁻¹ 2 Pas at 360 s ⁻¹	10 Pas 2 Pas	No	62°-67°	No	~110
	40	Weak pseudoplastic				No	65°-67°		
H2	23	Distinct Pseudoplastic	~0.5	8 Pas at 150 s ⁻¹ 2.5 Pas at 230 s ⁻¹	7 Pas 2 Pas	No	70°-74°	Weak ~5 s ⁻¹	~30
	40	Distinct Pseudoplastic				No	70°-74°		
Ref	23	Weak pseudoplastic	~0.3	5 Pas at 150 s ⁻¹ 1.5 Pas at 240 s ⁻¹	4 Pas * 1.5 Pas	No	60°-66°	Strong ~2 s ⁻¹	~45
	40	Weak pseudoplastic				No	48°-62°		





VISCOSITY

Definition

The resistance of a fluid to flow is called viscosity. Because of this resistance, energy must be continuously added in order to maintain the flow of a liquid.

Viscosity gives expression to the drag which adjacent layers of a fluid exert on each other when subjected to a shear force. Figure 1 illustrates the situation in the basic geometry of fluid flow, namely flow between parallel plates. Ink flow as it occurs in the press is a modification of the flow described by this simple geometry.

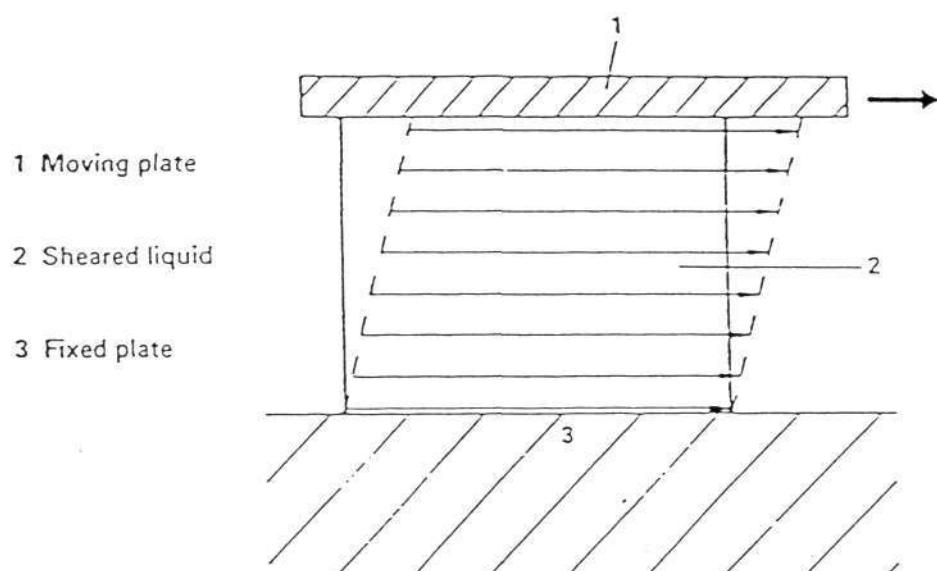


Figure 1. The flow of a liquid between two parallel plates.

The entire flow behaviour of an ink is depicted by the flow curve or rheogram which shows the relationship between a dimensionless speed, the shear rate D (s^{-1}) and the resulting force per unit area, the shear stress τ (Pa).

Shear rate gives expression to the drop of speed (in the direction of the applied force) over the thickness of the liquid layer. The force per unit in plain area needed to maintain a given shear rate is called the shear stress.

Two typical flow curves are shown in Figure 2. The basic parameter is viscosity which is defined as the ratio

$$\eta = \frac{\tau}{D}$$

where η is the viscosity (Pa s)
 τ is the shear stress (Pa)
 D is the shear rate (s^{-1})

When the relationship between shear stress and shear rate is linear, viscosity is independent of shear rate and then the fluid is called a Newtonian fluid. In other cases, more than one



Shear rate (s^{-1})	Viscosity (Pa s)	Change in viscosity (Pa s/ s^{-1})
1	50 ± 10	2.8000
10	25 ± 5	0.1100
10 ²	15 ± 5	0.0100
10 ³	6 ± 2	0.0002
10 ⁴	4 ± 1	≤ 0.0001

Shear rates ranging from 0 to 10^2 (s^{-1}) can occur in different regions of a roller nip, influencing ink transfer. This is one reason why the complete prediction of ink behaviour requires knowledge not only of the viscosity at a given shear rate but also the whole rheogram of the ink, i.e. the shear stress vs. shear rate relationship. For practical purposes, however, it suffices to cover a shear rate range of two powers of ten. Ink transfer mechanisms are dealt with in more detail in Chapter 6.

Temperature	(°C)	10	23	40
Viscosity	(Pa s)	13.1	7.8	2.9

Viscosity measurements should therefore be made at a standard temperature — most commonly at 23°C. In addition, the temperature dependence of the viscosity should be checked by determining the viscosity at different temperatures, preferably at 40°C, to take into account temperature increases in the press and, say at 10°C to represent low temperature storage conditions. High viscosity at low temperature may cause difficulties in ink pumping, whereas low viscosity at an increased temperature may contribute to excessive ink penetration into the paper in the printing nip.

Determination methods

Newsink viscosity is measured using a viscometer. Most viscometers in use operate according to one or other of the following principles:

- Coaxial cylinder
- Cone/plate
- Falling rod

INK REQUIREMENT

Definition:

amount of ink required per unit paper surface area to give a certain print density

Units:

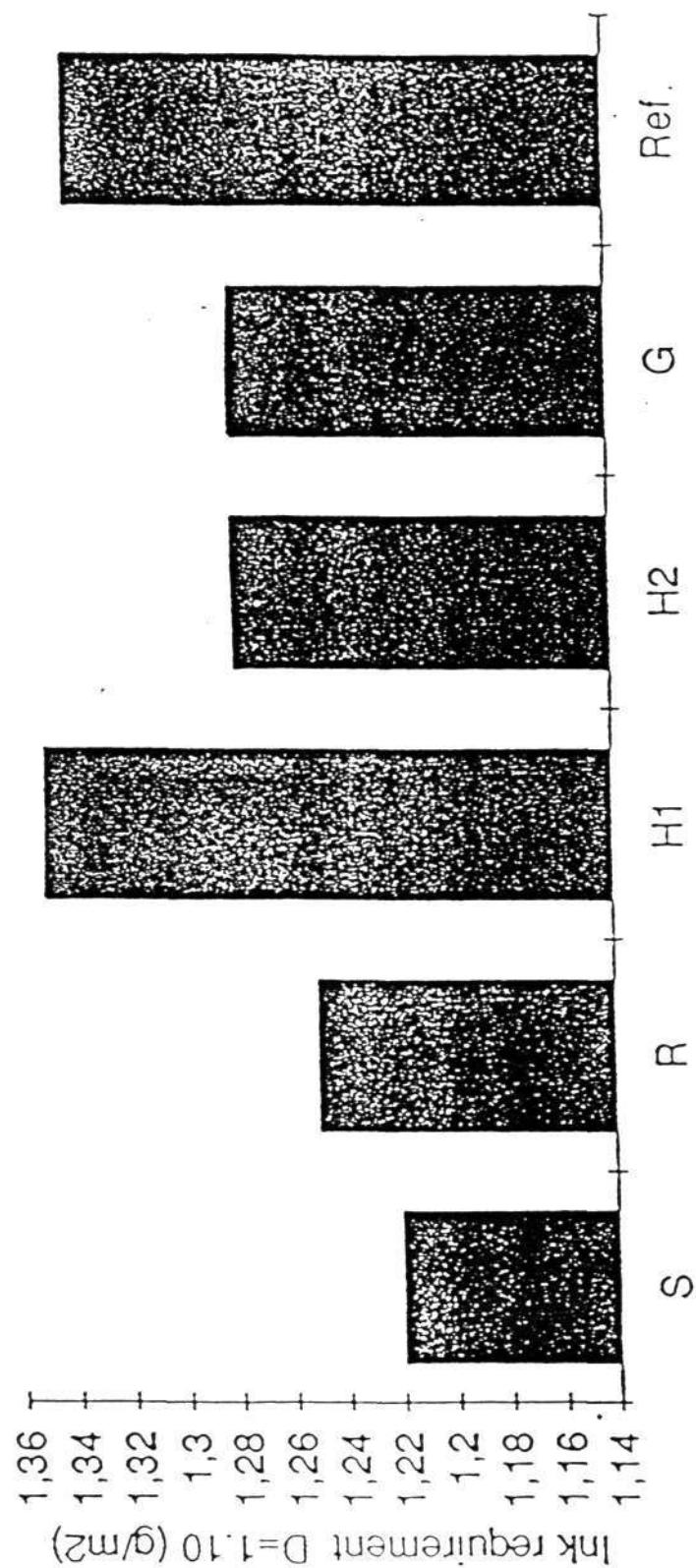
g/m^2

Normal values:

in a test of 32 European black inks
the ink requirement varied from
 1.05 to 1.65 g/m^2

The more ink is required for certain density, the more water is needed leading to more emulsification, smudging etc.



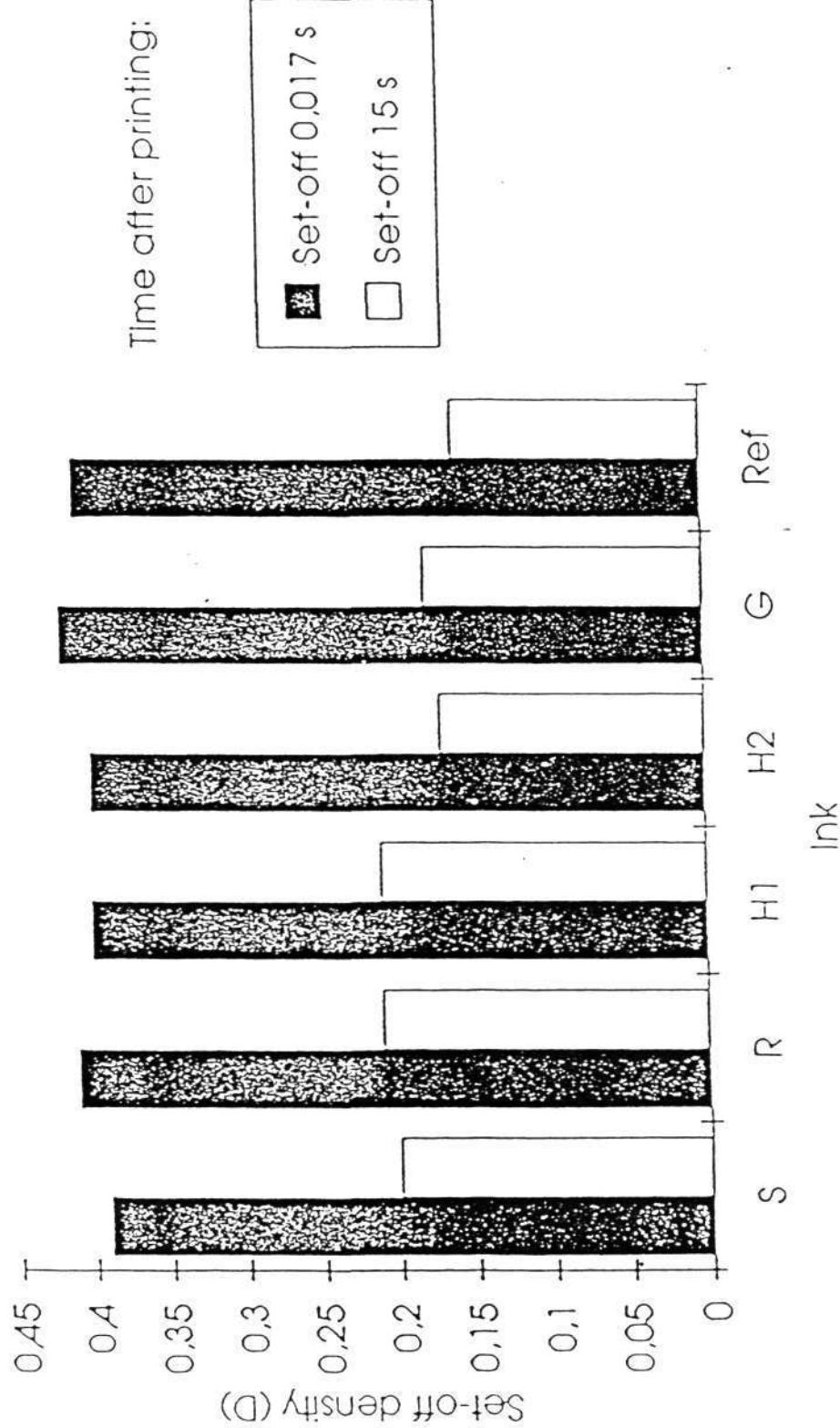


Set-off is ink attaching to other surfaces (cylinders, roller bars, opposite page) *immediately after printing.*

Tested in a test device which has two nips. The first to apply ink and the second to bring a test paper in contact with the ink. Density of the test paper is measured.

Rub-off is ink attaching to other surfaces when the surface is rubbed *1 - 24 hours after hours printing.*

Tested by a special device where a specified weight (50gr.) is covered with paper and rubbed against the printed surface. Density of the rubbing paper is measured.





Special Report

MATERIALS (1)

1.7

Correlations between Ink Measuring Methods and Printing Results

In general, we recommend the printer to set in-house target values and tolerances for ink printability properties. General guidelines for these values are given in Chapter 4 of this report, but they should be agreed upon individually (including measuring methods) by the printer and the ink manufacturer.

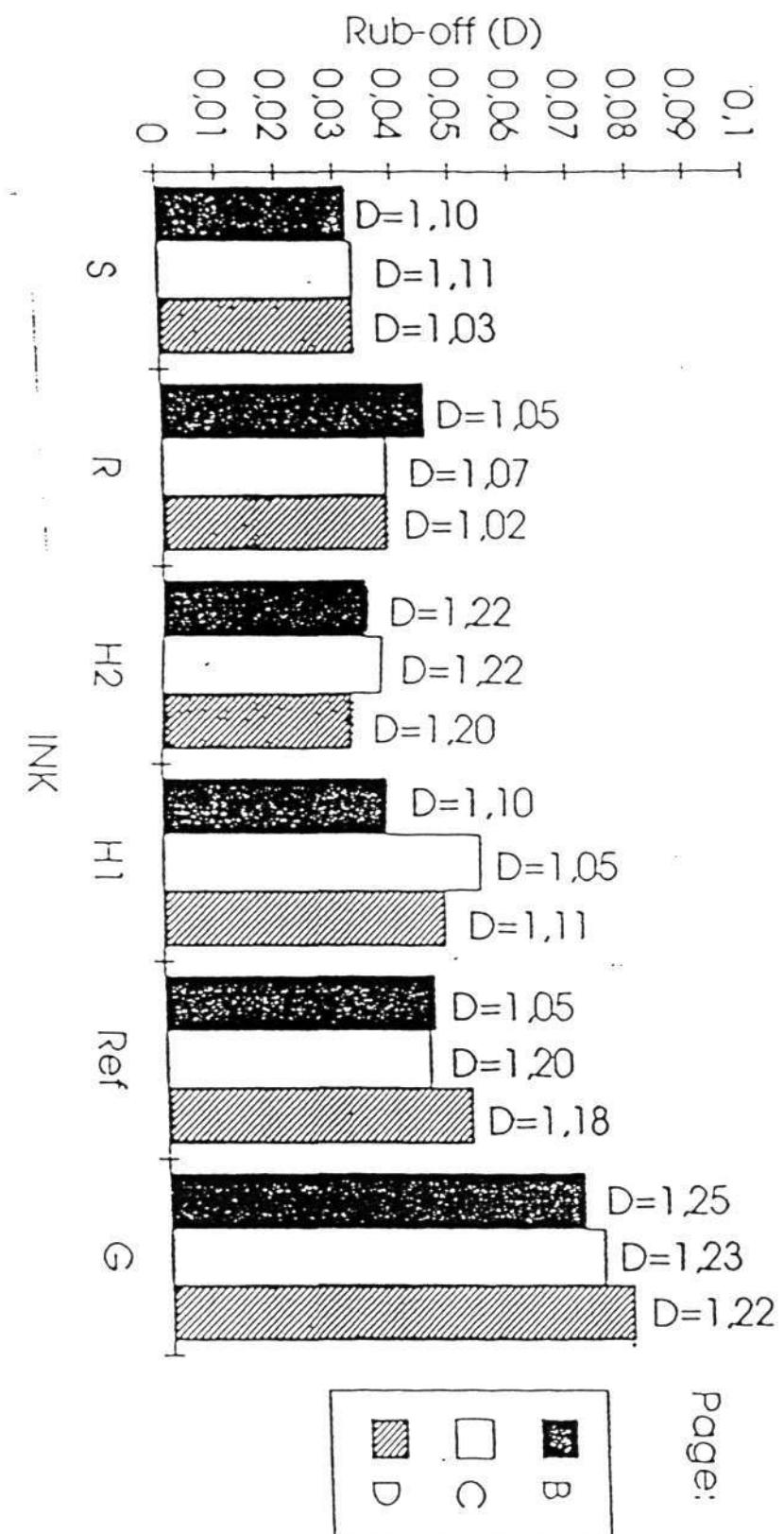
Following measurements (described in the IFRA Newsprint and Newsink Guide Chapter 5.4) can be considered as suitable for newspapers:

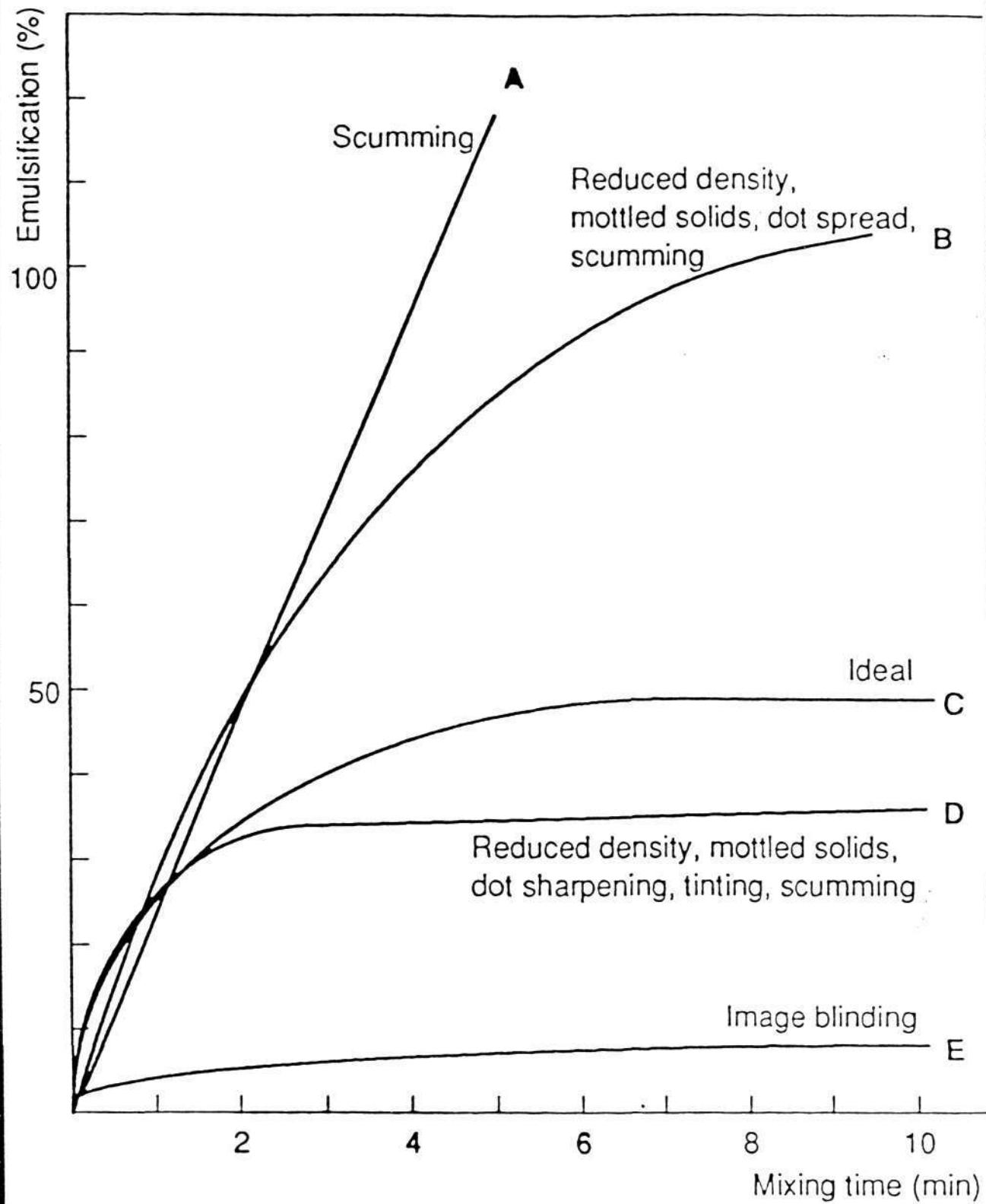
- ink mileage
- print through
- set-off
- rub-off

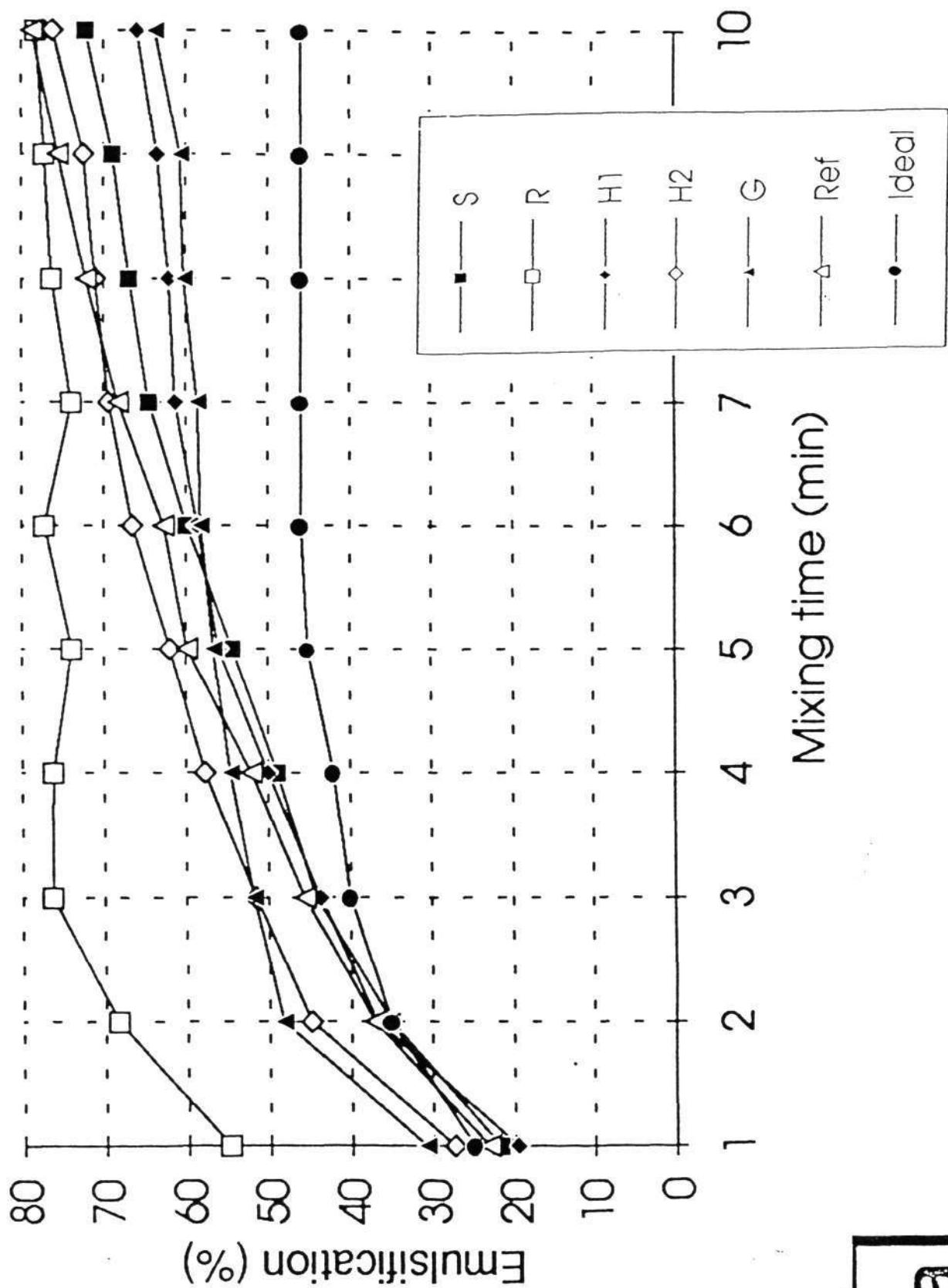
They can be used by specifying the testing conditions — such as test press (IGT or Prüfbau), paper grade (standard newsprint 40 or 45 g/m²), and test performer (preferably the ink manufacturer). In principle, each delivery should be checked against these in-house target values.

Regarding ink runnability, we recommend the rheological properties to be specified individually for each combination of press and ink type (ink manufacturer). This is done by determining the properties of inks with good on-press behaviour. Adequate measuring methods have again been given in the IFRA Newsprint and Newsink Guide Chapter 5.4 for ink viscosity, yield value (ink length) and tack. The testing conditions should always be specified.









2. damping solution

materials:

1. paper

plan

date

1. Standard news print:

Haindl Schongau 42,5 / 45 / 48,8 g/m²
 Norske Skog 45 g/m²
 Enso 45 g/m²
 Stora 45 g/m²
 Stracel 45 g/m²

Improved newsprint:

Haindl Schongau 48,8 g/m²
 Norske Skog 48,8 g/m²
 (300 sheets)

for ink metering and set-off:

Haindl Schongau:

Soganorm st 48,8 g/m²

Sogatop
recycl. spez. im 48,8 g/m²

2 x 3 rolls

2. Hostmann-Steinberg Hydrofix

Hostmann-Steinberg:
Substifix HD 10 kg

2. paper

arrivals

date

2. damping solution

arrivals

date

2. damping solution

arrivals

date

2. damping solution

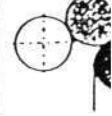
arrivals

date

09.03.1994

21.02.1994

21.02.1994

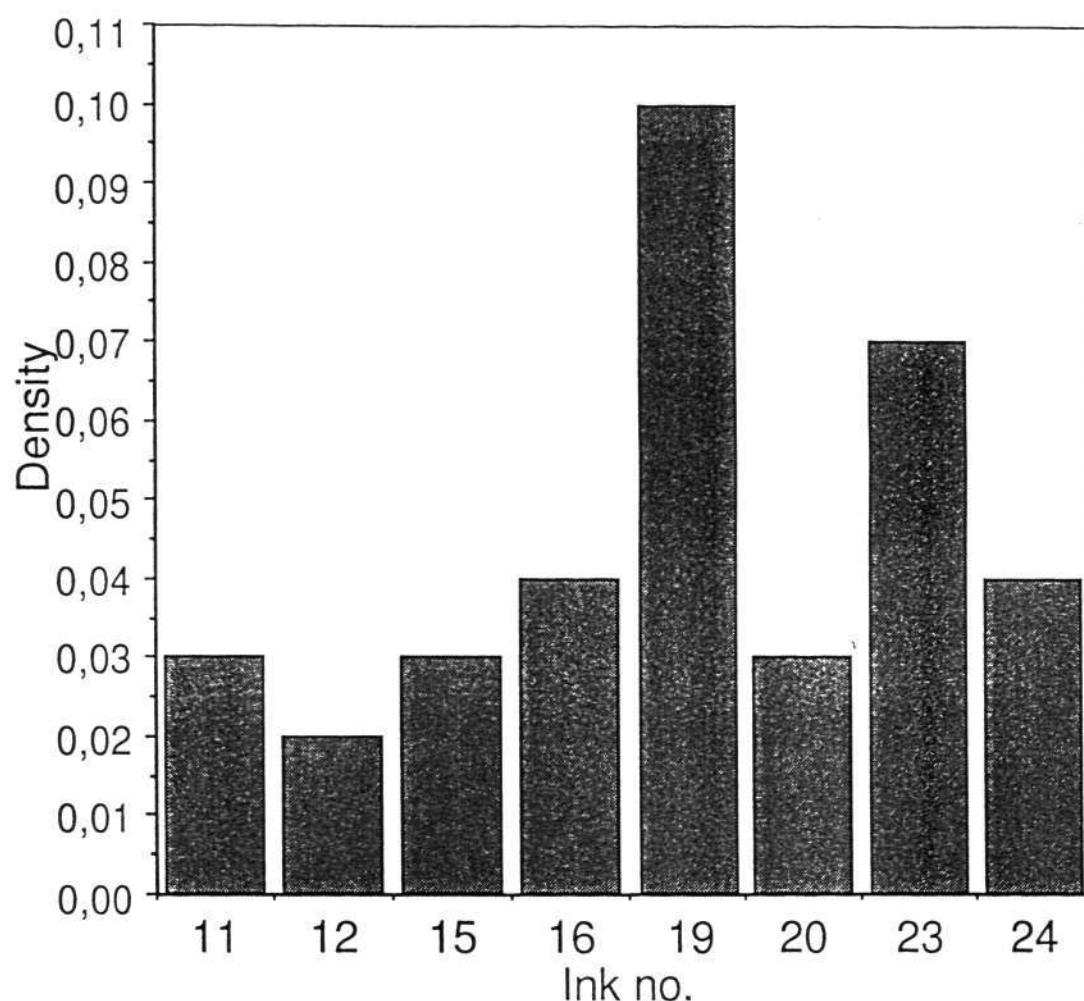


plan	date	materials : inks
Trenal BASF - K & E Hostmann-Steinberg Lindgens Sun Chemicals Gebr. Schmidt	16.05.1994	
per Standard ink black cyan optimised ink black cyan 1 kg		arrivals
		standard cyan vegetable oil based test blue vegetable based test blue mineral + vegetable based standard black vegetable oil based test black vegetable based
	1 kg 1 kg 1 kg 1 kg 1 kg	1 kg 1 kg 1 kg 1 kg 1 kg
Hostmann-Steinberg	21.02.1994	
per Standard ink black cyan optimised ink black cyan 1 kg		Rollotemp. - Blau Intensiv - Blau Rollotemp. - Schwarz Rollotemp. - Schwarz Rollotemp. - Schwarz
	4 x 2,5 kg 10 kg 10 kg 10 kg 1 kg	Skala Skala Schwarz Schwarz Schwarz
Lindgens	25.03.1994	
		Muster A, Cyan, normal pigm. Muster B, Cyan, höher pigm.
Sun Chemicals	25.04.1994	
		coldset web offset ink stand. process cyan coldset web offset ink strong process cyan coldset web offset ink stand. black coldset web offset ink strong process black
	1 kg 1 kg 1 kg 1 kg	1 kg 1 kg 1 kg 1 kg
Gebr. Schmidt	23.05.1994	
		Ro - zet - Blau Ro - zet - Blau Ro - zet - Schwarz Ro - zet - Schwarz
	1 kg 1 kg 1 kg 1 kg	1 kg 1 kg 1 kg 1 kg
additional: Siegwerk	02.06.1994	
		Roll - O-set - ZO - Cyan Roll - O-set - ZO - Cyan Roll - O-set - ZO - Schwarz Roll - O-set - ZO - Schwarz
	1 kg 1 kg 1 kg 1 kg	1 kg 1 kg 1 kg 1 kg
	11.04.1994	

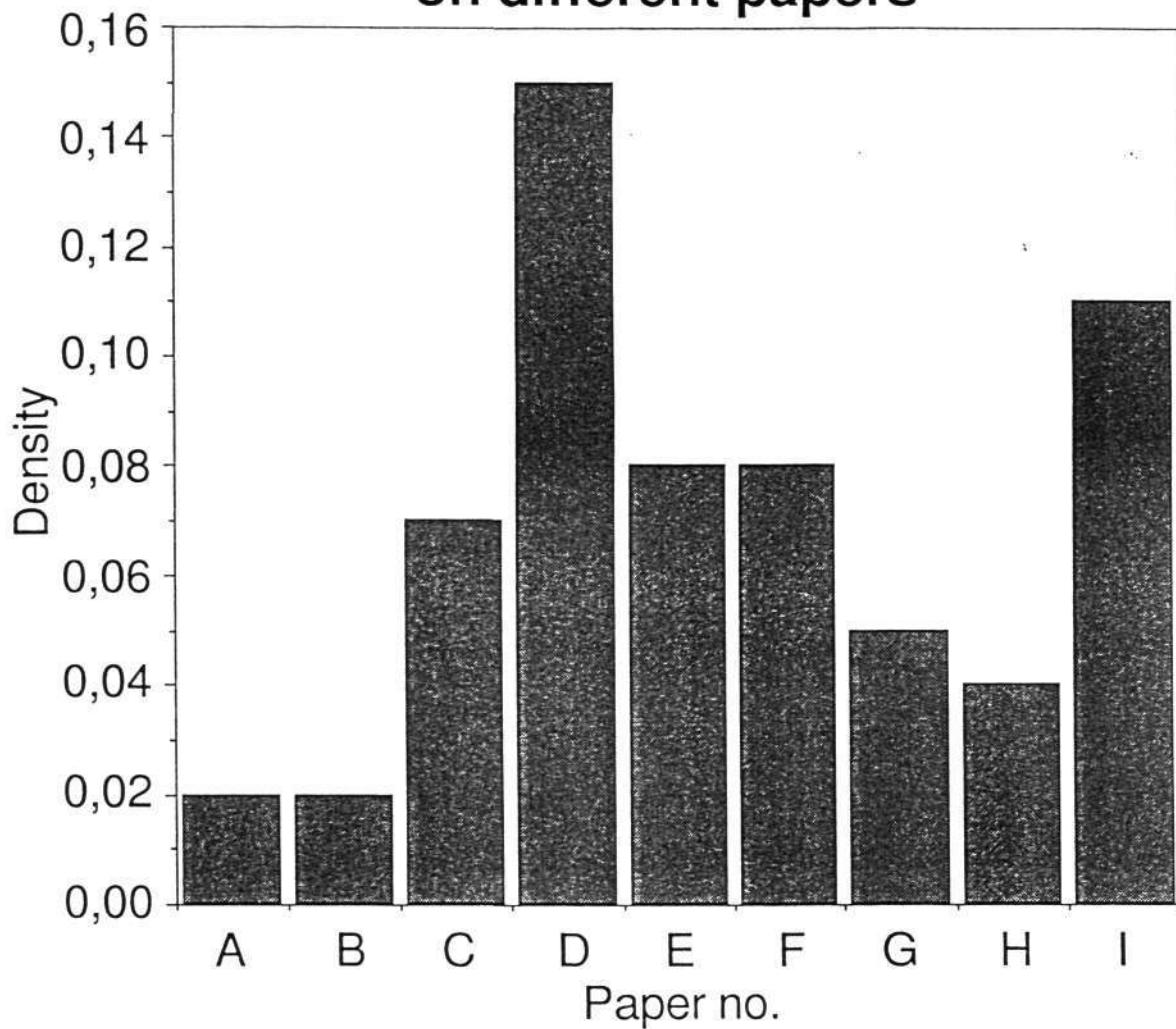
Properties	Paper						
	A	B	C	D	E	F	G
Ash content [%]	9.5	8.0	10.1	0.3	1.2	0.4	0.9
Sheet thickness [µm]	62.3	69.3	70.3	80.3	73.0	73.6	67.6
Sheet density [g/cm ³]	0.68	0.65	0.69	0.61	0.67	0.66	0.77
Roughness (Bendtsen) [ml/min]	227	211	237	152	123	122	78
at 10 N/cm ² , 15 mbar	225	186	203	124	107	125	96
Smoothness (Bekk), [s] at 10 N/cm ²	23 27	27 30	29 26	39 38	52 50	51 57	64 52
Smoothness (Bekk 10), [s] at 100 N/cm ²	239 240	205 232	265 251	261 257	293 288	347 374	432 366
Pliability (Bekk 10 / Bekk)	10.39	7.59	9.10	6.69	5.63	6.80	6.75
Oil absorption (Cobb-Unger) [g/m ²] against oil, 15 sec.	20.0 19.8	21.7 20.3	21.3 16.7	28.5 20.8	20.0 22.7	18.8 16.8	23.0 21.7
Air permeability [ml/min] at 100 mm WS	226	216	225	225	173	153	318
Brightness [%]	60.8 60.9	61.0 61.2	61.2 61.1	60.6 59.9	62.2 61.9	61.1 61.2	78.1 77.6
Opacity [%]	95.5	96.6	97.7	97.1	96.7	97.2	93.3



Rub-off test for different inks



Rub-off test of ink no.12 on different papers



It is assumed that, in the case of inks, viscosity and the composition of the binding agent have an important influence on the absorption and rub-off behaviour.

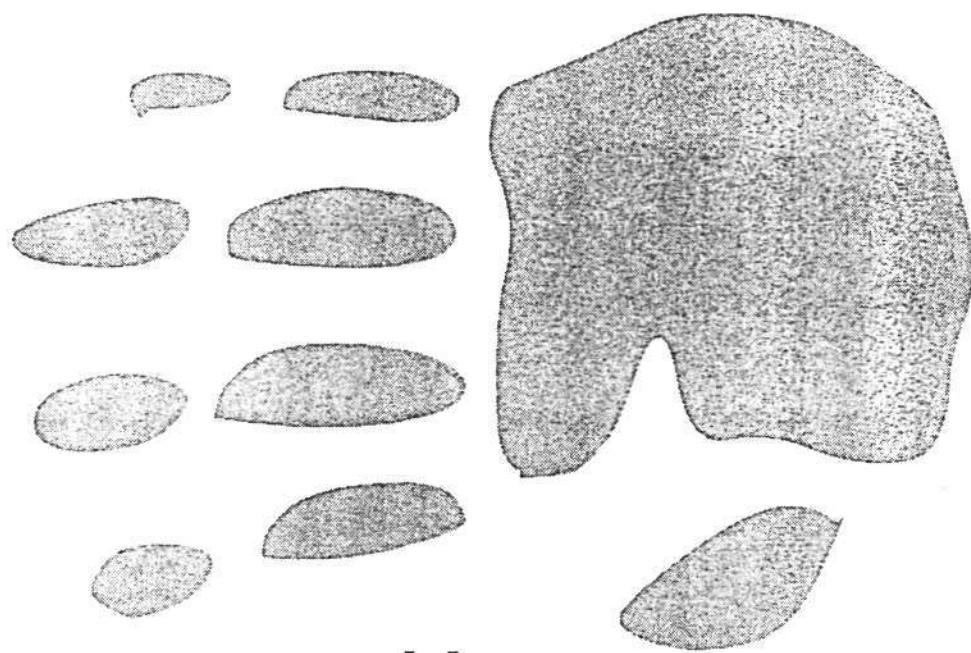
For the different types of paper, it was attempted to discover the causes for different rub-off densities in the characteristics of the paper concerned: (see paper characteristic values in section 1)

Of the tested materials, good papers have

- a high percentage of filler and a comparatively high sheet density,
- a high degree of surface roughness,
- a higher degree of hardness (pliability),
- a medium to low oil absorption capacity, although, for example, paper G from the medium paper group does not always correspond to these characteristics.

During the meeting of experts held in March 1994/5/ to discuss the runnability and printability of newsprint containing recycled paper, it was established that such newsprint has a higher density and is smoother than paper containing virgin fibres. An improvement in absorption capacity is achieved with a rougher paper surface produced by soft calandering. This is confirmed also by the test results of this research project.



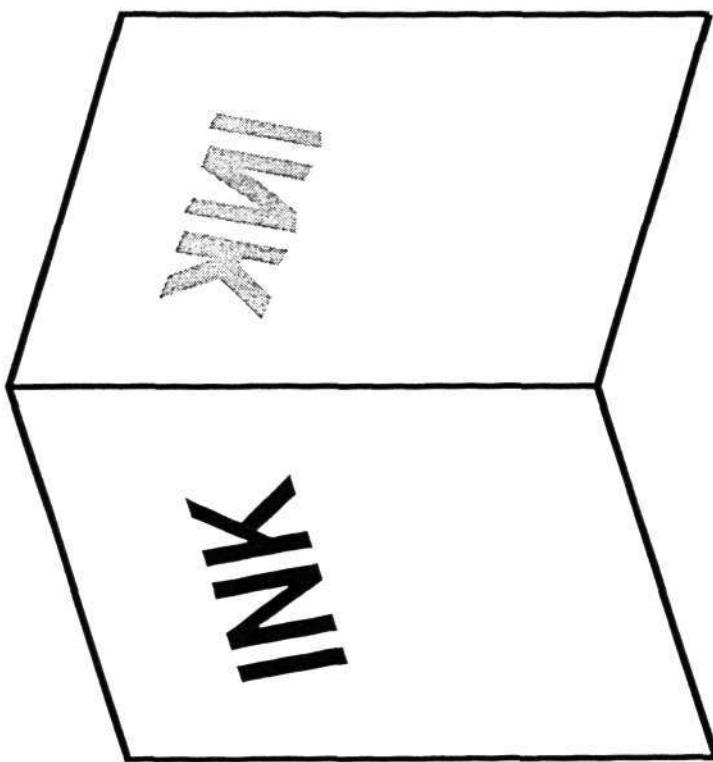


Complaint no. 1
in relation to newspapers:

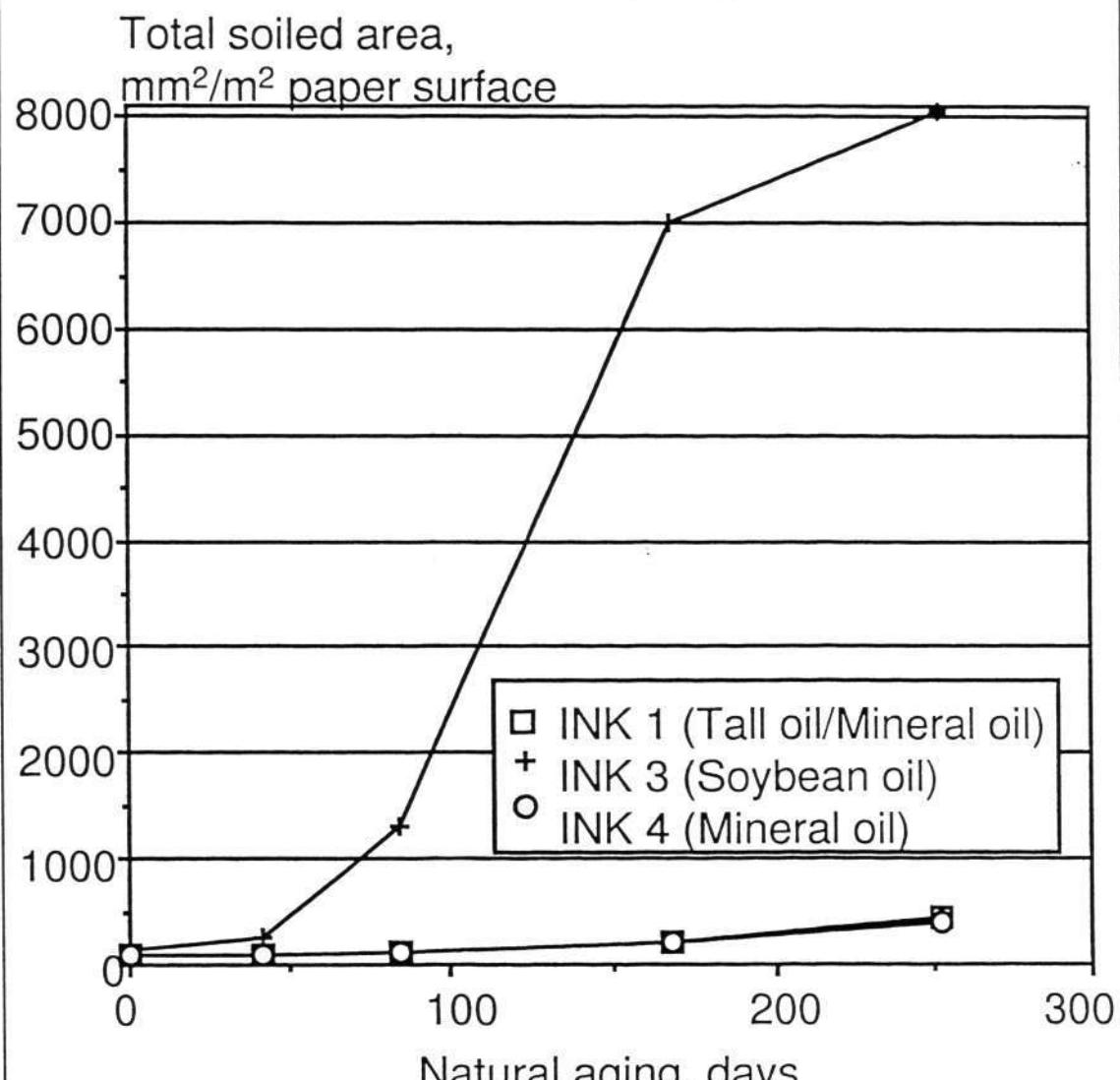
Ink rub-off!



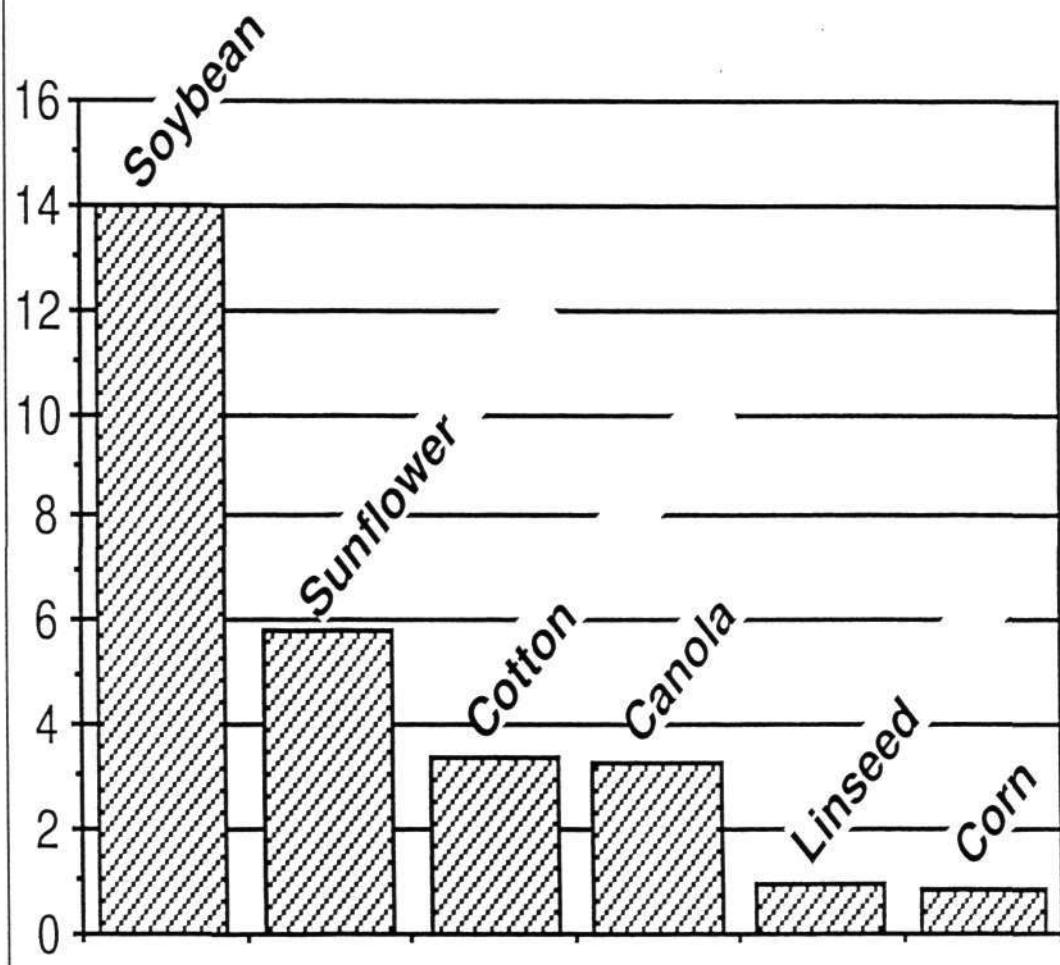
Complaints in relation to set-off:



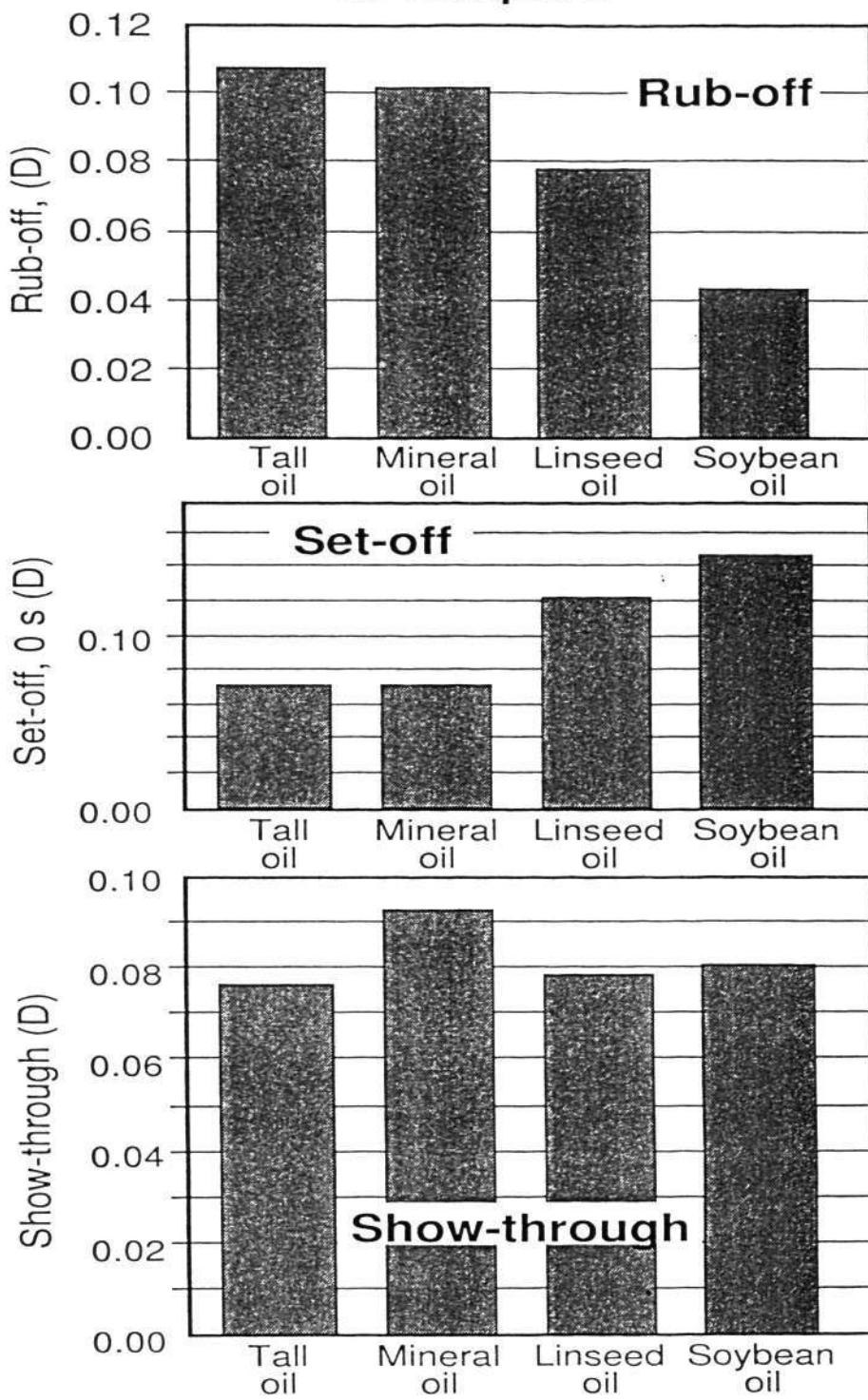
Natural aging

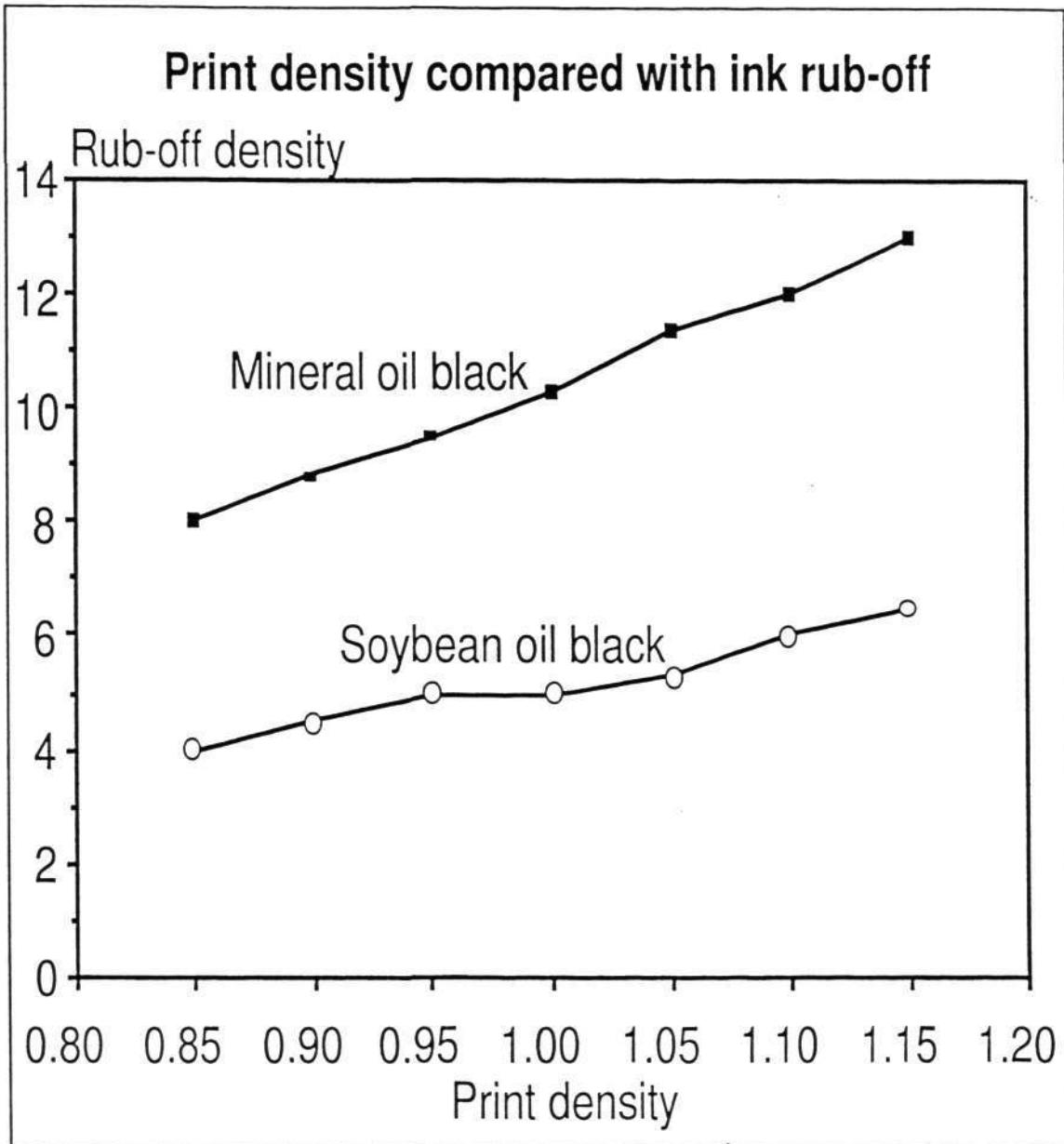


World production of vegetable-based oils (Total production in millions of tonnes)



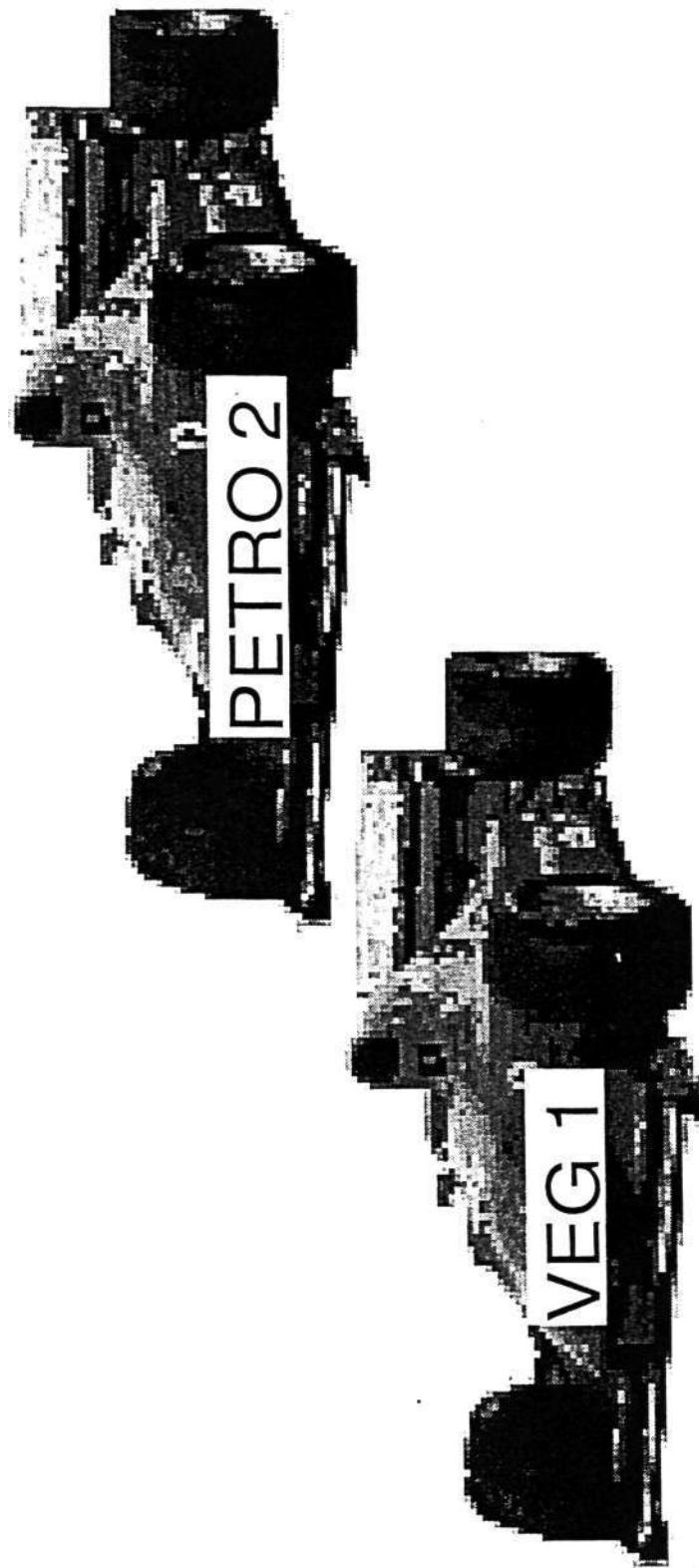
VTT tests at Aamulehti in Tampere

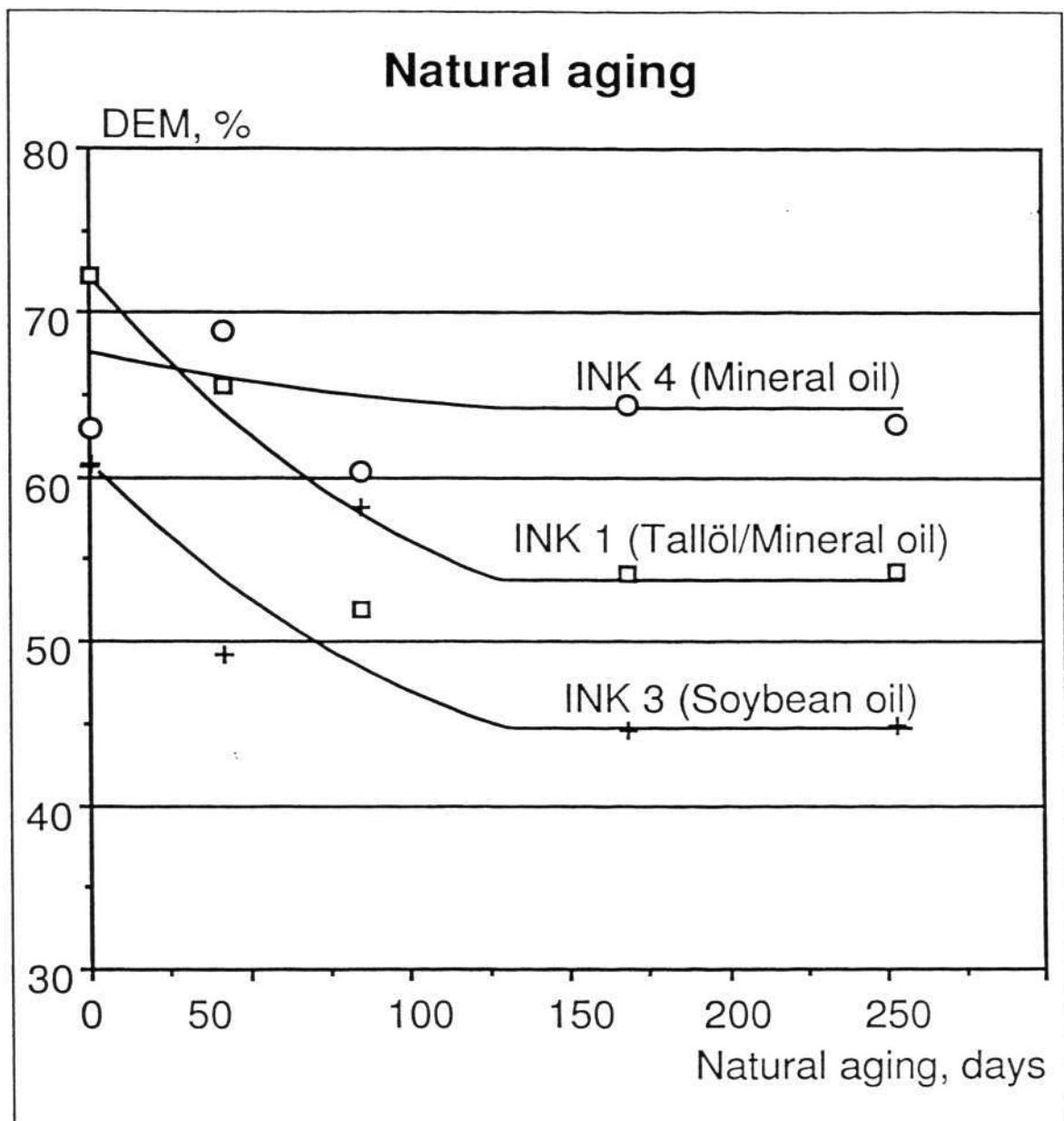




Ink mileage objectives:

Compared with other Times Mirror newspapers
that use mineral oil-based inks, a mileage
increase of 10%





Black newsinks

Type of ink	Method 24	Method 30
Standard mineral oil - black	5%	< 2%
Low rub-off black type A	5%	< 2%
Low rub-off black type B	15%	< 2%
Low rub-off black type C	28%	< 2%
Soybean oil black	2%	< 2%



vOC content

Type of ink	Method 24
European black ink A	13%
European black ink B	21%
European cyan ink A	10%
European cyan ink B	17%
European magenta ink A	19%
European magenta ink B	16%
European yellow ink A	11%
European yellow ink B	18%



VOC emissions of the Netherlands printing industry

	VOC emissions in t/a to		
	Air	Water	Waste
Offset plants			
Printing ink	300	90	
Damping agent	2000	500	
Cleaning agents	2000	600	*610
Total			
Printing industry	11735	1101	790

* + 4000 t cleaning cloths



COMPOSITION OF THE DAMPING SOLUTION

Type of component	Function
Surfactant, alcohol	Decreasing surface tension, improving wettability, increasing emulsification
Buffer system	Maintaining the pH value
Gum arabicum	Plate protection
Biocides	Slime prevention
Anti-corrosion agents	Corrosion prevention
Anti-foam agents	Foam prevention
Complex former (EDTA)	Inactivation of calcium and other metal ions

FOUNTAIN SOLUTION

Fountain solution in offset printing has the following tasks and requirements

TASKS

- to keep the non-image areas free from printing ink
- to act as a cooling vehicle
- to act as an anti-friction vehicle



REQUIREMENTS

- Ability to spread quickly and evenly.
The better the spreading, the less water is needed to cover non-image areas > less back transfer to the inking unit, less water marks
- Ability to form a homogeneous emulsion with the printing ink to form an ink/water balance. Correct emulsification
- Ability to achieve stable correct pH (4.8 - 5.3)
- Ability to resist slime formation



Emulsification is a key factor to achieve consistency in halftone areas. During printing, the fountain solution mixes with the ink forming an ink-water emulsion. The amount of water in this emulsion can be up to 40 %.

Emulsification:

- reduces the viscosity of the ink (overshot / undershot)
- reduces the relative pigment amount
- more ink is needed to achieve same density
- increases dot gain because of lower viscosity

A stable state of emulsification should be reached fast and it should be on a correct level.

Damping agent components and their tasks

Water 92 to 99%: Limited range of hardness to prevent printing difficulties (foaming when running blind, filling-in, etc.). Possible hardness: 4 to 15°dH. Optimal hardness: 8°dH.

Additives 8 to 1%

Wetting agent: Setting of a surface tension that should result in a spreading on the damping agent-carrying surfaces, and that realises an ideal emulsification with the ink.

$$\gamma_{(\text{damping agent})} = 35 \text{ to } 65 \text{ mN/m}$$

$$\gamma_{(\text{water})} = 72.3 \text{ mN/m}$$

Acid: Setting of a pH value to eliminate plate wear and tear and toning. pH value = 4.5 to 5.8

Buffer: Maintaining the set pH value.

Colloid: Maintaining and renewing the diffusion layer on the non-image parts of the plate, a precondition for ideal damping agent spreading and running free (similar to the colloid of gumming).

Glycerol: For maintaining all rubber surfaces.

Algicide agent: To protect against, or inhibit micro-organism build-up or decay.

Anti-corrosion agent: To protect against, or inhibit corrosion.

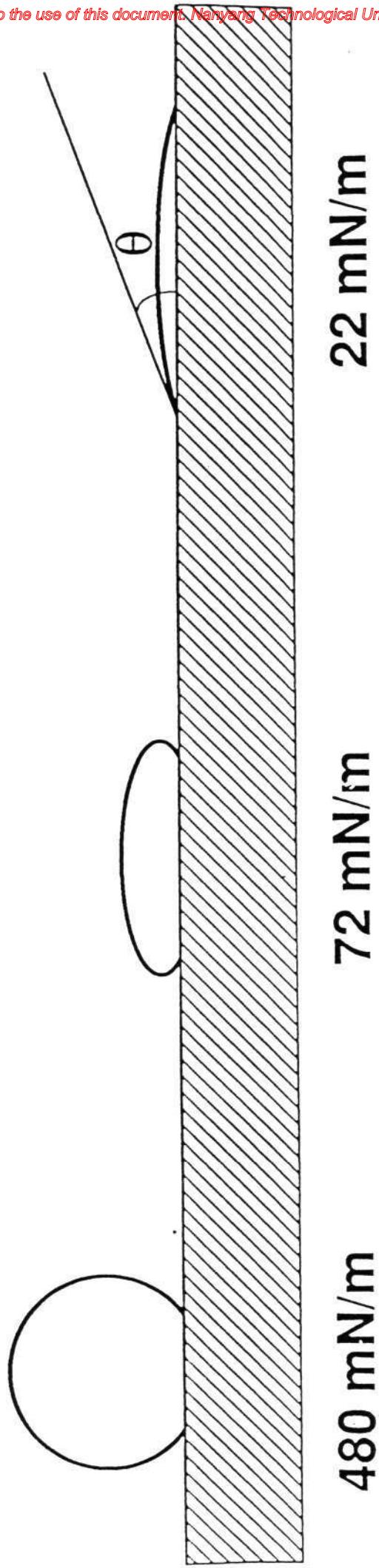
Case of alcohol damping

Isopropanol 5 to 30%: A further reduction in the surface tension leads to better wetting (up to $\approx 30 \text{ mN/m}$). Increase in viscosity, approximately double at 20% isopropanol (from about 1 cSt with additives to 2 cSt with additives and 20% isopropanol). Rapid evaporation causes a cooling effect. Physiologically not generally recognised as safe!



Surface tension of different liquids

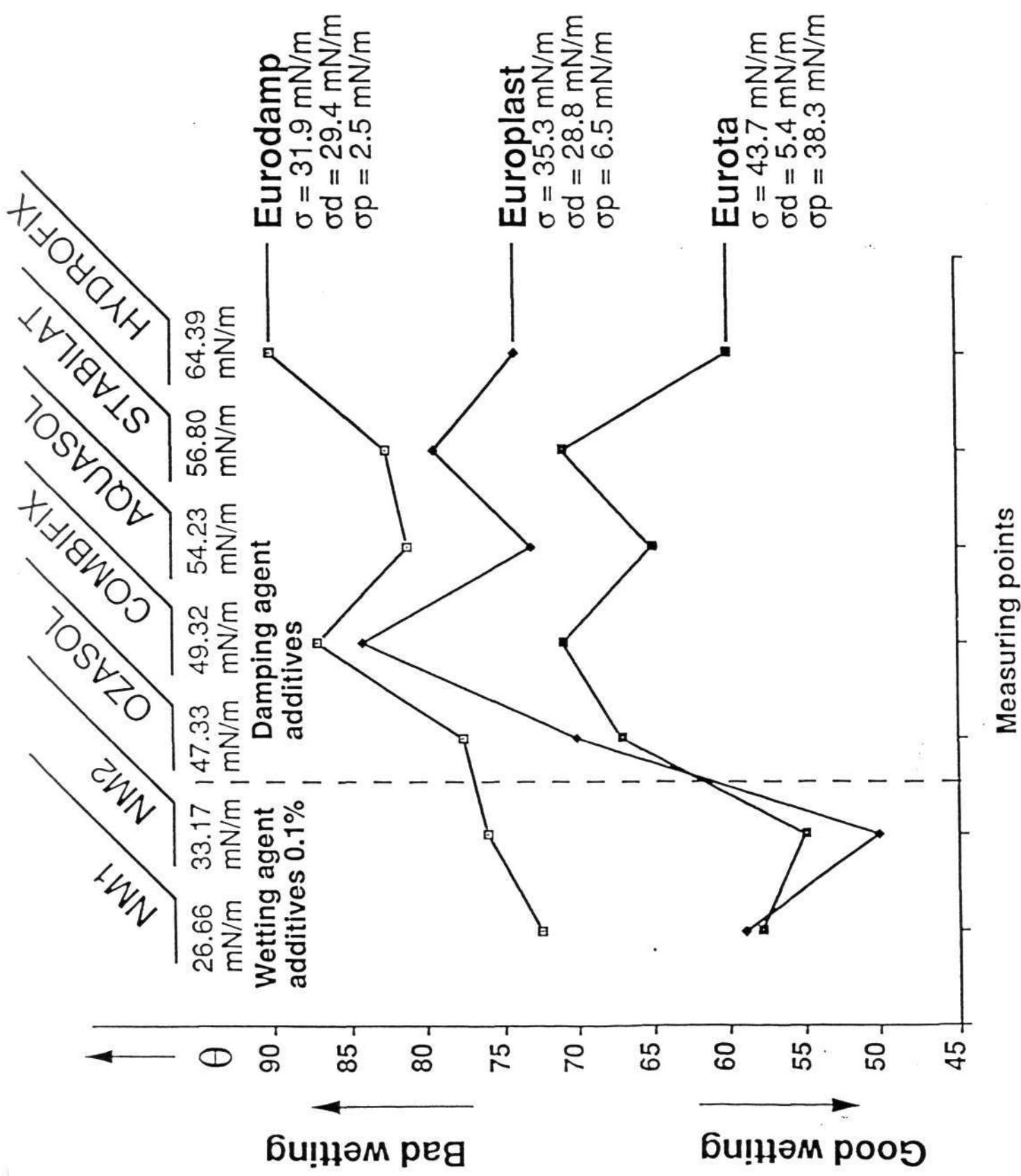
Quicksilver Water Alcohol

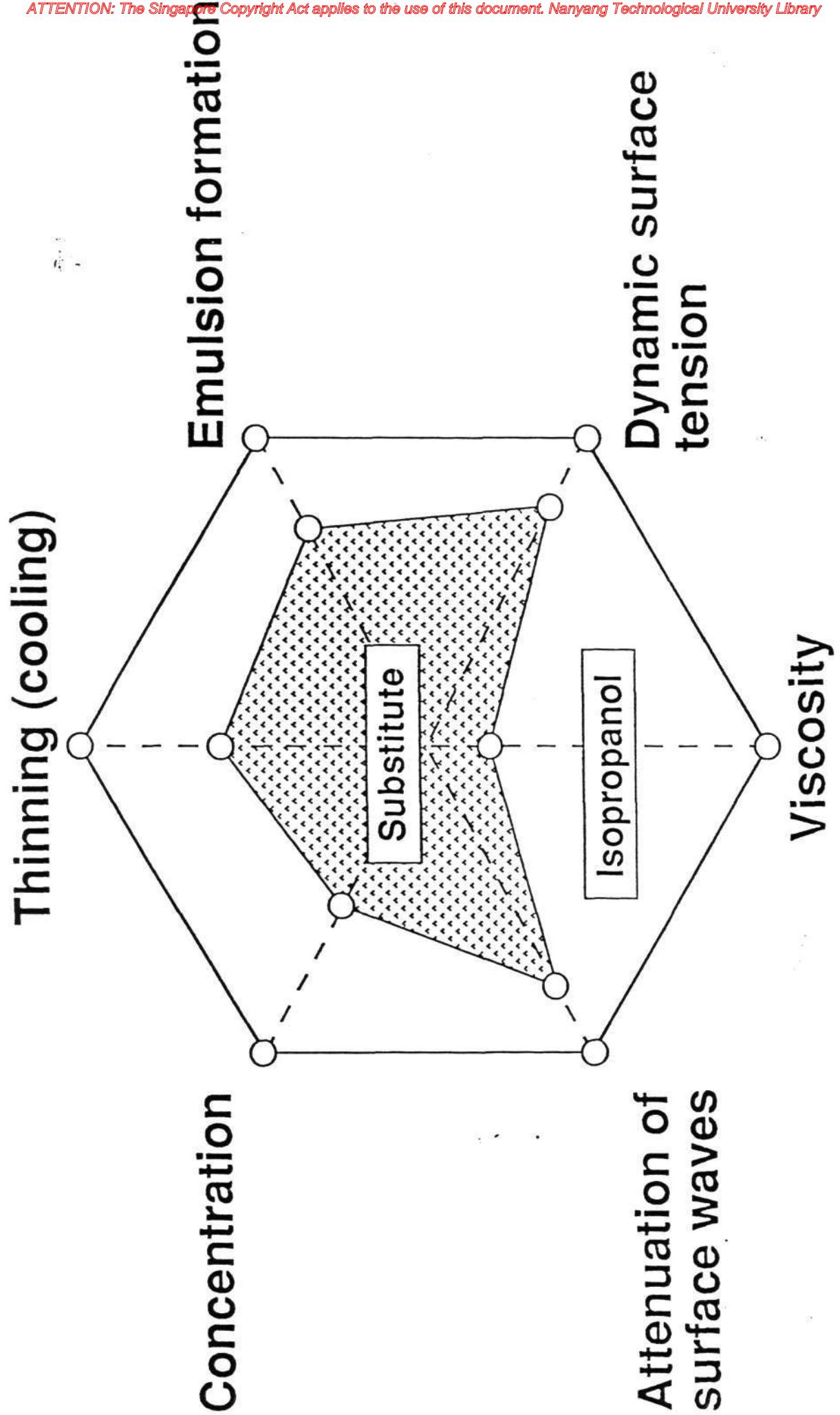


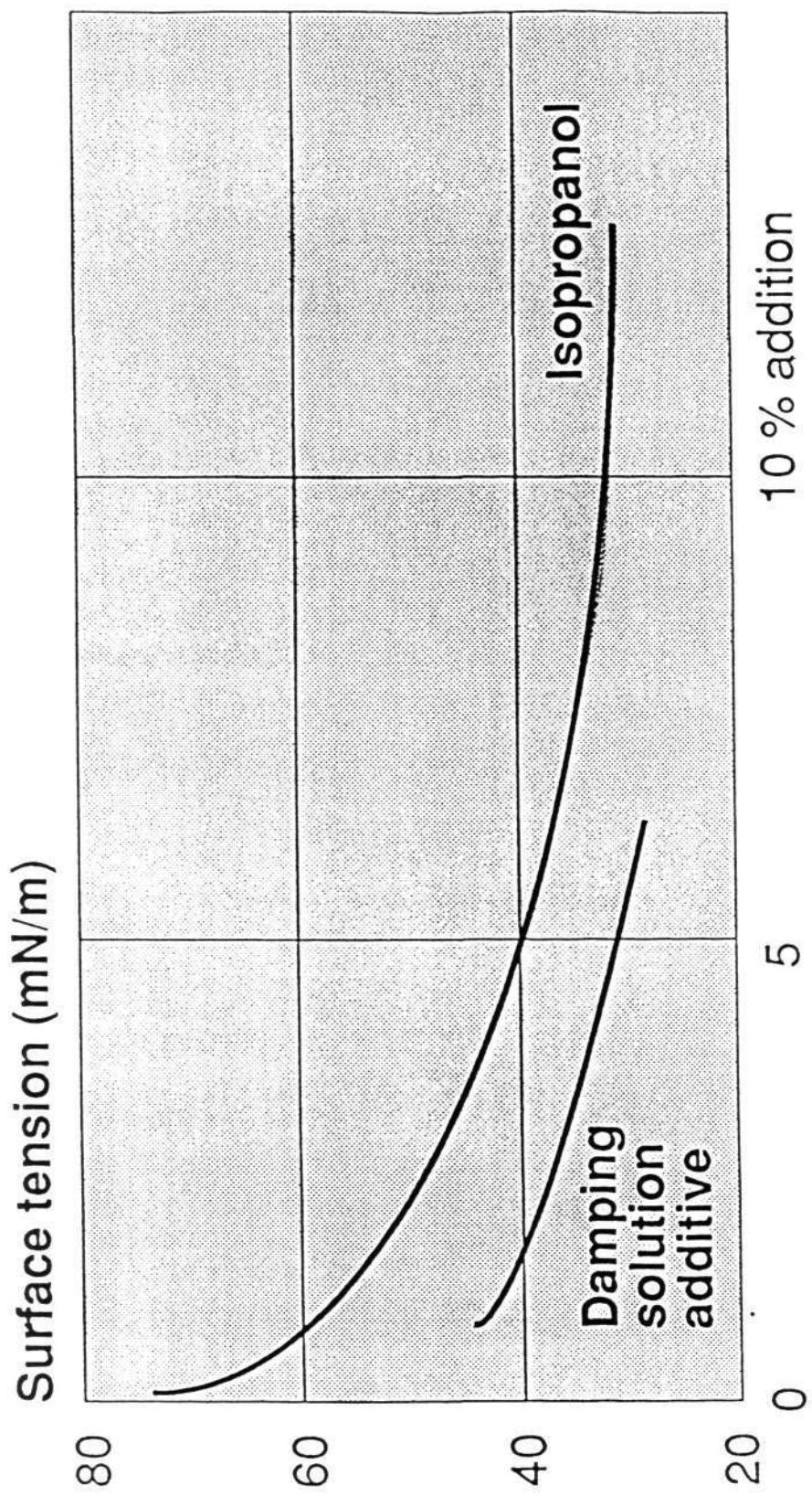
480 mN/m

72 mN/m

22 mN/m

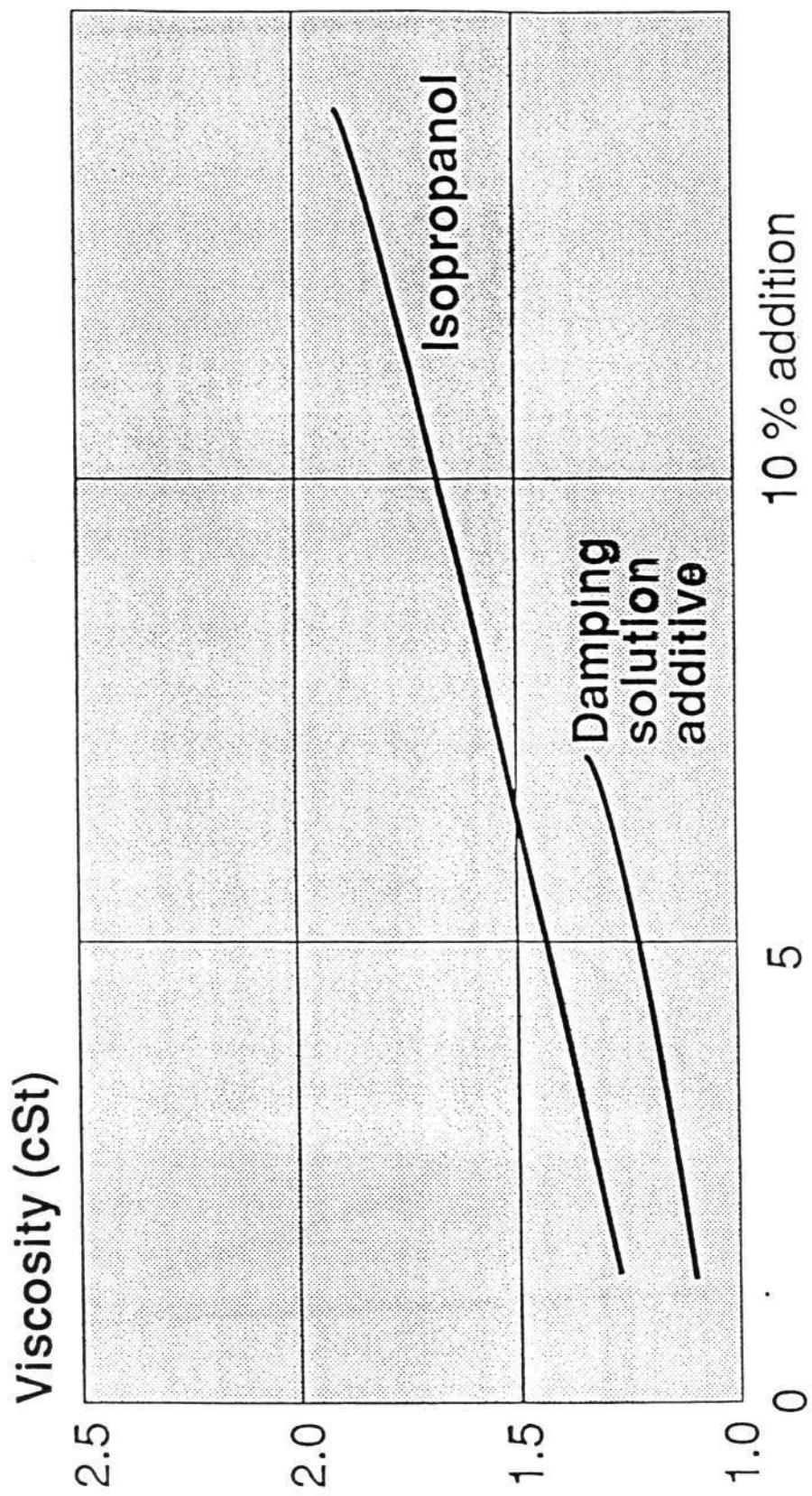






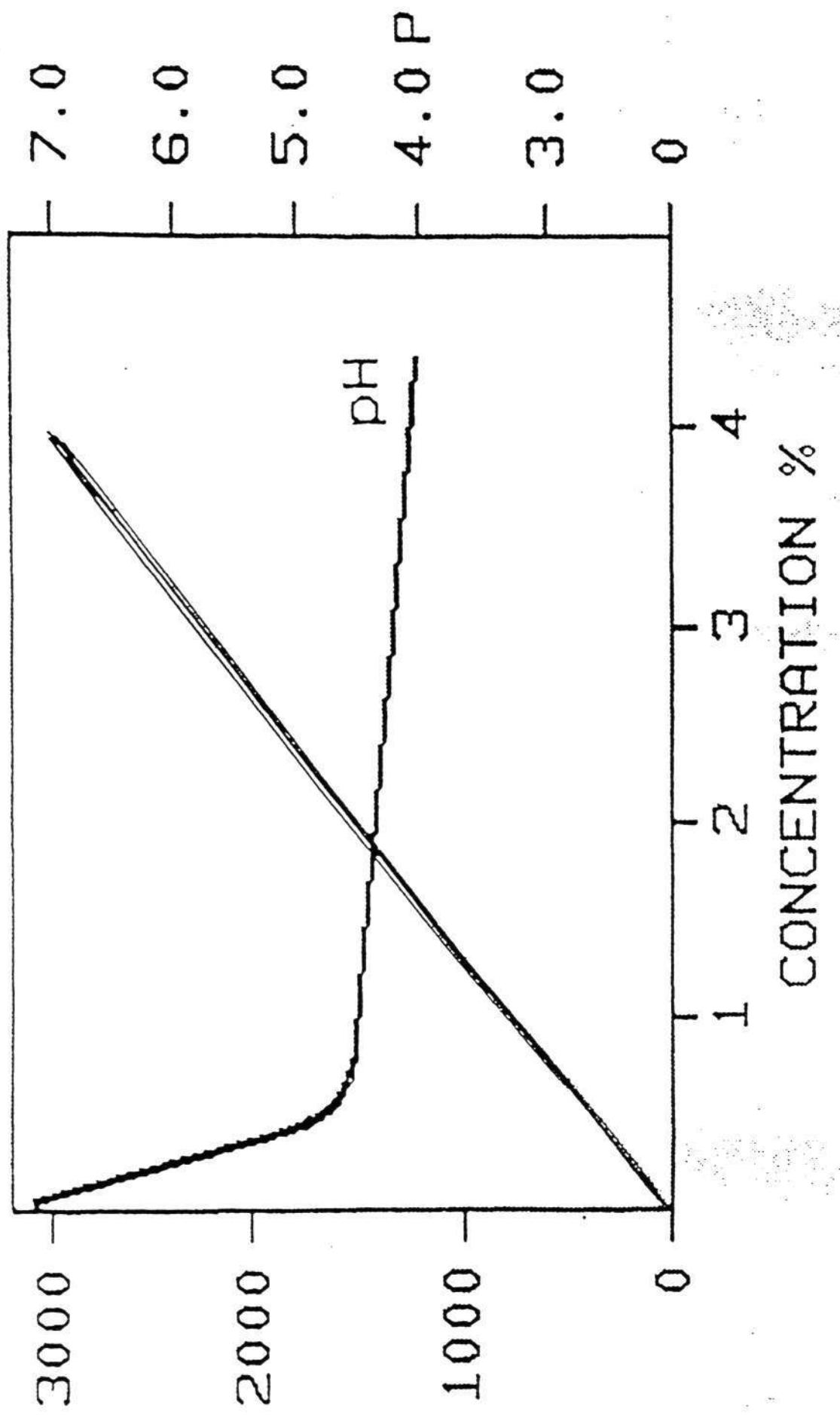
Isopropanol: moderate reduction of the surface tension

Damping solution additive: strong reduction of the surface tension

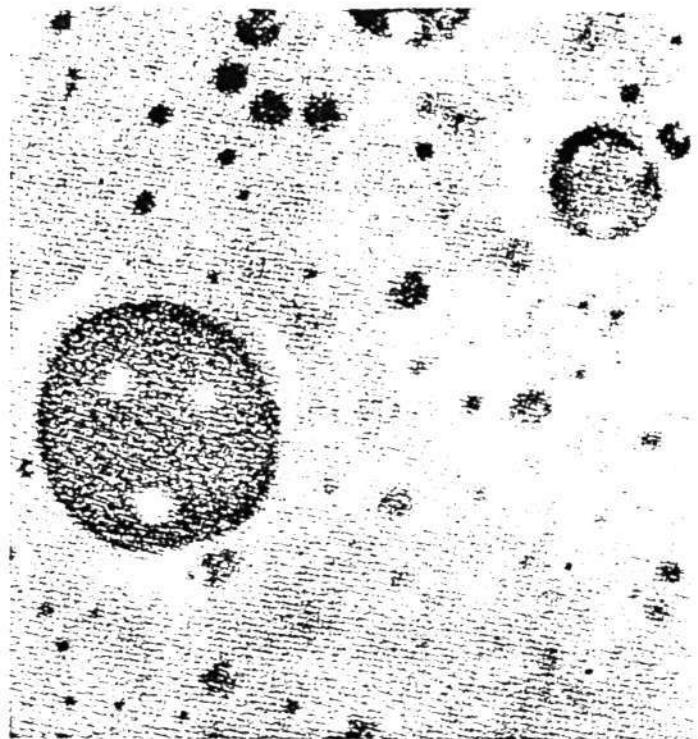


Isopropanol: clear viscosity increase

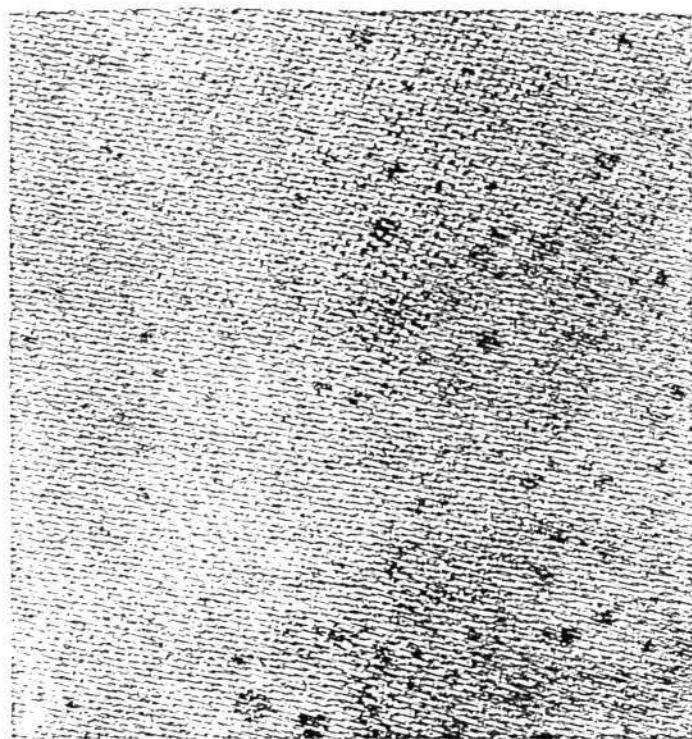
Damping solution additive: smaller viscosity increase



A comparisson of Conductivity and pH curves.



a. Inked area after passage of damping roll.



b. Figure 1a followed by inking roll

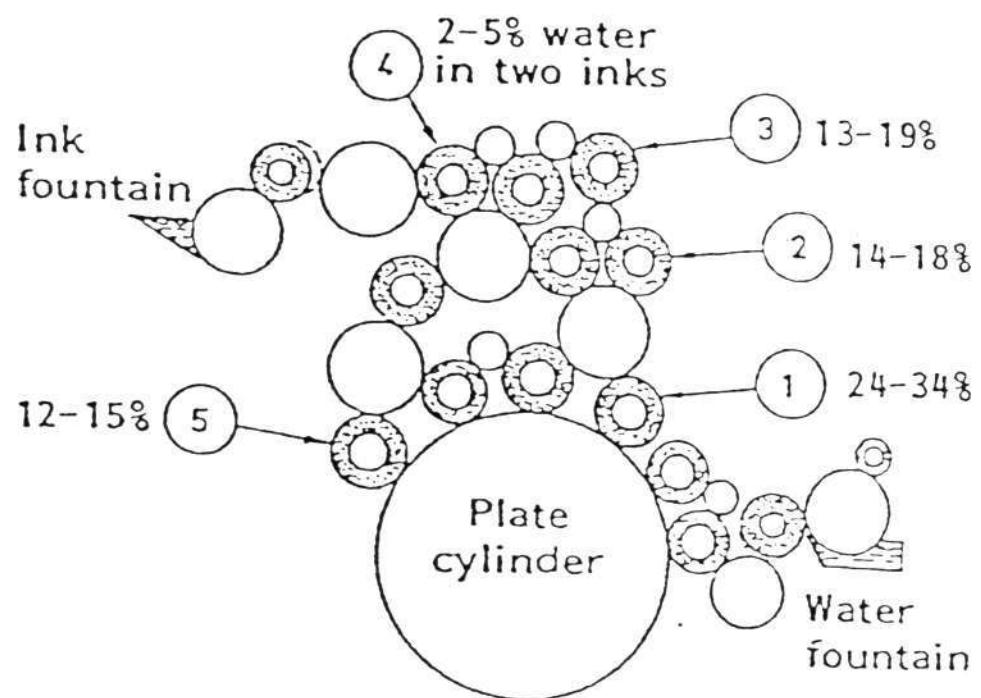


Figure 3. Water content at five sampling points in the inking unit of a newspress.
(Figure 1 and selected data from Table 1,
Lindqvist, *Graphic Arts in Finland*, 1976)

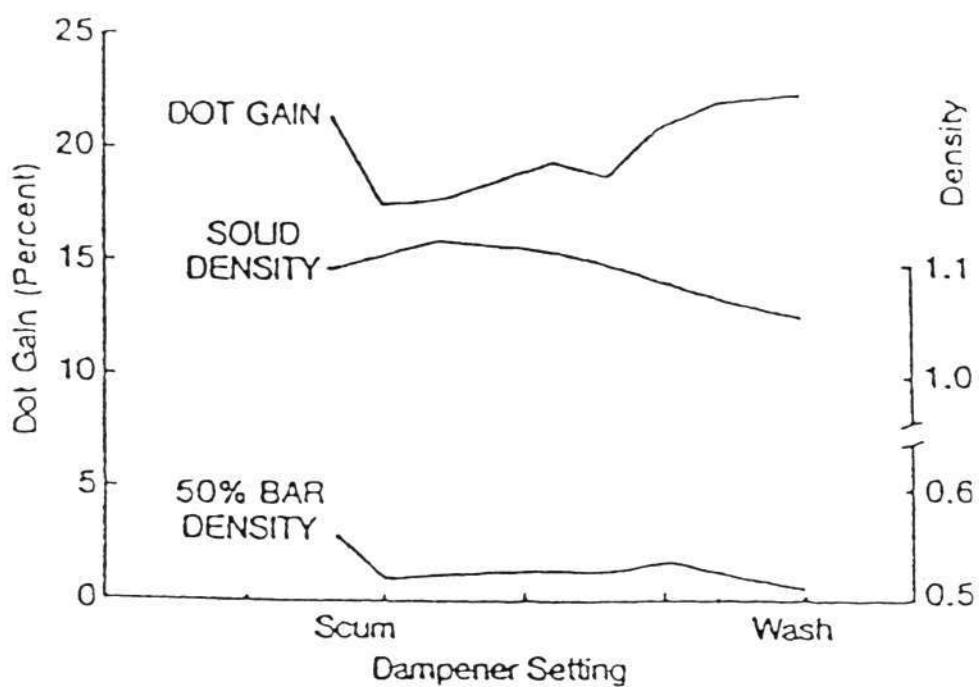
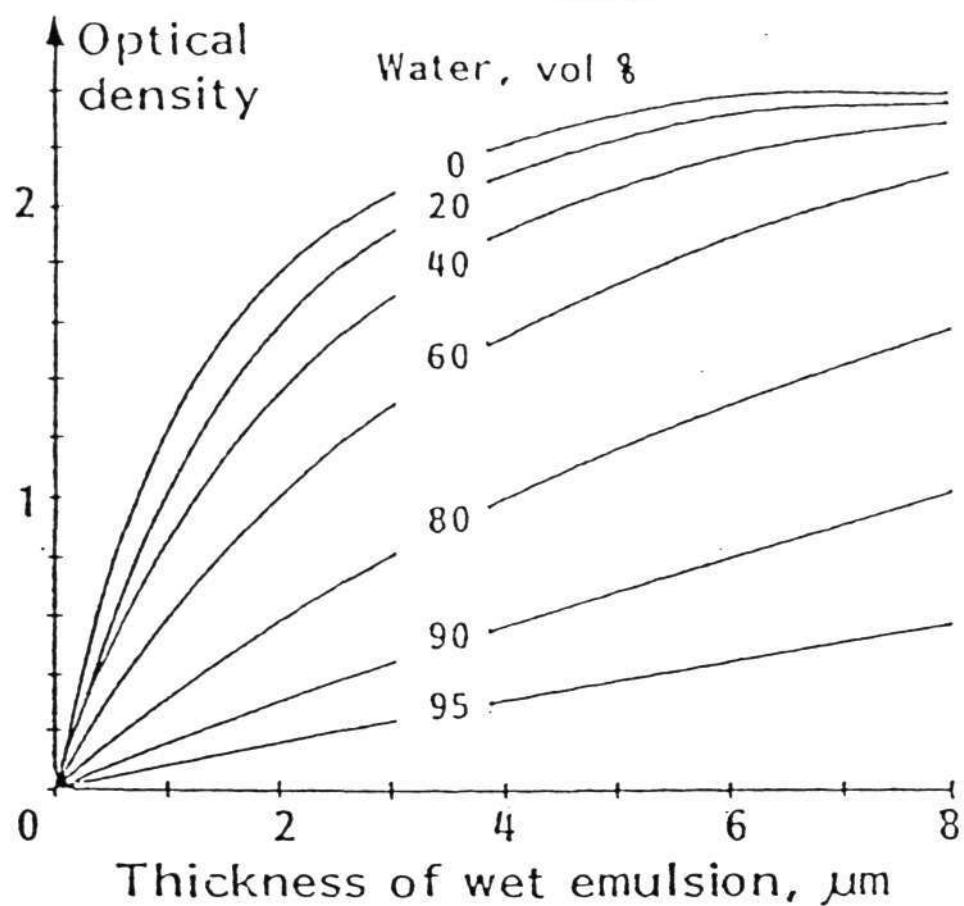
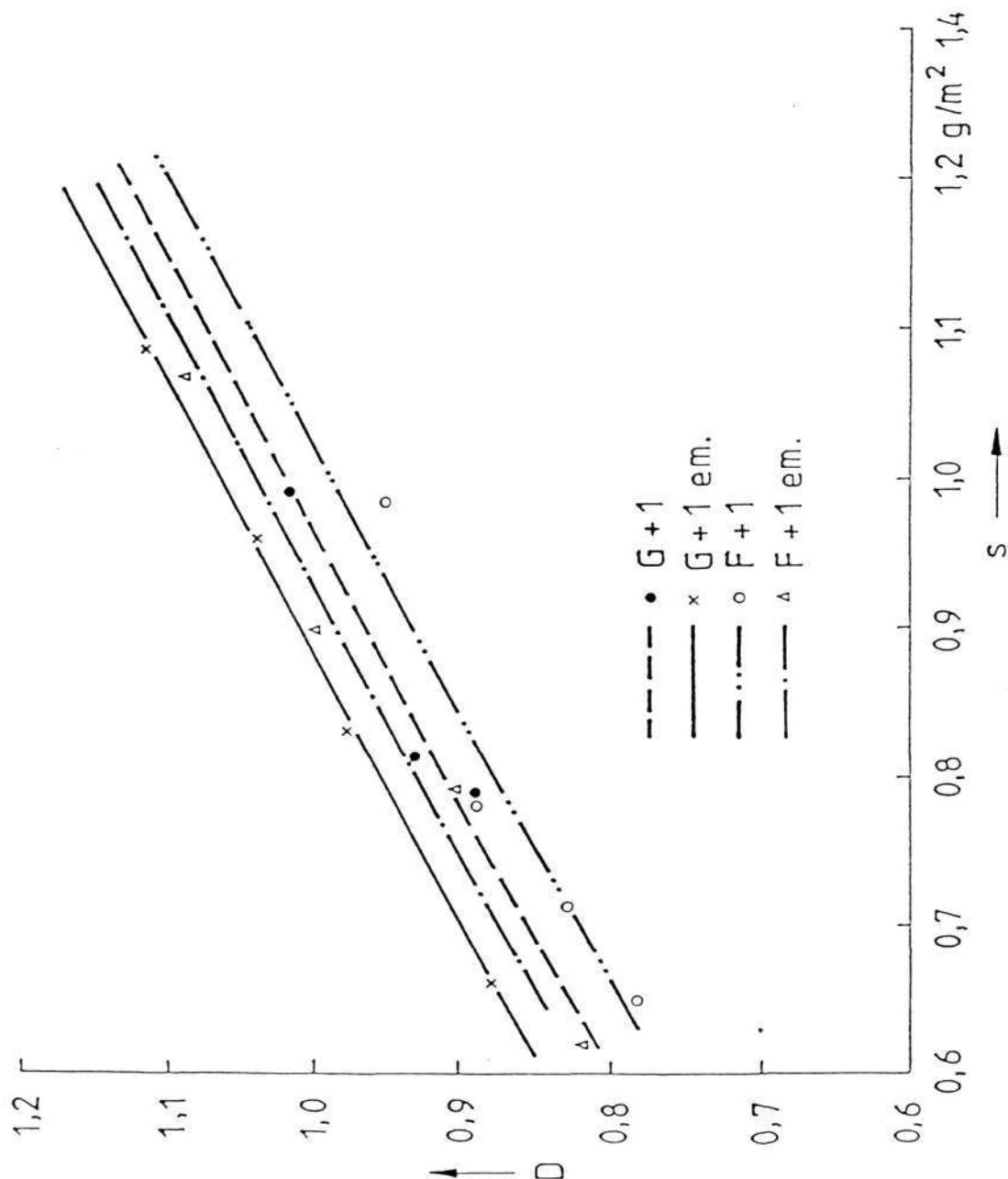


Figure 21. Apparent dot gain and solid optical density versus dampener setting on a newspress. (Figure 10, DePaoli, Taga Proceedings, 1981)



Comparision of the optical densities of pure and emulsified links



Tap Water:

< 3°d, < 30 mg/l chloride

Comment:

Danger of corrosion

Contact damping systems

Settling of ink on damping rollers

What to do:

Add 0.5 % conditioning concentrate

**Fountain Solution
2**

Tap Water:

7 -12 °d, < 30 mg/l chloride

Comment:

Perfect for printing

Water treatment:

Not necessary

Tap Water:

15 -20 °d, < 30 mg/l chloride

Comment:

Having small printing areas on plate (cyan, magenta)

Too much damping solution into ink

Ink splitting will be worse

Ink density of the printed paper goes down

Precipitates (white) on the damping rollers

Stripping of ink rollers

What to do:

1. Deharden water to 7 - 12 °d (chloride will not be removed)

or

2. Reversed osmosis (removes 95% of all ions and all fungis and bacterias), then mixing with tap water to give 7 - 12 °d, or better (when tap water quality is not constant: add 0.5% conditioning concentrate)

Tap Water:

> 50 mg/l chloride

Comment:

Danger of corrosion

What to do:

Reversed osmosis (removes 95% of all ions and all fungis and bacterias), then mixing with tap water to give 7 - 12 °d, or better (when tap water quality is not constant: add 0.5% conditioning concentrate)

SPRAY DAMPING

ADVANTAGES:

- No circulating water
- Lower temperature of the water
- Quicker start up
- Less water consumption
- Better adjustability (1/2 page)

PROBLEMS:

- Incoming water must be clean not to block the nozzles
- Nozzles must be maintained from time to time to avoid blockages

DAMPING SYSTEMS

PRINCIPLES:

contact - non-contact

direct - indirect

predamping - postdamping

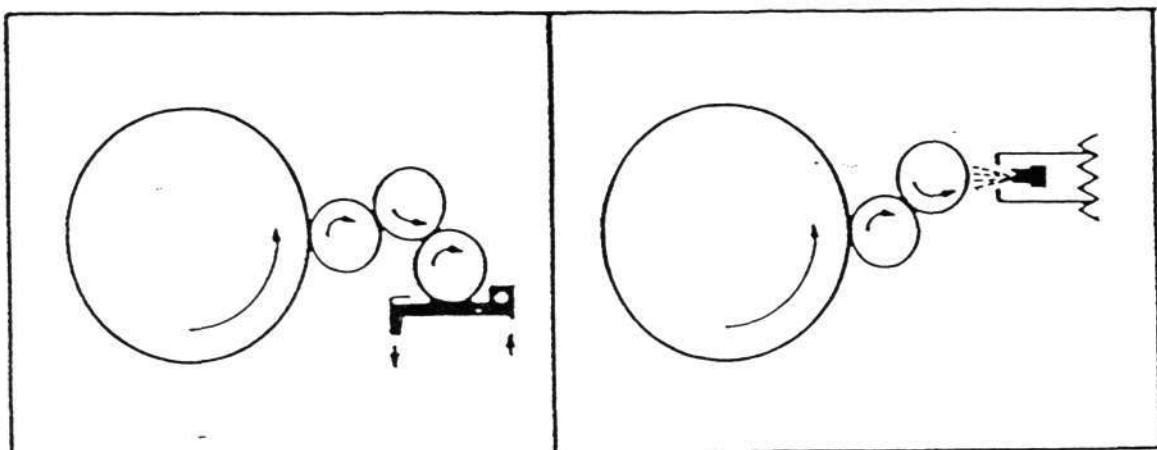
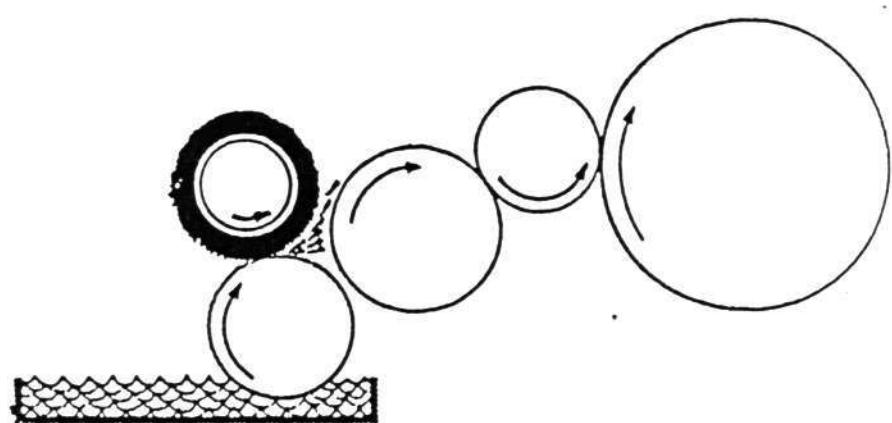
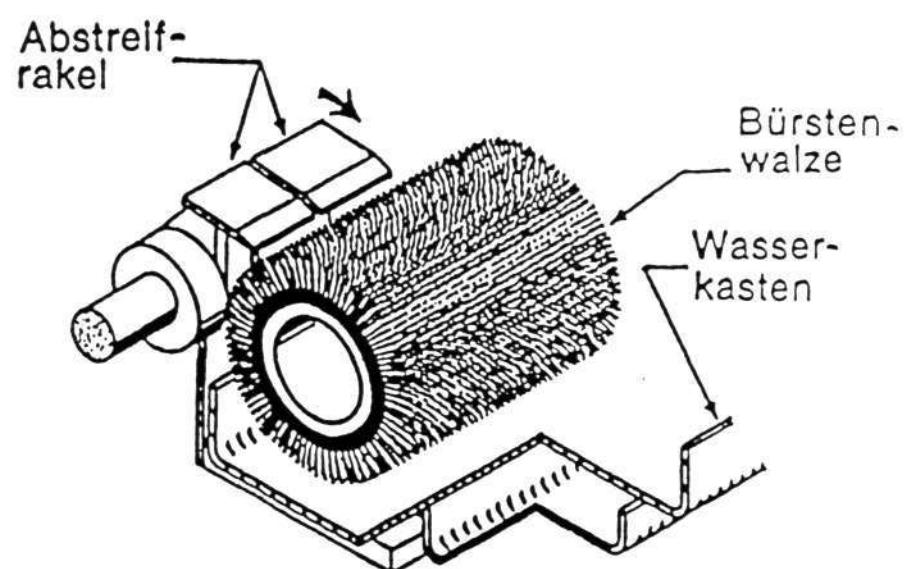
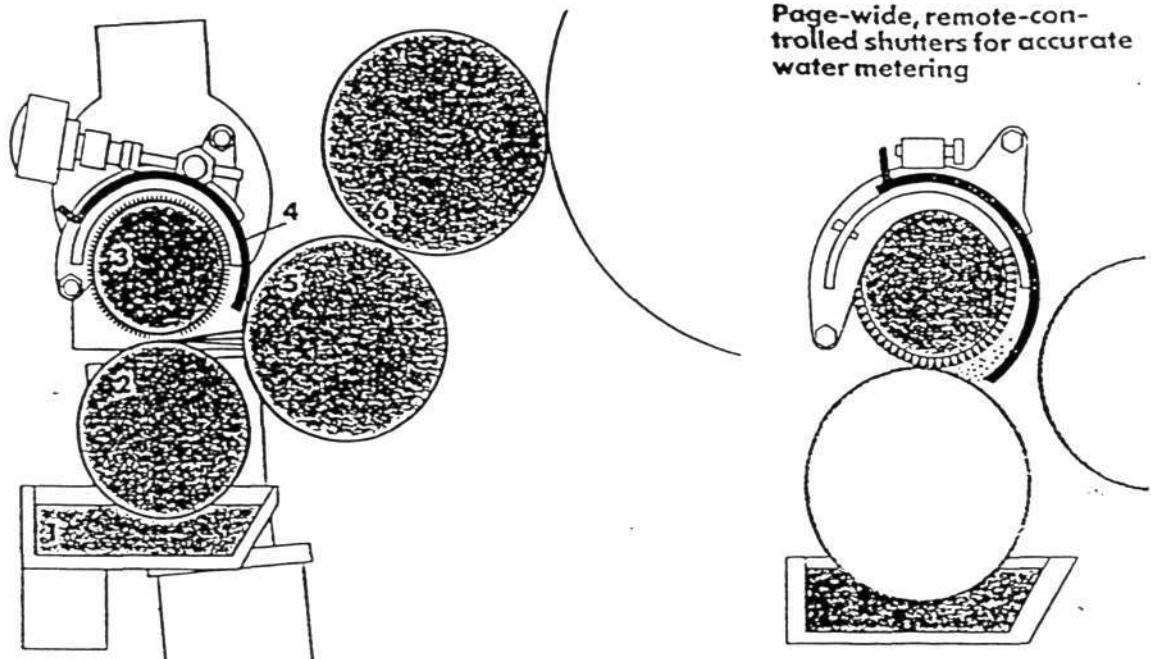


Figure 4. A conventional contact damping system (left) and a contactless system (right).

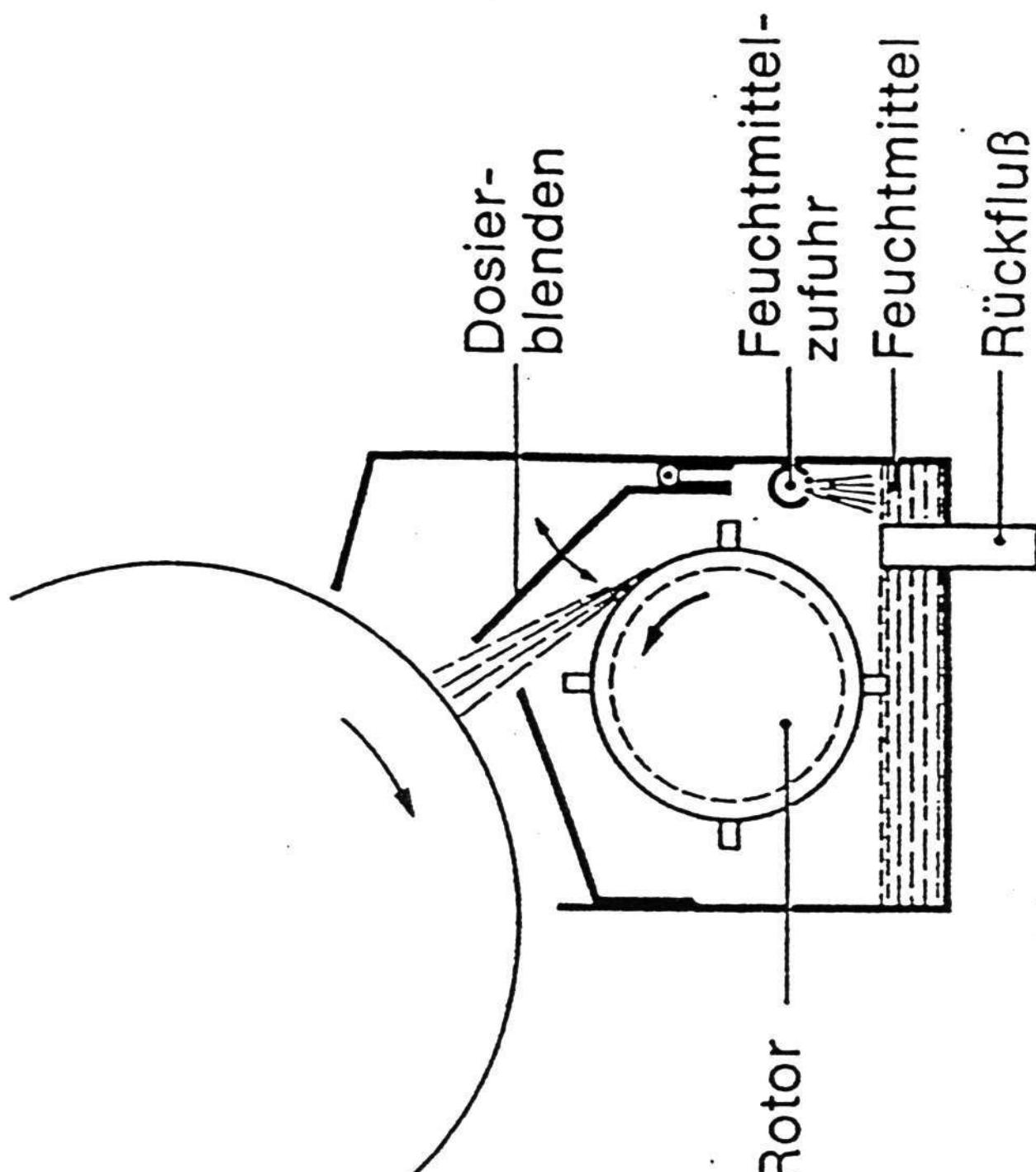
A preferable way is:

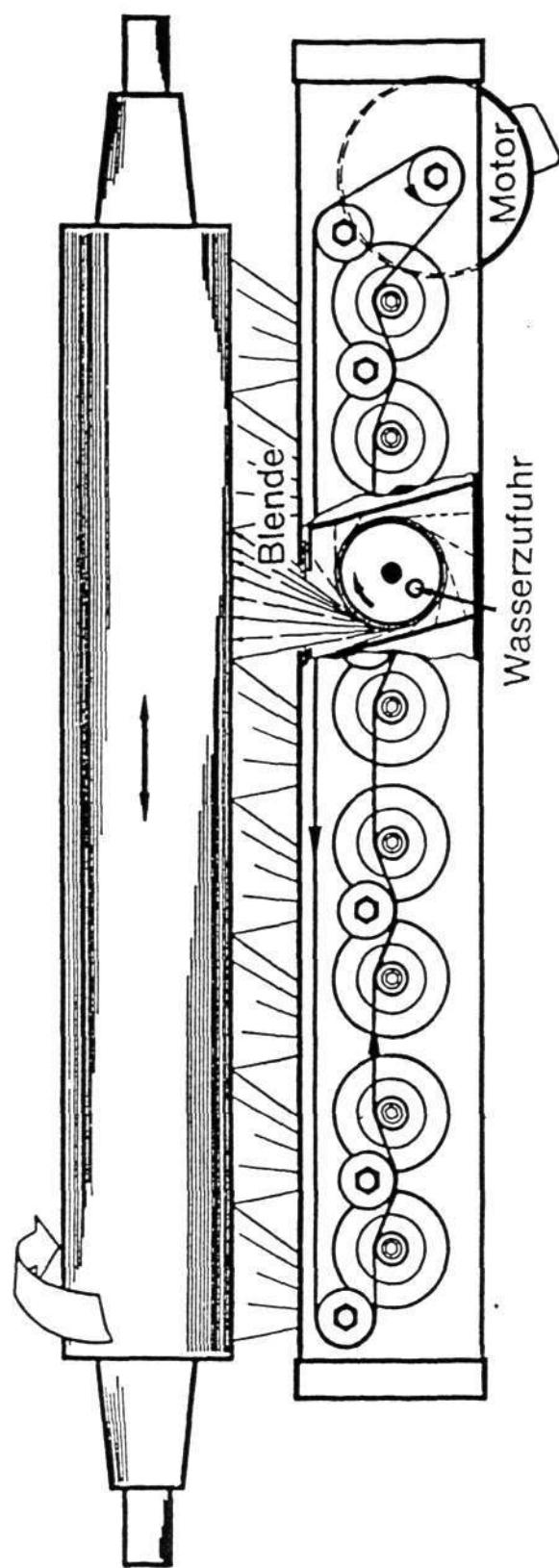
- non-contact (to avoid ink feed back)
- direct (to avoid over emulsification)
- post damping (because of wider tolerances)



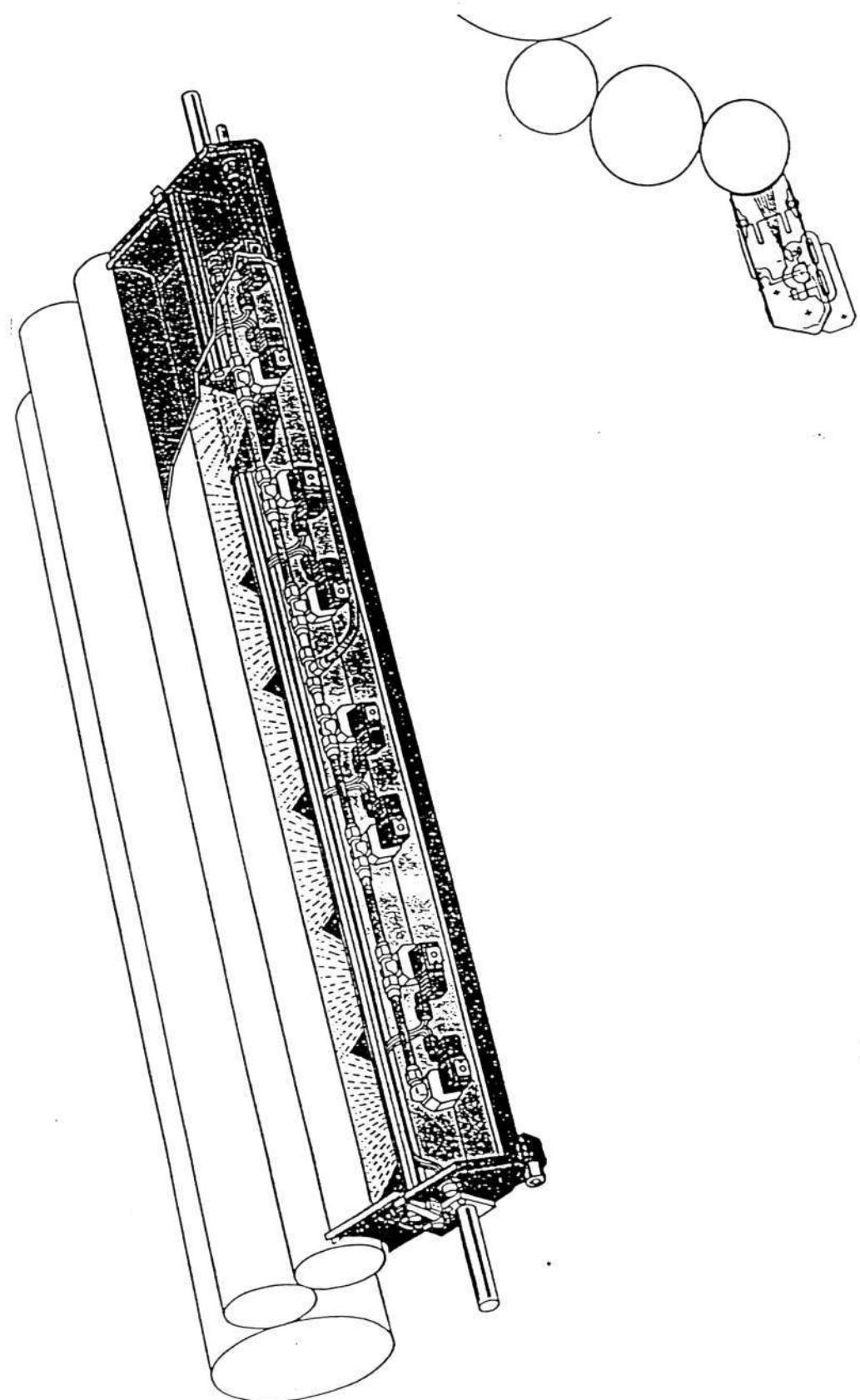


1. Insulated water pan
2. Motorised, infinitely-variable water fountain rollers
3. Motorised brush roller
4. Page-wide brush shutters
5. Driven chrome roller
6. Plate dampener.

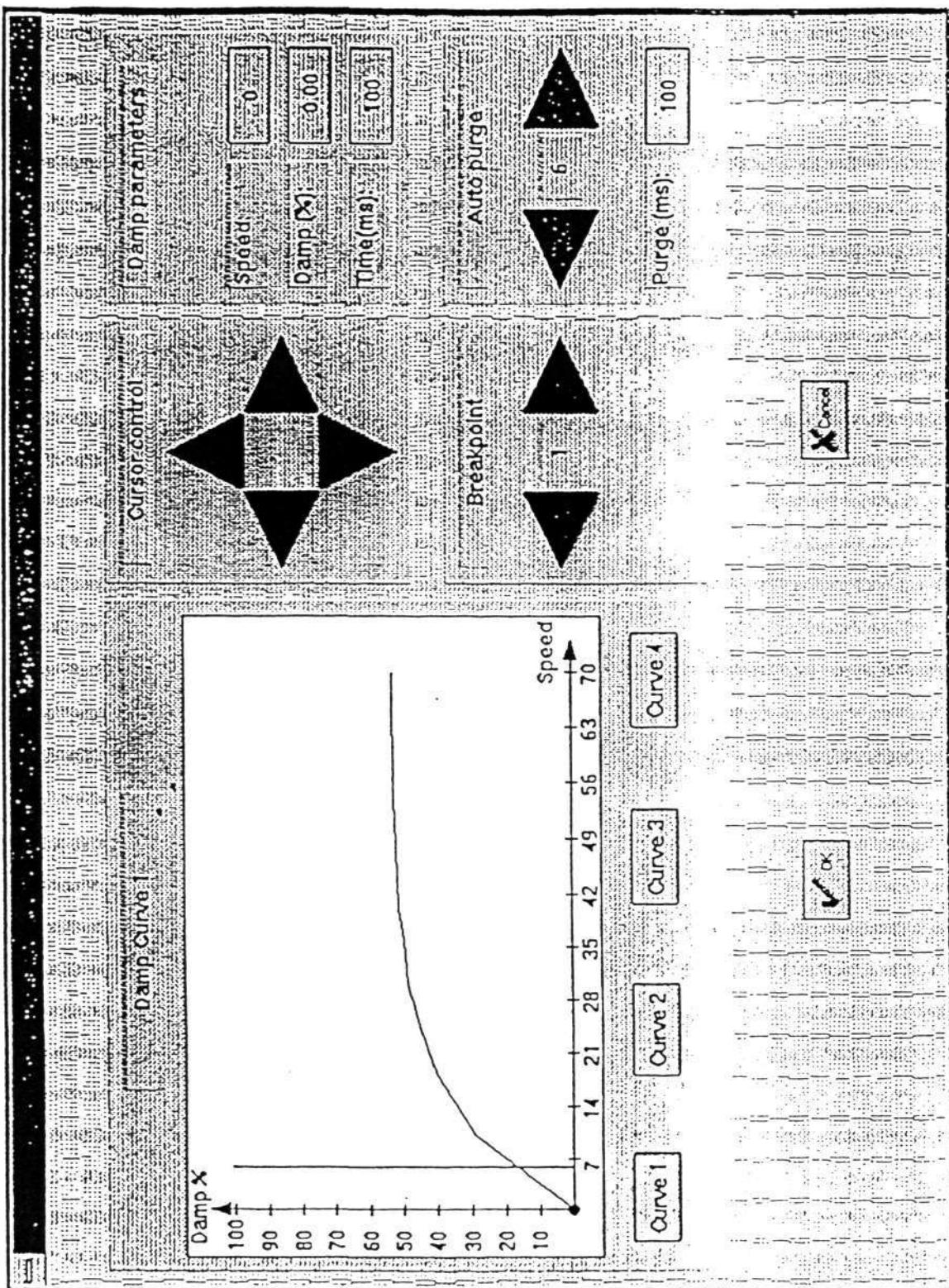




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Examples of the application of damping units in web presses

Damping unit with ductor roller

Zirkon: Forta, Supra
Miller: WEB 66
Albert Frankenthal: A 101
Heidelberg: WEB 8, WEB 16
MAN-Roland: Octoman, Lithoman, Rotoman
Solna: C 50 H, C 96 H
Harris: M 110, M 200, M 1000, M 300
Hitachi: 660 E, 1000 E
Komori: 20 A, 38 A, 40 A
Koebau: Compacta S 80
Nebiolo: Target III
WIFAG: QE 9
Goss: Urbanite II, Community

Turbo system damping unit (centrifugal force rollers)

MAN-Roland: Colorman 35, Uniman 4/2
MAN-Roland: Colorman
Miller: OP 16
Heidelberg: not manufactured anymore
Goebel: format print

Damping unit with brush

WIFAG: QE 7, QE 9.2, QE 5
MAN-Plamag: Cromoset
MAN-Roland: Octoman, Lithoman
Miller: CW 68, Nobab
Koebau: Commander 4070, Anilox Commander
Hantscho: Mark 10
Goss: Vista/Gazette
Toshiba: OA-1600/1800, OA 1400/1000
Baker Perkins: G 16, G 12, G 14
Harris: M 850, M 200, M 1000, M 300, M 110
Hitachi: 660 E, 1000 E
Albert Frankenthal: ROF A 500

Damping unit with vibrator

Nebiolo: Target

Nozzle damping unit

Suppliers: Jimek (Sweden), Roto-Screen (USA),
Smith (USA), Ryco (USA)
Koebau: Commander 70
MAN-Miller: OP 1500
Harris Marconi: Color Journal, N 1600
MAN-Roland: Uniman
TKS: Anilox Offset
(Newspaper presses underlined)

Performance of damping units

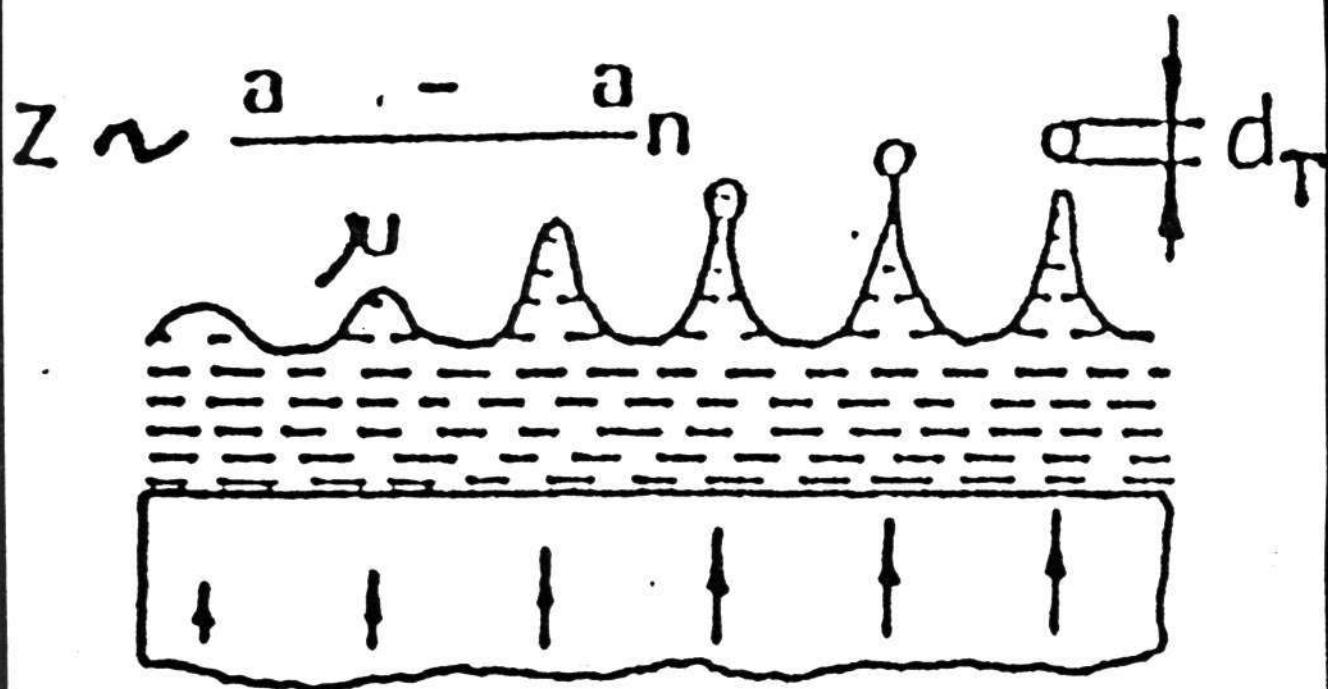
		Brush damp. unit with damping duct rollers	Brush damp. unit with fountain brush	Centrifugal force damping unit with rotor	Spray bar damping unit	Turbo system damp. unit
Metering provided	zonal	0	0	0	0	0
	page-wise	8	4	2	3	9
	overdamping possible	8	4	1	3	2
	edge overdamping	5	2	0	3	0
Assessment of the metering possibilities	very important	9	3	1	3	8
	important	0	1	1	0	1
Metering over the web width	sensitive	6	2	1	3	7
	medium	3	2	0	0	2
	rough	0	0	1	0	0
Possibility of adjusting the plate rollers	sensitive	9	3	1	3	8
	rough	0	1	1	0	1
Maintenance of the damping unit	easy	4	4	0	3	7
	medium	4	0	1	0	1
	sophisticated	1	0	1	0	1
	maintenance intervals (shifts)	20-200	1-50	1-200	10-60	180-360
Cooling	yes	7(9-20°C)	4(15-20°C)	2(12-16°C)	1(11°C)	8(8-17°C)
Influence of the ink	equal	4	1	1	2	6
	unequal	5	3	1	1	2
Influence of the printing substrate	equal	5	2	2	3	6
	unequal	4	2	0	0	1
Response when changing the damp. solution settings	DS increase (cyl. rev.)	0-20	10-20	15-20	0	15-130
	DS decrease	0-20	10-20	15-20	0	15-130
Response when increasing printing speed	very good	6	2	2	3	7
	manually	3	2	0	0	3
Response when decreasing printing speed	very good	5	2	1	2	8
	manually	4	2	1	0	2
Wash interval	1000 cylinder revolutions	Ø 100	200	100-150	40-100	80-1500 (Ø 150)
Printing stoppages	adjusting the DS	3	3	1	0	2
	adjusting the ink	0	2	1	1	4
	operating conditions DU	4	1	0	2*	2
		9	4	2	3	9
DS: damping solution DU: damping unit *: no cooling Ø: average	Manufacturers	7 Koebau 1 Wifag 1 Albert- Frank.**	Wifag Albert- Frank.**	MAN	Koebau Harris MAN	MAN

Table 3.2.1

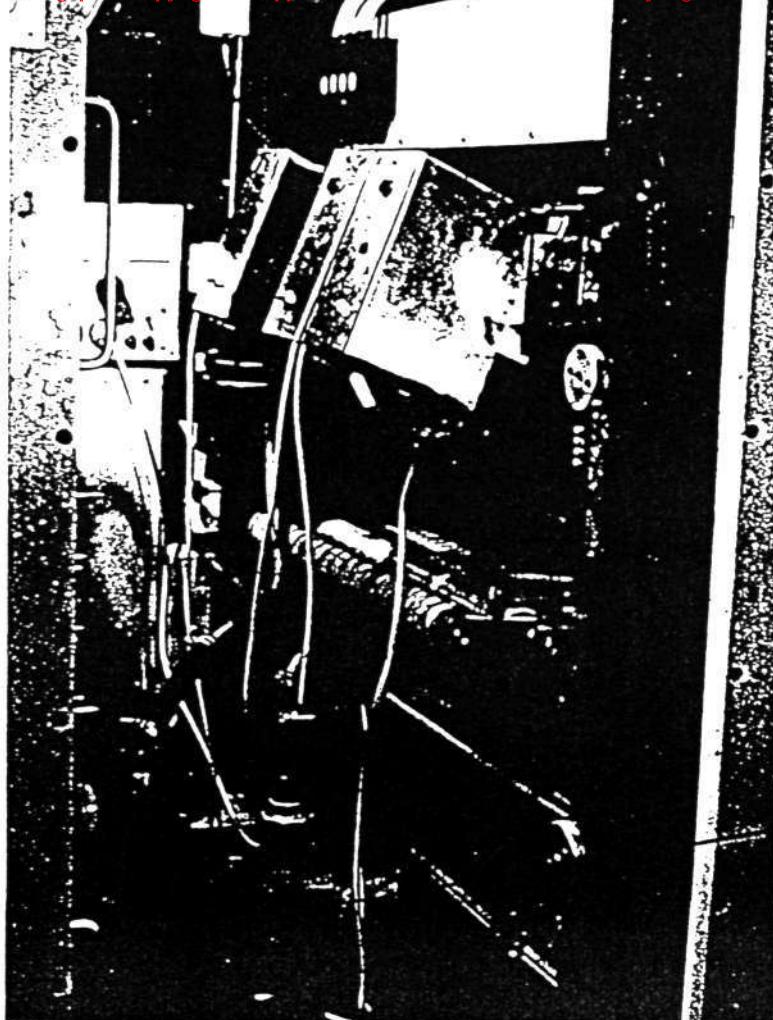
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Table 3.2.1.a: Performance of damping units.

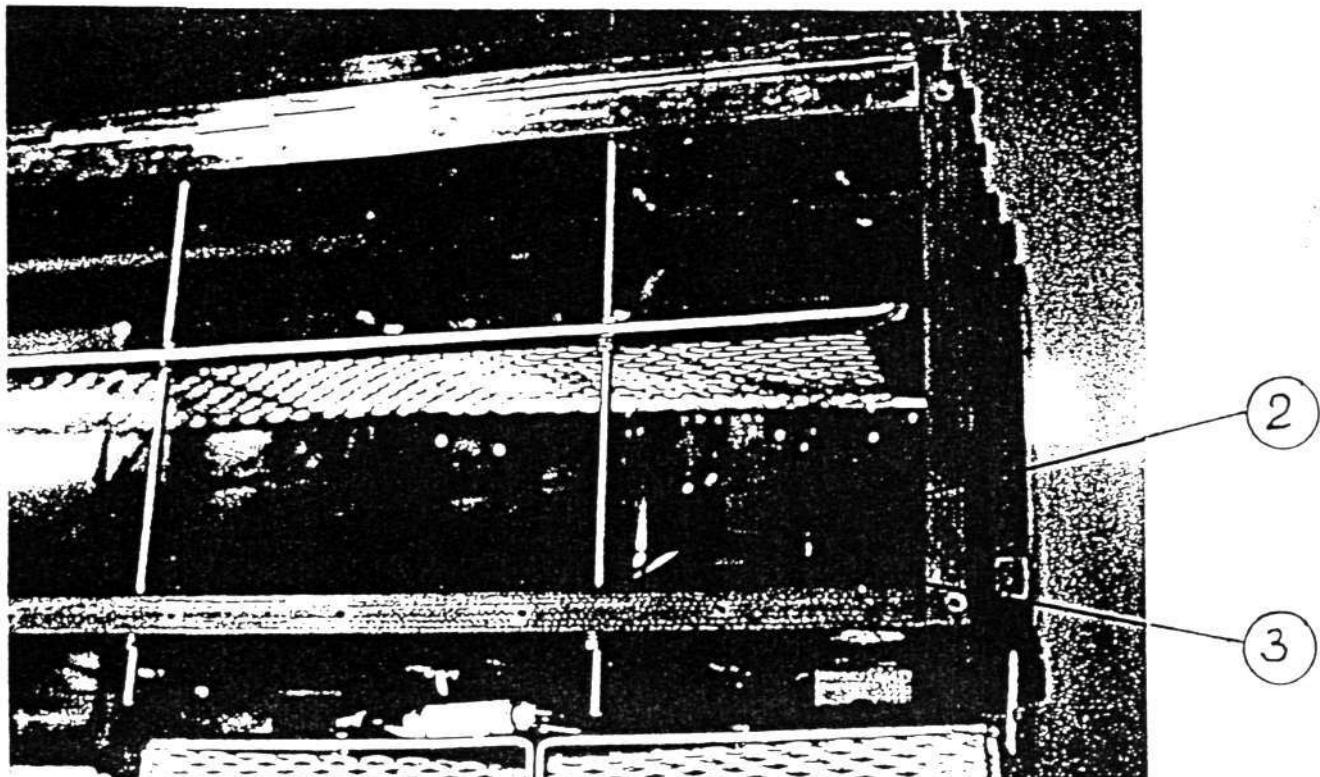
$$d_T \approx 0,73 \sqrt[3]{\frac{G \cdot 1}{g f_a}}$$



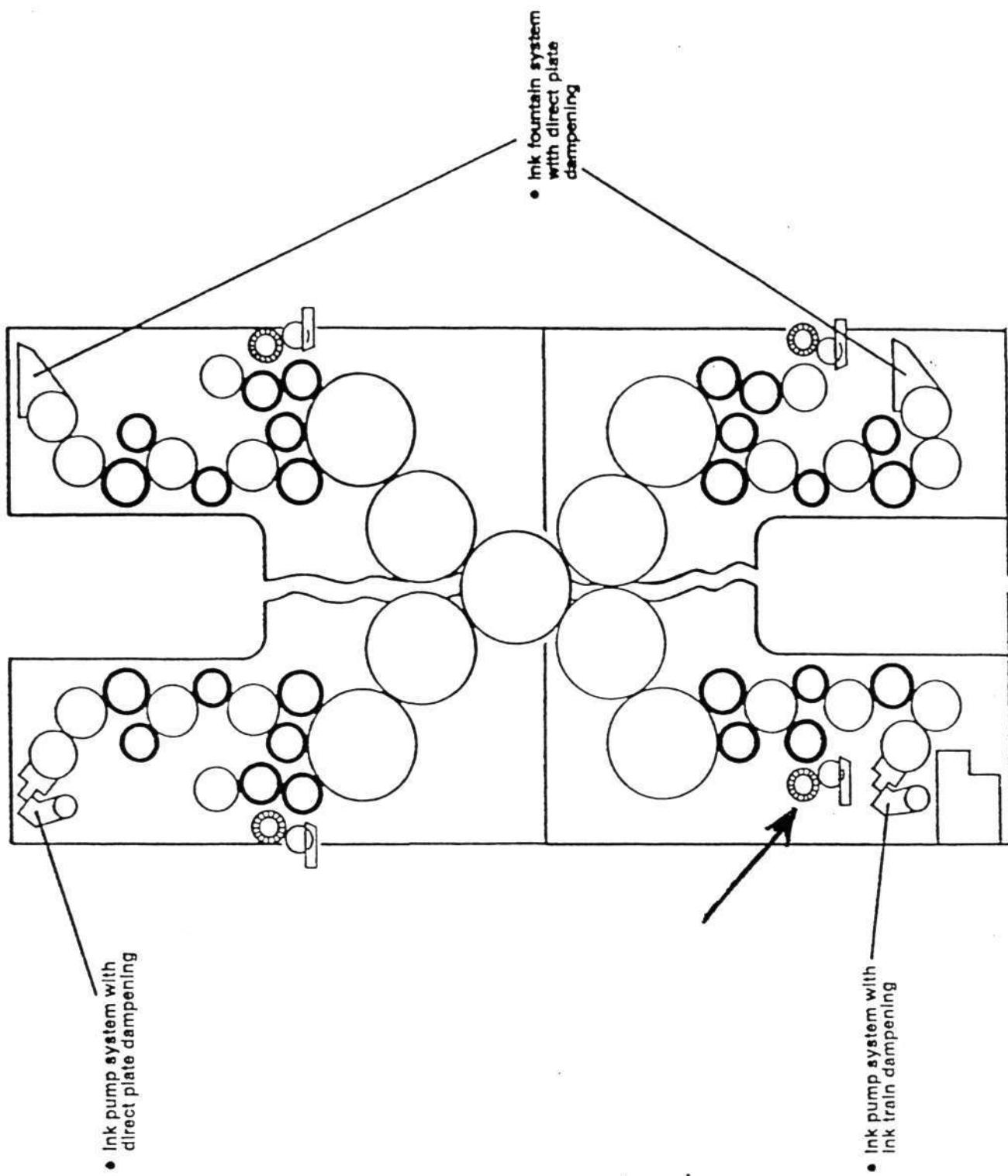
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Location of the test damping unit in the Zirkon 660



View into the test damping unit with air guiding elements



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WIFAG

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