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EVALUATION OF THE POTENTIAL OF THREE BURMESE

HARDWOOD SPECIES FOR NEWSPRINT

19

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Contents

SUMMARY

Commissioned by the United Nations Industrial Development Organization (UNIDO) Burmese hardwood species were investigated at the Finnish Pulp and Paper Research Institute. Chemimechanical pulping methods were used to manufacture pulp for the mechanical pulp component in the newsprint furnish. The objective of the work was to find the pulping conditions for each species, and manufacture paper with the experimental papermachine from the best pulps for the pilot printing tests.

Wood raw material and bamboo bleached chemical pulp were delivered from Burma. Wood logs were debarked and chipped in Finland. Ceiba was partly damaged during the transportation. Other species tolerated fairly well the long transportation.

Wood properties were measured. The main difference between the species was density. Density of Euca was very high over 600 kg/m^3, that of Ceiba was exceptional low less than 200 kg/m^3 (normally around 300 kg/m^3). This was due to the damage during the transportation. Swintonia's density was about 500 kg/m^3.

The pulping experiments were carried out in pilot scale. Euca and Swintonia were tested in both CMP and CTMP processes, but Ceiba only in mild CTMP process. Bleachability with peroxide was tested and optimized in laboratory scale.

The results indicated that CMP and CTMP with good strength properties can be manufactured from Swintonia. Brightness and light scattering potential of the pulps did not reach the level of the typical mechanical pulp (TMP from softwood, brightness over 55 % and light scattering coefficient over 55 m^2/kg) in newsprint furnish. The maximum brightness with 3 % peroxide dosage was 53 % ISO and max. light scattering coefficient 50 m^2/kg.

Strength properties of Ceiba reached the level of spruce groundwood pulp. The right idea of the full potential of Ceiba was not obtained because of the transportation damages of the wood raw material.

According to the results of pulping experiments with Euca the potential for CMP/CTMP manufacture can only roughly be evaluated. This was due to the too low chemical charge used in the experiments. Wider pulping tests could not be performed because of shortage of wood raw material. The final potential of Euca for chemimechanical pulping cannot be predicted without further tests.

Based on the results of the first part of the experimental work four chemimechanical pulps were manufactured for papermaking experiments. These pulps were Euca CMP, Euca CTMP, Swintonia CTMP and Ceiba CTMP. Furnishes for newsprint trials were prepared by using bamboo chemical pulp as reinforcement pulp. Newsprint was produced on the pilot papermachine for pilot printing trials and laboratory tests. As a reference paper newsprint of typical Finnish furnish was manufactured as well.

The results of the papermaking and printing experiments pointed out fairly clearly that Euca pulps as such are not convenient for newsprint production. The main reason is the low strength properties which also deteriorate the printability of the paper. The pulp properties had presumable become better if stronger chemical charge had been applied.

Newsprint made of the furnish containing 80 % Swintonia CTMP and 20 % bamboo bleached kraft had good strength properties; tensile index clearly higher and tear index a bit lower than those of the reference newsprint. Also the runnability on the printing press and the printability were on the acceptable level. A drawback was lower opacity than that of the reference even with 10 % filler content. Lower opacity effects higher print through in the printing trials. It can be stated that Swintonia CTMP has a good potential for newsprint production if the lower brightness of paper is accepted.

The results with Ceiba CTMP indicated fairly good potential, too. But because of the partly bad condition of wood raw material the final idea of the usability remained still unclear.

INTRODUCTION

The Government of Burma is seeking possibilities to substitute for the import of newsprint with a domestic newsprint production. The preliminary investigations carried out in Burma have resulted in three hardwood species as raw material for chemimechanical pulps such as CMP and CTMP. The reinforcement pulp in the newsprint furnish would be bleached bamboo kraft.

Because there is not enough previous experience in the country about newsprint production and no pilot plant facilities for chemimechanical pulping or papermaking, the Government of Burma has requested UNDP to organize pilot plant experiments to verify the suitability of selected wood species for newsprint manufacture.

Commissioned by UNIDO the Finnish Pulp and Paper Research Institute has conducted the pilot scale pulping, papermaking and printing experiments to investigate the potential of three hardwood species sent from Burma for newsprint production.

The work was carried out in two parts. The first part includes pulping and bleaching experiments and laboratory handsheet testing of the manufactured pulp samples. In the second part papermaking and printing tests were performed.

The experimental work is described and the results are summarized in this report. A collection of samples of paper produced during the papermaking trials is annexed in a separate booklet.

Part 1: PULPING TESTS

1

INTRODUCTION

In this first part of the work pulping and bleaching experiments and results of the laboratory handsheet testing of the manufactured pulp samples are described.

2

CTMP PULPING EXPERIMENTS

2.1

Raw material

Three hardwood species were investigated. In this report they are called Euca, Swintonia and Ceiba. The general and scientific names are given below.

Table 1. Characteristics of the wood and chip quality.

General name	Scientific name	Density kg/m^3	DS %
Eucalyptus	Eucalyptus Camaldulensis	605	65.7
Taung Thayet	Swintonia Sloribunda	512	61.4
Thinbaw Let-pan	Ceiba Pentandra	158	35.7

The wood was delivered as unbarked logs. Debarking and chipping were carried out in Teollisuuden hake Oy at Kuusankoski. Eucalyptus and Swintonia wood was in good condition, but Ceiba was badly decayed. The results of the test classification of chips are given in appendix 1.

2.2 Equipment

The pulping experiments were carried out at the CTMP pilot plant of the Finnish Pulp and Paper Research Institute. A pilot batch digester and a counterrotating 40 inch Bauer-refiner were employed in the experiments. Detailed information of the equipment is given in reference 1.

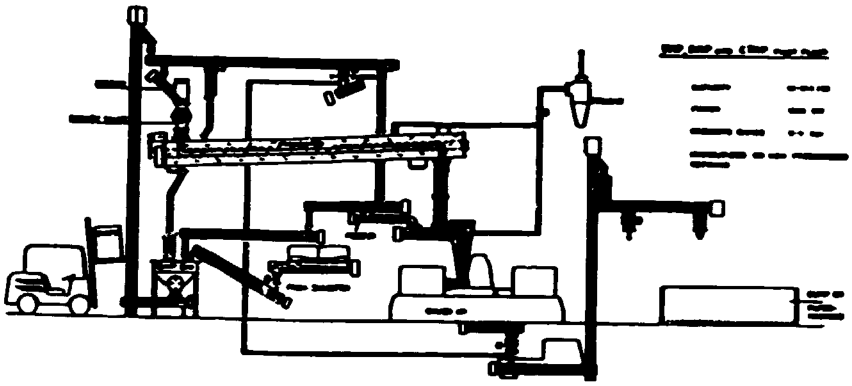

Fig. 1. Refiner mechanical pulp plant.

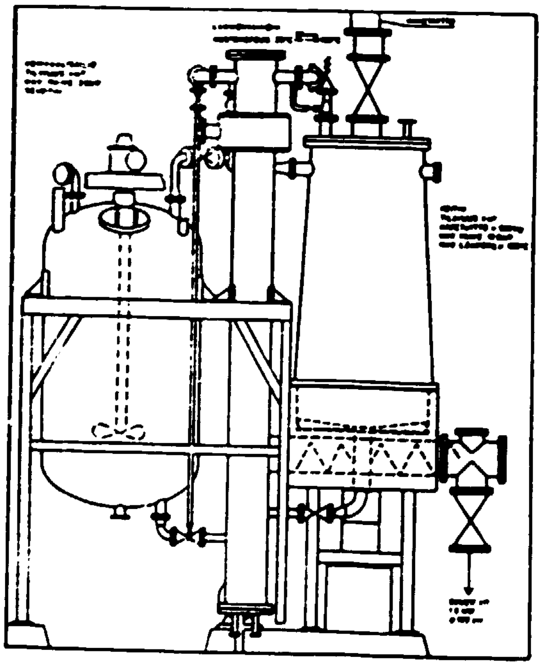

Fig. 2. CTMP-digester with heat exchanger and cooking liquor tank.

2.3
Conditions of chemical pretreatment

The chemical pretreatment of chips consisted of presteaming of chips, impregnation of chemicals and retention of impregnated chips at desired temperature. The pretreatment mode was called CMP when the retention of impregnated chips was carried out under atmospheric conditions and CTMP when under pressurized conditions. The impregnation of chips was done by circulating the fresh chemical liquor through the chips packed into the digester. After the impregnation waste liquor was pumped into the chemical tank, and temperature was raised with fresh steam up to the reaction temperature.

The cooking conditions of each chemical pretreatment are given in table 2. The composition of cooking liquors is given in appendix 2. The calculated chemical consumption values given in appendix 2 are only indicative because they are based on the volume measurements of liquor, which are not accurate. In appendix 3 are the pulping yields and parameters describing the environmental load.

Table 2. Cooking conditions.

Wood species	Euca		Swintonia			Ceiba
Process	CMP	CTMP	CMP	CMP	CTMP	CTMP
Na_2SO_3 g/l	-	20	-	-	30	20
NaOH g/l	10	5	20	30	15	5
DTPA % on Na_2SO_3	-	1	-	-	1	1
Presteaming						
time min	20	20	20	20	20	20
temp. ^0C	90	90	90	90	90	90
Impregnation						
time min	15	15	15	15	15	15
temp. ^0C	20-40	20-40	20-40	20-40	20-40	20-40
liquor:wood	5:1	5:1	5:1	5:1	5:1	5:1
Retention						
time min	30	10	30	30	10	10
temp. ^0C	90	130	90	90	130	130

2.4

Refining conditions

Refining was carried out in 3-4 stages. The first refining stage was pressurized and the subsequent stages were atmospheric. The reason for several refining stages was the poor loadability of the refiner in the first stage with pretreated hardwood chips. The refining conditions are given in appendix 4.1 and 4.2. In figures 4 and 5 are shown the plots of the specific refining energy vs pulp freeness.

3

PEROXIDE BLEACHING EXPERIMENTS

The peroxide bleaching experiments were divided in three stages. In the first stage the bleachability of pulp samples prepared at different conditions was tested and the bleaching conditions were optimized. After that pulp samples for furnish tests were bleached in selected conditions. For the last, pulps aimed for the papermachine run were bleached in pilot scale.

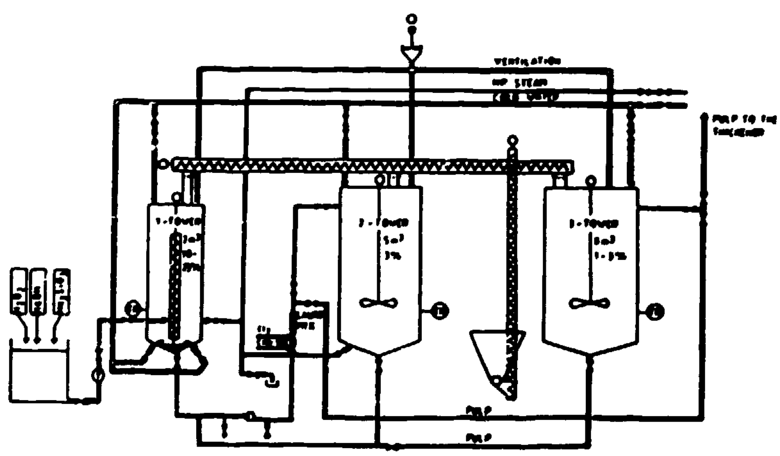

Fig. 3. Bleaching plant with high consistency tower and low consistency tank.

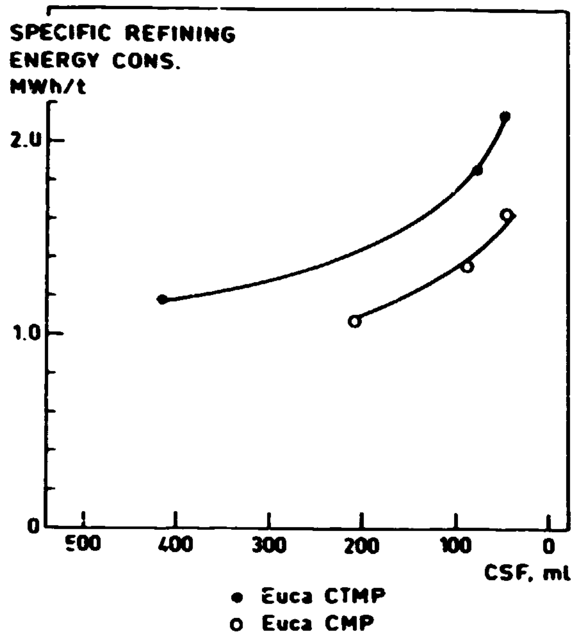

Figure 4. Specific refining energy consumption vs freeness of Euca pulps.

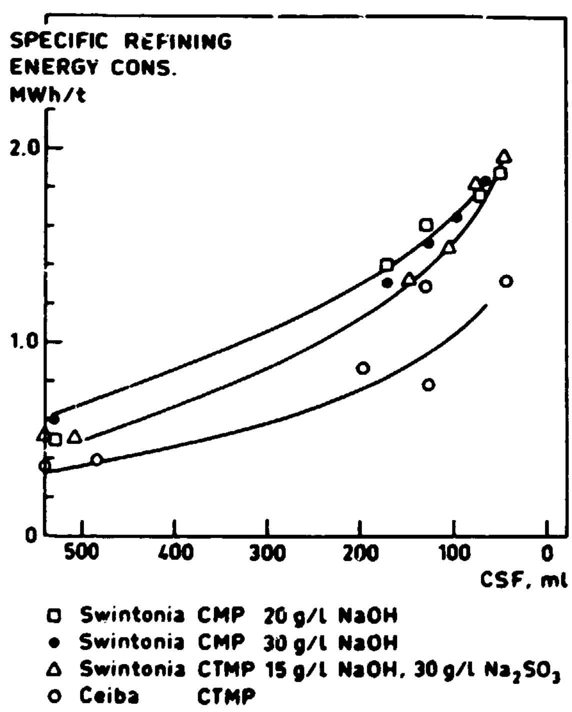

Figure 5. Specific refining energy consumption vs freeness of Swintonia and Ceiba pulps.

3.1
Optimization of bleaching conditions

The optimization of bleaching conditions was done in laboratory with 20 g batches. The bleaching conditions and results are given in appendix 5.1 and 5.2. The conditions chosen for further bleaching experiments are in table 3 below. Swintonia and Ceiba samples of 500 g were bleached with the optium conditions for furnish tests. The results of these bleaching series are in appendix 6.

3.2
Pilot bleaching of papermachine pulps

The peroxide bleaching of papermachine pulps was carried out for screened pulps in the pilot bleaching plant shown in figure 3. The bleaching conditions are given in appendix 7. The pulp was circulated in the high consistency tower by means of a vertical screw conveyor, and the temperature was raised with fresh steam.

Table 3. Peroxide bleaching conditions.

Conditions:		Hot disintegration	Peroxide stage
Consistency	%	3	15
Temperature	^0C	55-60	65
Time	min	15	180
DTPA	%	.2	.2
$MgSO_4$ $7H_2O$	%	-	.05
Sodium silicate	%	-	3.5
NaOH	%	-	-
H_2O_2	%	-	2.0

4
RESULTS OF OPTIMIZATION OF PULPING CONDITIONS

In order to find the best pulping conditions for each wood species both CMP- and CTMP-modes were employed to prepare pulp from Eucalyptus and Swintonia. From Ceiba only mild CTMP was manufactured. Due to the small quantity of Eucalyptus chips no more than two doses of caustic could be tested. The pulp types prepared are listed below. Details of the pulping conditions are given in table 2. The pulp types marked with an asterisk were manufactured for the papermachine run, too.

4.1
Results of pulp testing

Pulp testing results of the unbleached and bleached samples are given in appendix 8. The strength and optical characteristics of pulp samples made from Ceiba and Swintonia vs freeness are plotted in figures 6-9.

*Euca	CTMP	20 g/l	Na_2SO_3
		5 g/l	NaOH
*Euca	CMP	10 g/l	NaOH
Swintonia	CMP	20 g/l	NaOH
Swintonia	CMP	30 g/l	NaOH
*Swintonia	CTMP	30 g/l	Na_2SO_3
		15 g/l	NaOH
*Ceiba	CTMP	20 g/l	Na_2SO_3
		5 g/l	NaOH

The tear index ranks the pulps in the order of Swintonia CTMP > Swintonia CMP 30 g/l caustic > Swintonia CMP 20 g/l caustic > Ceiba CTMP. Tear vs CSF plot is shown in figure 8. The tensile index of Swintonia CTMP and CMP 30 g/l NaOH are at the same level as shown in figure 6. The Swintonia pulps do not differ from each other by the optical properties. Both the light scattering coefficient, figure 7, and the unbleached and bleached brightness are at the same level, figure 9. The strength characteristics of Ceiba are lower and light scattering coefficient is higher than those of Swintonia. This is mainly due to the decayed wood material of Ceiba.

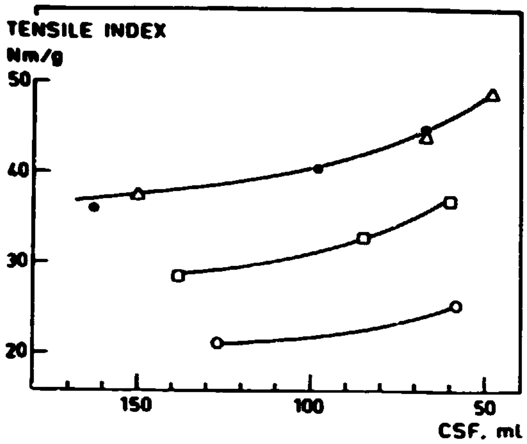

Figure 6. Tensile vs freeness of Swintonia and Ceiba pulps.

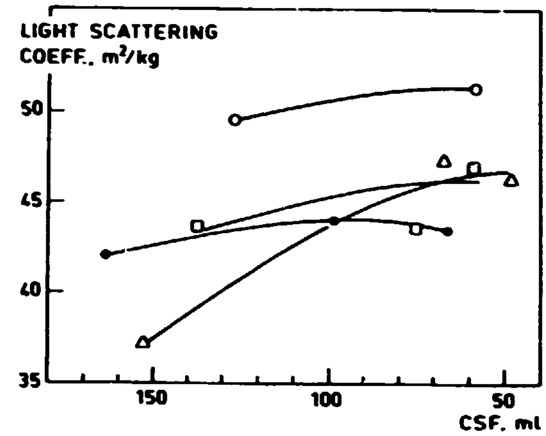

Figure 7. Light scattering coeff. vs freeness of Swintonia and Ceiba pulps.

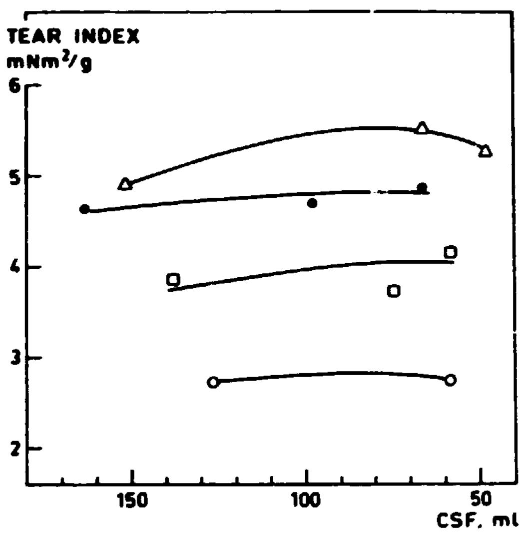

Figure 8. Tear vs freeness of Swintonia and Ceiba pulps.

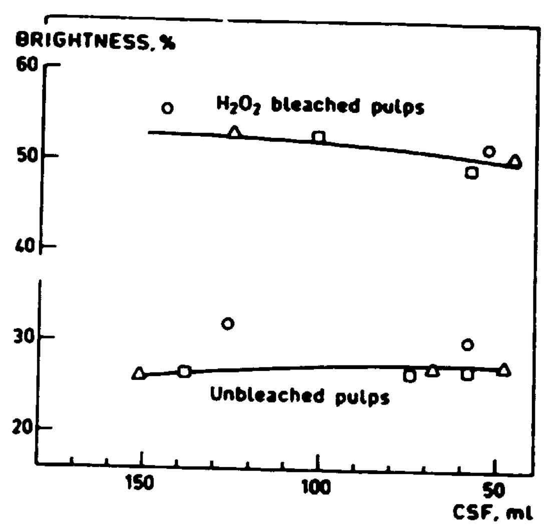

Figure 9. Unbleached and bleached brightness of Swintonia and Ceiba pulps.

□ Swintonia CMP 20 g/l NaOH
• Swintonia CMP 30 g/l NaOH
△ Swintonia CTMP 15 g/l NaOH, 30 g/l Na_2SO_3
○ Ceiba CTMP

4.2

Furnish tests

The objective of the handsheet furnish tests was to investigate a wider range of variables than in the papermachine runs.

For the tests were chosen Swintonia CMP 20 g/l, Swintonia CTMP and Ceiba CTMP samples. The variables in the test series were:

- CSF of furnish, varied by the CSF of mechanical pulp, 50-150 ml
- amount of chemical pulp, 10, 20, 30 %
- grammage, 45 and 52 g/m^2

4.3

Results of the furnish tests

The results of the handsheet testing are in appendix 9. Plots of the tensile and tear indeces and light scattering coefficient are in the figures 10-18.

Freeness of the furnish

The tensile and tear indeces are increasing by the increasing freeness, figures 10 and 12. The light scattering coefficient is slightly increasing with increasing freeness, figure 11. The characteristics of the papermachine pulp, CSF 99, are not as good as those of the other two samples. The reason for this is the different history of pulp samples. The papermachine pulp was screened and dewatered in ¡ ɔt scale, which means both loss of a portion of long fibers and fines.

Amount of chemical pulp

Due to the low strength of the chemical pulp the tensile and tear indeces are decreasing with the increasing amount of chemical pulp, figures 13 and 15. The light scattering coefficient also decreases when the amount of chemical pulp is increased, figure 14.

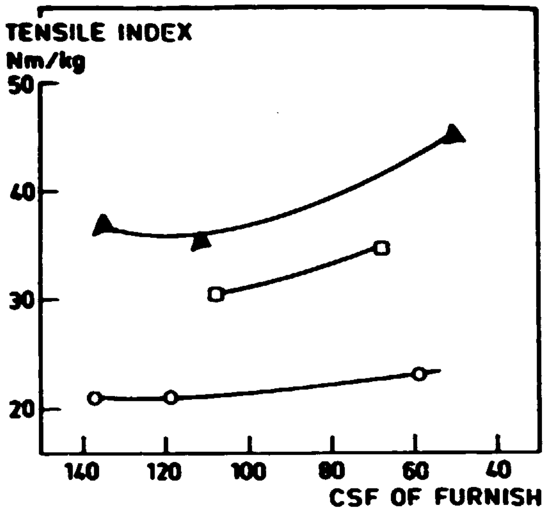

Figure 10.

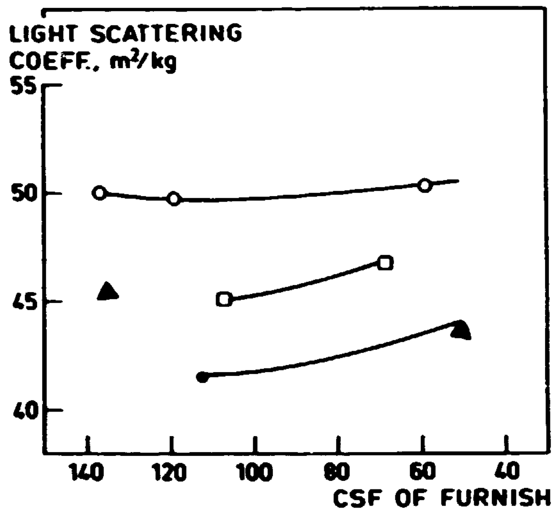

Figure 11.

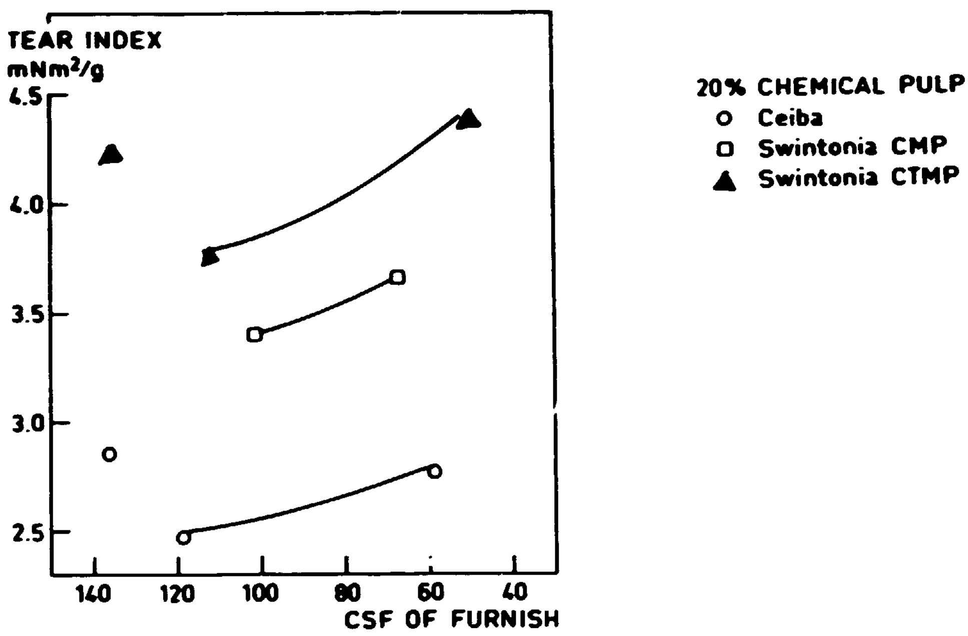

Figure 12.

Figures 10-12. Results of the furnish tests. The effect of the freeness of pulp mixtures on the characteristics of the handsheets. Freeness has been changed by changing the mechanical pulp freeness.

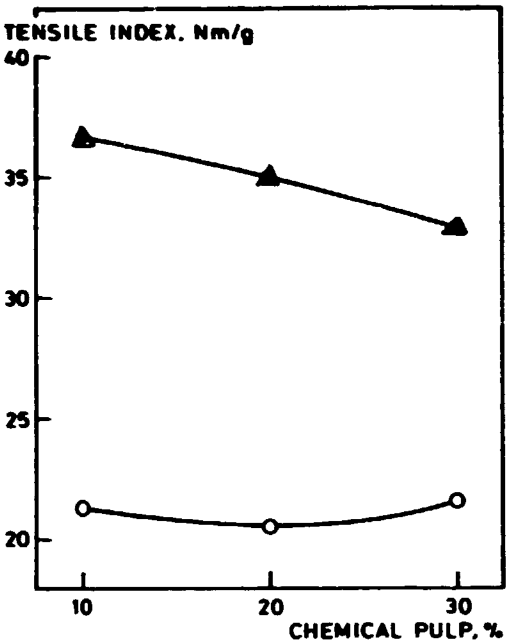

Figure 13.

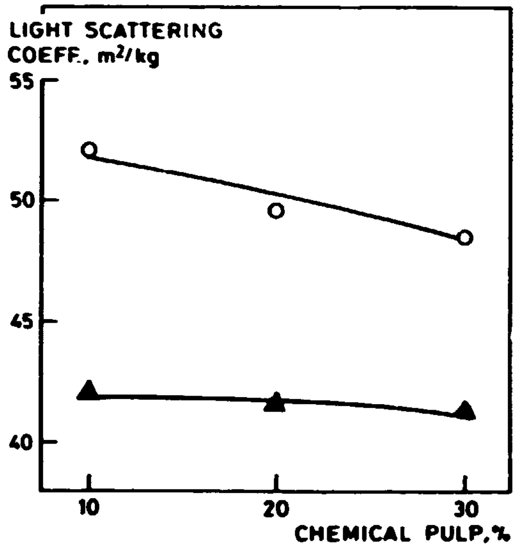

Figure 14.

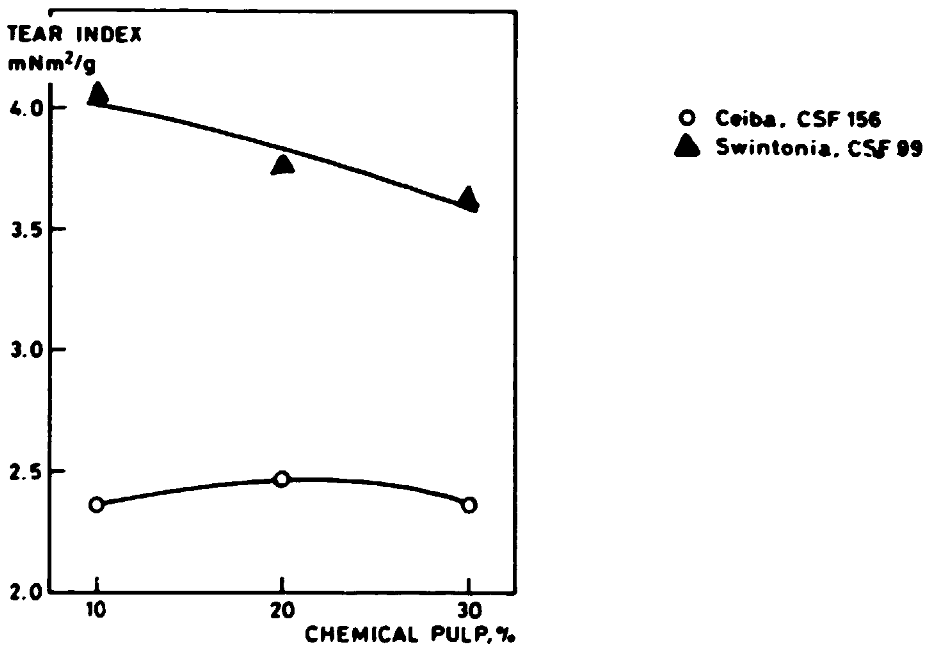

Figure 15.

Figures 13-15. Results of the furnish tests. The effect of the chemical pulp addition on the characteristics of the handsheets. Mechanical pulp is the same sample as used in the papermachine runs.

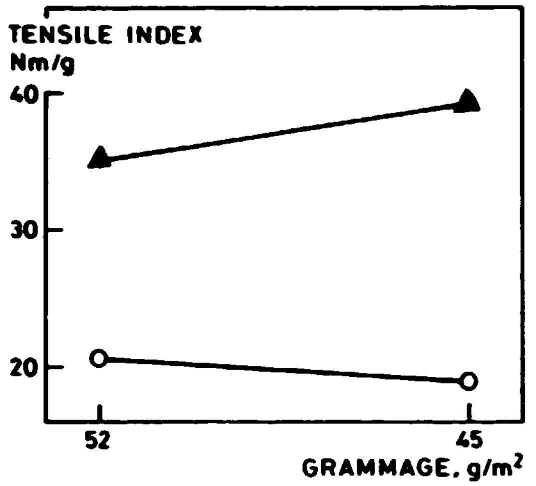

Figure 16.

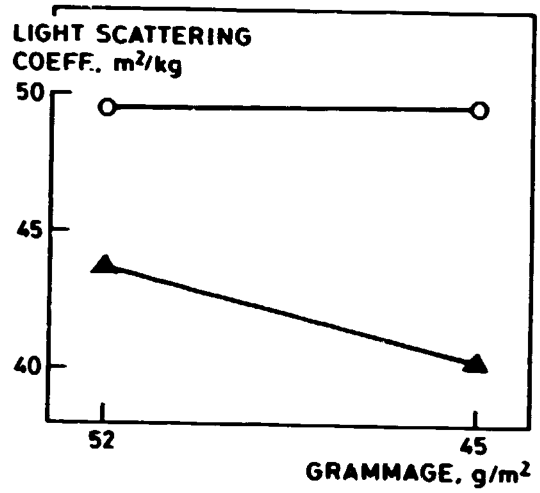

Figure 17.

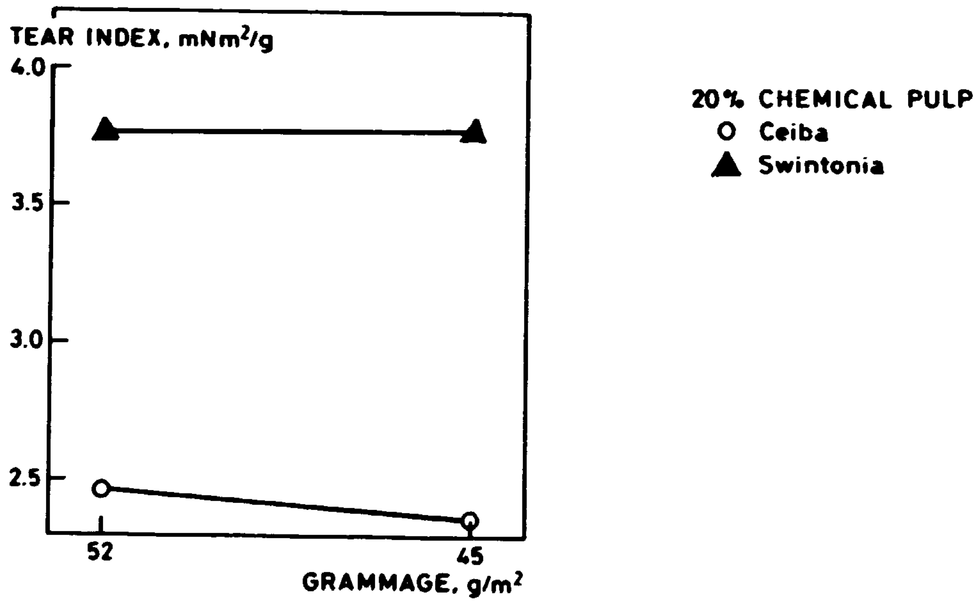

Figure 18.

Figures 16-18. Results of the furnish tests. The effect of the grammage on the characteristics of the handsheets. Mechanical pulp is the same sample as used in papermachine runs.

Grammage of the handsheets

The change of the grammage from 52 to 45 g/m^2 has only a slight effect on any properties of the handsheets, figures 16-18.

5 SUMMARY

Swintonia

Both CMP and CTMP processes can be employed to manufacture strong mechanical hardwood pulp from Swintonia. Increasing the caustic dose in the impregnation increases the pulp strength. Same strength properties of pulp can be achieved with CMP 30 g/l NaOH and CTMP 15 g/l NaOH, 30 g/l Na_2SO_3. Increasing the refining energy of pulp developes all pulp strength properties until the tear strength reaches a plateau.

The unbleached brightness of Swintonia pulps is under 30 % ISO. With 3 % peroxide the brightness can be increased to above 50 % ISO maximum 53 % ISO. The light scattering coefficient of bleached pulps is the same for both CMP and CTMP, around 47-50 %, however, in the furnish tests the light scattering coefficient of CMP is higher than that of CTMP.

There are large differences in the top side and wire side optical properties of the handsheets. These are due to the high amount of dissolved coloured material. Effective washing of pulp before bleaching would improve the results.

Ceiba

The density of Ceiba wood material is normally around 300 kg/m^3. This low density means good processability in the refining and low need of chemicals in the impregnation. With mild CTMP, 5 g/l NaOH and 20 g/l Na_2SO_3, could be manufactured pulp that had the strength characteristics at the level of spruce groundwood, although the wood material had suffered during the long transport.

The density of Ceiba used in the experiments was only 150 kg/m^3. It means this series doesn't give the right idea of the full potential of Ceiba.

Eucalyptus

The mild CMP and CTMP processes employed for Eucalyptus could not develope the strength of this Eucalyptus species. Due to the very high density of wood, 600 kg/m^3, higher caustic doses are required for proper defiberization. Increasing the caustic dose decreases the pulp brightness and effects the pulp bleachability. Without further experiments cannot be predicted what would be the final bleachability of stronger pulps.

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CHIPCLASSIFICATION RESULTS

	Eucalyptus		Swintonia	Ceiba	
Perforated screen fractions					
32 %	3,5	4,5	16,7	9,6	15,0
25	8,6	10,4	24,4	18,8	17,4
19	17,3	20,8	26,2	24,2	22,2
16	13,7	15,6	11,1	12,3	9,9
13	22,0	18,6	10,1	11,5	10,2
6	31,1	27,3	10,8	17,6	18,0
3	2,6	2,0	0,4	3,6	4,3
0	1,2	0,8	0,3	2,5	2,9
Slotted screen					
10	5,5	3,4	4,2	22,1	26,1
8	10,4	9,2	12,0	21,3	22,2
6	23,8	19,2	30,0	21,8	21,1
4	37,5	35,9	37,1	18,3	15,8
2	19,4	26,9	15,1	10,9	8,9
0	3,3	5,4	1,7	5,6	5,9
Average length of chips, mm	10,2	13,2			14,6
Average thickness of chips, mm	3,4	3,6			5,9
Density of wood, kg/m^3		605	512		158

Appendix 2. COMPOSITION OF COOKING LIQUORS C584-6

Wood species		Euca		Swintonia			Ceiba
Process		CMP	CTMP	CMP	CMP	CTMP	CTMP
Cook No.		18	17	21	22	24	23
Amount of wood	kg	289	289	240	247	355	245
Fresh liquor*							
NaOH	g/l	10,2	6,4	24,0	31,2	18,0	4,8
Na_2SO_3	g/l	-	21,4	-	-	46,3	18,9
pH		13,1	13,1	13,5	13,6	13,4	13,0
Volume	dm^3	1315	1360	1100	1150	1075	750
Combined waste liquor							
NaOH	g/l	4,3	2,1	10,7	21,1	6,4	1,2
Na_2SO_3	g/l	-	13,9	-	-	22,7	12,3
pH		13,0	12,7	13,3	13,4	13,0	12,5
Volume	dm^3	1700	1880	1275	1225	1325	875
Chemical consumption							
NaOH	kg	6,1	4,8	12,8	10,0	10,9	2,7
Na_2SO_3	kg	-	3,0	-	-	19,7	3,4
NaOH	% on wood	2,1	1,6	5,3	4,1	3,1	1,4
Na_2SO_3	% on wood	-	1,0	-	-	5,6	1,1

*) contains 1 % DTPA based on Na_2SO_3

Appendix 3.

C584-6

Woods species		Euca		Swintonia			Ceiba
Process		CTMP	CMP	CMP	CMP	CTMP	CTMP
NaOH		5	10	20	30	15	5
Na_2SO_3		20	-	-	-	30	20
Yield, %		90	91,2	86,9	84,9	85,7	82,9
Evap. residue	kg/t	282,3	160,5	272,9	392,0	462,0	415,2
Ignition residue	"	171,5	64,5	122,5	213,9	294,8	209,1
Ignition loss	"	110,8	96,0	150,4	178,1	167,2	206,1
TOC	"	50,9	41,7	70,2	81,4	85,3	114,4
BOD	kgO_2/t	22,9	24,0	61,6	71,5	55,0	85,2
CODcr	kg/t	145,9	130,8	182,9	204,0	212,5	287,1
Color	kgPt/t	291,1	310,2	658,1	689,2	568,3	360,7

Cook No.		17. Euca	Na_2SO_3 20 g/l		NaOH 5 g/l
Sample No.		451	454	457	459
Ref. stage		1.	2.	3.	4.
Power	kW	333	405	504	264
Prod. rate	t/h	872	512	739	906
Spec. ref. energy	MWh/t	0,38	0,79	0,68	0,29
Total spec. ref. energy	MWh/t	0,38	1,17	1,85	2,14
Dry solids cont.	%	30,4	31,8	28,2	25,0
CSF	ml	710	416	89	47

Cook No.		18. Euca NaOH 10 g/l				
Sample No.		452	453	455	456	458
Ref. stage		1.	2.	3.	3.	4.
Power	kW	202	441	390	430	221
Prod. rate	t/h	949	512	1215	1215	958
Spec. ref. energy	MWh/t	0,21	0,86	0,32	0,35	0,23
Total spec. ref. energy	MWh/t	0,21	1,07	1,39	1,42	1,64
Dry solids cont.	%	29,1	31,0	25,4	-	23
CSF	ml	-	212	85	-	46

Cook No.		21. Swintonia	NaOH 20 g/l			
Sample No.		466	467	468	469	470
Ref. stage		1.	2.	3.	3.	3.
Power	kW	308	484	522	372	217
Prod. rate	t/h	692	505	1096	1096	1096
Spec. ref. energy	MWh/t	0,45	0,95	0,48	0,34	0,20
Total spec. ref. energy	MWh/t		1,40	1,88	1,74	1,60
Dry solids cont.	%	31,3	25,5	22,2	23,8	22,5
CSF	ml	639	139	58	75	119

Cook No.		22. Swintonia NaOH 30 g/l				
Sample No.		471	473	474	475	476
Ref. stage		1.	2.	3.	3.	3.
Power	kW	391	402	272	437	150
Prod. rate	t/h	683	527	833	833	833
Spec. ref. energy	MWh/t	0,57	0,76	0,33	0,52	0,18
Total spec. ref. energy	MWh/t	0,57	1,33	1,66	1,85	1,51
Dry solids cont.	%	36,3	29,3	23,5	27,2	26,9
CSF	ml	565	164	97	67	127

Cook No.		23. Ceiba Na_2SO_3 20 g/l NaOH 5 g/l		
Sample No.		474	477	478
Ref. stage		1.	2.	3.
Power	kW	128	271	251
Prod. rate	t/h	295	762	466
Spec. ref. energy	MWh/t	0,43	0,36	0,54
Total spec. ref. energy	MWh/t	0,43	0,79	1,33
Dry solids cont.	%	18,0	16,2	13,3
CSF	ml	481	126	58

Cook No.		24. Swintonia		Na_2SO_3 30 g/l		NaOH 15 g/l
Sample No.		479	480	481	482	483
Ref. stage		1.	2.	3.	3.	3.
Power	kW	351	419	367	475	207
Prod. rate	t/h	666	530	717	717	717
Spec. ref. energy	MWh/t	0,53	0,79	0,51	0,66	0,29
Total spec. ref. energy	MWh/t		1,32	1,83	1,98	1,61
Dry solids cont.	%	35,3	28,0	26,5	29,5	-
CSF	ml	617	153	67	48	-

<u>Appendix 4.2</u> PULP FOR PM-RUN C584-6

Cook No.		Ceiba	Na_2SO_3 20 g/l	NaOH 5 g/l
Sample No.		537	542	543
Ref. stage		1.	2.	3.
Power	kW	187	232	191
Prod. rate	t/h	0,482	0,473	0,418
Spec. ref. energy	MWh/t	0,39	0,49	0,46
Total spec. ref. energy	MWh/t	0,39	0,88	1,34
Dry solids cont.	%	14,2	20,2	10,8
CSF	ml	550	195	139

Cook No.		Swintonia	Na_2SO_3 30 g/l		NaOH 15 g/l
Sample No.		535	536	540	541
Ref. stage		1.	1.	2.	3.
Power	kW	415	464	408	352
Prod. rate	t/h	707	718	868	885
Spec. ref. energy	MWh/t	0,59	0,65	0,47	0,40
Total spec. ref. energy	MWh/t			1,09	1,49
Dry solids cont.	%	28,7	30,4	24,6	21,0
CSF	ml	507	517	-	102

Cook No.		Euca	Na_2SO_3 20 g/l	NaOH 5 g/l
Sample No.		460	462	464
Ref. stage		1.	2.	3.
Power	kW	366	365	415
Prod. rate	t/h	822	432	1035
Spec. ref. energy	MWh/t	0,45	0,84	0,40
Total spec. ref. energy	MWh/t	0,45	1,29	1,69
Dry solids cont.	%	36,9	29,6	29,5
CSF	ml	-	350	-

Cook No.		Euca	NaOH 10 g/l	
Sample No.		461	463	465
Ref. stage		1.	2.	3.
Power	kW	400	325	353
Prod. rate	t/h	891	459	910
Spec. ref. energy	MWh/t	0,45	0,71	0,39
Total spec. ref. energy	MWh/t	0,45	1,16	1,55
Dry solids cont.	%	37,6	28,0	27,8
CSF	ml	675	-	97

Appendix 5.1 PEROXIDE BLEACHING OF CTMP AND CMP

	Sample No.	Wood species	Bleaching No.	Hot disintegr. Final pH	Hot disintegr. Brightn. ISO	PEROXIDE STAGE Conc. %	Temp. C⁰	Time min	DTPA %	$MgSO_4 \cdot 7H_2O$	Sodium silicate %	NaOH %	H_2O_2 %	pH initial/final	H_2O_2 residual %	Brightness ISO ts/ws
CTMP	464	Euca	88379													
			P1	-	- *)	10	80	60	0,2	0,05	2,0	2,5	3,0	10,4/8,3	0,53	53,5/50,7
			P3	6,0	32,3/28,7	12	80	60	-	0,05	2,0	2,5	3,0	10,2/8,8	0,82	61,6/59,5
CMP	465	Euca	88378													
			P1	-	- *)	10	80	60	0,2	0,05	2,0	2,5	3,0	10,4/8,1	0,68	51,1/48,0
			P3	6,2	26,6/26,1	12	80	60	-	0,05	2,0	2,5	3,0	10,4/8,1	0,71	57,8/57,7
			P4	"	"	12	70	60	-	0,05	3,5	3,0	3,0	10,6/8,9	0,64	57,8/55,4
			P5	"	"	12	70	60	-	0,05	2,0	3,0	4,0	10,6/8,5	1,09	59,7/58,6
CMP	20 g/l	Swintonia	88390													
			P1	-	24,3/23,4	12	65	60	-	0,05	2,0	2,5	3,0	10,3/9,4	0,23	46,5/46,3
			P2	-	"	12	70	60	0,1	0,05	3,5	2,3	3,0	10,4/9,2	0,88	48,4/48,3
			P3	-	"	12	65	60	0,1	0,05	3,5	1,9	3,0	10,6/9,4	1,24	45,8/46,4
															0,98**	47,5/47,8**
CMP	30 g/l	Swintonia	88391													
			P1	-	25,1/23,3	12	65	60	-	0,05	2,0	2,5	3,0	10,3/9,9	0,02	43,3/43,1
			P2	-	"	12	70	60	0,1	0,05	3,5	2,2	3,0	10,4/9,4	0,69	47,0/46,7
			P3	-	"	12	65	60	0,1	0,05	3,5	1,8	3,0	10,4/9,9	1,19	44,3/44,5
															0,95**	48,3/47,8**
CTMP	30/15 g/l	Swintonia	88396													
			P1	8,5	26,4/25,0	12	70	60	0,1	0,05	3,5	2,2	3,0	10,5/9,5	0,71	47,1/48,8
			P2	"	"	12	70	60	0,1	0,05	3,5	2,2	4,0	10,6/9,4	1,52	49,6/50,1
			P3	"	"	12	65	60	0,1	0,05	3,5	1,8	3,0	10,8/9,3	0,93**	48,8/48,8**

Conditions of hot disintegration: consistency 3 %
temperature 55-60 ⁰C
time 15 min
DTPA 0,2 % on od.pulp

*) no hot disintegration
**) after 120 min

Appendix 5.2 PEROXIDE BLEACHING OF CTMP AND CMP C584-6

Sample No.		Wood species	Bleaching No.	Hot disintegr. Final pH	Hot disintegr. Brightn. ISO ts/ws	PEROXIDE STAGE NaOH %	H_2O_2 %	pH Initial	pH 1h	pH 2h	H_2O_2 residual % 1h	H_2O_2 residual % 2h	Brightness ISO 1h ts/ws	Brightness ISO 2h ts/ws
CTMP	477	Ceiba	88408	7,8	31,8/26,4	1,5	2,0	10,3	9,0	8,7	0,87	0,71	48,5/44,5	49,0/47,0
			88405	"	"	1,8	3,0	10,6	9,5	9,1	1,80	1,59	54,1/50,0	56,8/53,1
			88433	"	"	2,3	4,0	10,3	9,5	9,2	1,95	1,60	58,8/56,8	60,3/59,1
CTMP	478	Ceiba	88454	7,5	29,7/26,9	1,5	2,0	10,4	9,2	8,8	0,71	0,45	45,3/42,4	48,4/44,9
			88452	"	"	1,9	3,0	10,3	9,3	9,0	1,01	0,79	50,2/47,7	54,5/52,2
			88455	"	"	2,3	4,0	10,4	9,4	9,0	1,43	1,03	51,1/50,8	53,1/54,2
CTMP	480	Swintonia	88444	8,0	23,7/22,9	1,5	2,0	10,4	9,5	9,3	0,80	0,60	40,9/40,2	46,6/46,6
			88445	"	"	1,9	3,0	10,2	9,3	9,2	1,27	1,03	46,1/46,7	47,8/47,6
			88439	"	"	2,3	4,0	10,6	9,7	9,5	1,76	1,44	49,5/49,8	51,5/51,5
CMP	467	Swintonia	88441	8,1	-	1,5	2,0	10,4	9,3	9,0	0,77	0,55	42,7/41,9	46,4/45,2
			88443	"	-	1,9	3,0	10,5	9,3	9,0	1,31	1,13	-	49,7/49,0
			88438	"	-	2,3	4,0	10,4	9,5	9,3	1,58	1,33	48,8/49,2	52,8/52,9

CONDITIONS:	Pretreatment	P-stage
Consistency, %	3	12
Temperature, ^{0}C	55-60	65
Time, min	15	120
DTPA % on od.pulp	0,2	0,1
$MgSO_4 \cdot 7H_2O$, %	-	0,05
Sodium silicate (40 Bé)	-	3,5
NaOH, %	-	variable
H_2O_2, %	-	variable

Amount of pulp 20 g od.

Appendix 6. PEROXIDE BLEACHING OF CTMP AND CMP C584-6

Sample No.	Wood species	Bleaching No.	Hot disintegr. Final pH	Hot disintegr. Yield %	PEROXIDE STAGE NaOH %	pH Initial	pH 1h	pH 2h	pH 3h	H_2O_2 residual % 1h	2h	3h	Brightness ISO 2h ts/ws	Brightness ISO 3h ts/ws	Bleaching yield %	Total yield %
CTMP 477	Ceiba	88419	7,1	84,4	2,0	10,3	9,6	9,2	9,0	1,15	0,99	0,78	52,8/49,6	54,1/51,7	95,8	80,9
CTMP 478	Ceiba	88420	7,0	90,7	2,0	10,2	9,3	9,1	9,0	0,91	0,71	0,59	51,3/49,0	53,7/52,7	94,6	85,8
CTMP 482	Swintonia	88421	7,8	94,1	2,0	10,2	9,7	9,4	9,1	1,23	0,92	0,77	46,8/47,9	51,5/50,3	95,2	89,6
CTMP 480	Swintonia	88422	7,8	89,3	2,0	10,3	9,8	9,5	9,3	1,32	0,96	0,86	50,2/49,8	52,1/51,8	95,5	85,3
CMP 467	Swintonia	88423	7,8	91,9	2,0	10,5	9,7	9,3	9,0	1,24	1,08	0,94	48,8/49,1	53,4/53,3	98,0	90,0
CMP 469	Swintonia	88424	7,5	93,9	2,0	10,3	9,7	9,2	9,1	1,22	0,92	0,81	50,2/50,5	50,7/51,5	95,5	89,7

CONDITIONS:	Pretreatment	Peroxide stage
Consistency, %	3	15
Temperature, °C	55-60	65
Time, min	15	180
DTPA, % on od.pulp	0,2	0,2
$MgSO_4 \cdot 7H_2O$, %	-	0,05
Sodium silicate (40 Bé)	-	3,5
NaOH, %	-	2,0
H_2O_2, %	-	3,0

Amount of pulp 500 g od.

6.9.88	CTMP	Euca	190 kg	65 °C - 70 °C, 50 min	DTPA	0,2 %		Acidifying with $NaHSO_3$	pH 6
				Consistency 15 %	Epsom salt	0,05 %		Brightness	62,9/62,5
					Na-silic.	3,5 % (40 Bé)		Unbleached brightness	42,1/40,0
					NaOH	3,0 %			
					P	3,0 %	Residual 0,2 %	Final pH 8,5	
7.9.88	CMP	Euca	200 kg	70 °C, 50 min	DTPA	0,2 %		Acidifying with $NaHSO_3$	pH 6
				Consistency 15 %	Epsom salt	0,05 %		Brightness	56,6/55,0
					Na-silic.	3,5 % (40 Bé)		Unbleached brightness	36,9/35,3
					NaOH	3,0 %			
					P	3,0 %	Residual 0,08 %	Final pH 8,9	
11.10.88	CTMP	Swintonia	180 kg	65 °C, 50 min	DTPA	0,3 %		Acidifying with $NaHSO_3$	pH 6,5
				Consistency 14 %	Epsom salt	0,05 %		Brightness	40,3/39,3
					Na-silic.	3,5 % (40 Bé)		Unbleached brightness	30,4/30,0
					NaOH	2,1 %			
					P	3,0 %	Residual -	Final pH 9,7	
12.10.88	CTMP	Swintonia	100 kg	65 °C, 60 min	DTPA	0,3 %		Acidifying with $NaHSO_3$	pH 6,5
				Consistency 14 %	Epsom salt	0,05 %		Brightness	45,7/45,4
					Na-silic.	4,0 % (40 Bé)		Unbleached brightness	28,3/28,5
					NaOH	1,9 %			
					P	3,0 %	Residual 0,2 %	Final pH 9,6	
13.10.88	CTMP	Swintonia	195 kg	65 °C, 60 min	DTPA	0,3 %		Acidifying with $NaHSO_3$	pH 6,3
				Consistency 14 %	Epsom salt	0,05 %		Brightness	45,7/45,5
					Na-silic.	4,0 % (40 Bé)			
					NaOH	1,8 %			
					P	3,0 %	Residual 0,36 %	Final pH 9,5	
19.10.88	CTMP	Ceiba	65 kg	65 °C, 90 min	DTPA	0,2 %		Acidifying with $NaHSO_3$	pH 5,5
				Consistency 12 %	Epsom salt	0,05 %		Brightness	49,0/44,7
					Na-silic.	4,0 %			
					NaOH	1,7 %			
					P	3,0 %	Residual 1,0 %	Final pH 8,6	

Appendix 8. Euca CTMP 20 g/l Na_2SO_3
5 g/l NaOH

C584-6

PM-pulp

Sample No.	454	457	459		464
Dry solids content, %	31,8	28,2	25,0		29,5
Reject 0,16 mm, %	-	-	-		-
CSF, ml	416	89	47		127
Somerville-shives, %	0,58	0,15	0,12		0,14
PFI-shives, %	-	-	-		-
Bauer McNett, % + 28	0,6	0,1	0,1		0,3
+ 48	26,7	14,7	15,9		25,0
+ 100	23,8	20,4	23,0		20,7
+ 200	17,5	18,0	20,3		17,6
- 200	31,4	46,8	40,7		36,4
52 g/m2 hand sheets prepared with white water:					
Tensile index, Nm/g	3,13	7,65	10,5		10,5
Stretch, %	0,92	1,14			1,24
Burst index, $kPam^2/g$	-	-	-		-
Tear index, mNm^2/g	0,54	0,80	0,98		1,02
Density, kg/m^3	220	275	296		259
Air permeability resistance, s	0,1	0,9	2,1		0,9
Opacity, %	97,4	98,9	98,2		98,5
Brightness, %	36,1	38,0	44,2		39,2
Light scattering coeff., m^2/kg	43,2	56,1	60,7		55,0
Light absorption coeff., m^2/kg	10,9	12,8	9,23		11,3

Appendix 8. (cont.) Euca 10 g/l NaOH C584-6

PM-pulp

Sample No.	453	455	458		465
Dry solids content, %	31,0	25,4	23,0		27,8
Reject 0,16 mm, %	-	-	-		-
CSF, ml	212	85	46		97
Somerville-shives, %	1,40	0,62	0,17		0,13
PFI-shives, %	-	-	-		-
Bauer McNett, % + 28	1,1	0,5	0,1		0,08
+ 48	18,9	18,0	16,2		21,7
+ 100	21,9	23,0	23,5		20,8
+ 200	17,6	20,0	20,6		18,6
- 200	40,5	38,5	39,6		38,8
52 g/m2 hand sheets prepared with white water:					
Tensile index, Nm/g	5,46	7,37	9,81		11,4
Stretch, %	1,0	1,11	1,16		1,24
Burst index, kPam^2/g	-	-	-		-
Tear index, mNm^2/g	0,77	0,80	0,93		1,17
Density, kg/m^3	251	270	284		287
Air permeability resistance, s	0,4	0,9	1,8		1,6
Opacity, %	98,6	98,9	98,4		99,2
Brightness, %	34,0	35,6	43,9		36,2
Light scattering coeff., m^2/kg	47,5	52,6	61,4		57,4
Light absorption coeff., m^2/kg	13,9	14,2	9,90		14,5

Appendix 8. (cont.) Swintonia CMP 20 g/l NaOH C584-6

H_2O_2 bleached pulp

Sample No.	467	469	468	467	469
Dry solids content, %				20,8	15,3
Reject 0,16 mm, %				-	-
CSF, ml	139	75	58	102	58
Somerville-shives, %	0,30	0,15	0,15	0,12	0,05
PFI-shives, %	-	-	-	-	-
Bauer McNett, % + 28	15,1	14,4	14,6	15,7	15,3
+ 48	37,5	36,1	35,5	38,3	36,7
+ 100	11,6	11,6	11,6	11,5	12,5
+ 200	7,0	7,1	7,2	7,2	7,2
- 200	28,8	30,8	31,1	27,3	28,3
52 g/m2 hand sheets prepared with white water:					
Tensile index, Nm/g	28,1	33,7	36,7	34,2	37,6
Stretch, %	2,46	2,46	2,40	2,49	2,4
Burst index, $kPam^2/g$	-	-	-	1,59	1,86
Tear index, mNm^2/g	3,84	3,76	4,15	3,82	4,31
Density, kg/m^3	345	366	381	402	436
Air permeability resistance, s	9,6	28	46	29	72
Opacity, %	99,4	99,4	99,6	90,4	90,5
Brightness, %	26,4	26,8	39,5/26,6	52,4	49,7
Light scattering coeff., m^2/kg	43,8	43,7	45,6/48,3	47,9	49,7
Light absorption coeff., m^2/kg	21,1	20,6	23,1	2,79	-

Appendix 8. (cont.) Swintonia CMP 30 g/l NaOH C584-6

Sample No.	473	474	475		
Dry solids content, %					
Reject 0,16 mm, %					
CSF, ml	164	97	67		
Somerville-shives, %	0,24	0,29	0,11		
PFI-shives, %	-	-	-		
Bauer McNett, % + 14	21,3	22,9	19,4		
+ 28	37,6	35,9	36,1		
+ 48	9,7	9,7	10,0		
+ 200	5,6	5,6	5,9		
- 200	25,8	25,9	28,6		
52 g/m2 hand sheets prepared with white water:					
Tensile index, Nm/g	36,0	40,6	44,4		
Stretch, %	3,13	3,17	3,30		
Burst index, kPam^2/g	-	-	-		
Tear index, mNm^2/g	4,61	4,72	4,76		
Density, kg/m^3	387	396	424		
Air permeability resistance, s	23	50	120		
Opacity, %	99,3	99,4	99,3		
Brightness, %	26,0	26,8	26,8		
Light scattering coeff., m^2/kg	42,2	44,7	43,7		
Light absorption coeff., m^2/kg	20,0	20,1	20,0		

Appendix 8. (cont.) Swintonia CTMP 15 g/l NaOH
30 g/l $Na_2S^n_3$ C584-6

				H_2O_2 bleached pulp		
Sample No.	480	481	482	480	482	541
Dry solids content, %	28,0	26,5	29,5	22,3	18,1	2,61
Reject 0,16 mm, %	-	-	-	-	-	-
CSF, ml	153	67	48	125	33	99
Somerville-shives, %	0,29	0,12	0,10	0,15	0,05	0,03
PFI-shives, %	-	-	-	-	-	-
Bauer McNett, % + 28	22,6	22,5	21,3	24,3	22,0	16,6
+ 48	36,8	35,7	34,8	37,2	35,4	40,4
+ 100	9,1	9,3	9,8	9,8	9,8	10,6
+ 200	5,2	5,6	5,7	5,4	5,8	6,4
- 200	26,3	26,9	28,4	23,3	27,0	26,0
52 g/m2 hand sheets prepared with white water:						
Tensile index, Nm/g	36,7	44,0	48,4	40,0	55,8	39,1
Stretch, %	3,06	3,29	3,27	2,6	3,23	2,6
Burst index, $kPam^2/g$	-	-	-	2,22	3,45	1,92
Tear index, mNm^2/g	4,92	5,52	5,22	3,56	5,44	4,83
Density, kg/m^3	388	426	459	432	508	433
Air permeability resistance, s	25	100	200	50	440	46
Opacity, %	98,7	99,6	99,5/99,1	90,0	90,1	92,9
Brightness, %	26,7	40,4/27,0	40,7/27,2	52,9	50,3	46,8
Light scattering coeff., m^2/kg	37,3	47,1	45,9/42,7	50,1	47,1	46,3
Light absorption coeff., m^2/kg	17,6	22,7	22,2/18,4	-	2,77	4,43

Appendix 8. (cont.) Ceiba 5 g/l NaOH
20 g/l Na_2SO_3

C584-6

H_2O_2 bleached PM-pulp

Sample No.	472	477	478	477	478	543
Dry solids content, %		16,2	13,3	17,3	17,9	2,8
Reject 0,16 mm, %		-	-	-	-	-
CSF, ml		126	58	145	53	156
Somerville-shives, %		0,36	0,26	0,19	0,14	0,38
PFI-shives, %		-	-	-	-	-
Bauer McNett, % + 28		10,9	9,4	11,1	15,3	6,6
+ 48		18,5	15,6	16,6	10,0	22,5
+ 100		9,2	9,9	9,0	10,6	11,5
+ 200		10,2	11,1	10,0	11,9	12,3
- 200		51,2	54,0	53,3	52,2	47,1
52 g/m2 hand sheets prepared with white water:						
Tensile index, Nm/g		21,2	25,5	21,5	25,7	23,6
Stretch, %		1,54	1,65		1,41	1,4
Burst index, $kPam^2/g$		-	-	0,73	0,91	0,79
Tear index, mNm^2/g		2,74	2,75	3,23	2,53	2,34
Density, kg/m^3		329	355	317	355	371
Air permeability resistance, s		14	30	11	29	22
Opacity, %		99,5	99,8	92,0	95,8	96,1
Brightness, %		32,0/35,1	30,5/33,3	55,9	52,4	50,0
Light scattering coeff., m^2/kg		49,5/57,5	52,9/60,8	53,8	59,6	57,5
Light absorption coeff., m^2/kg		19,5/17,7	24,4/22,4	2,95	5,10	5,78

Appendix 9. RESULTS OF FURNISH TESTS C584-6

%		CSF	Bamboo chemical pulp %	Target grammage	CSF (of furnish)	Grammage g/m^2	Density kg/m^3	Brightness %	Opacity %	Scatt. coeff. m^2/kg	Dom. wave length nm	Excitation purity %	Tensile index N.m/g	Tear index $mN.m^2/g$	Burst index $kPa.m^2/g$
80	Swintonia CTMP	125	20	52	135	51,8	443	53,4	88,4 (52 g/m^2)	45,2	576,5	19,1	36,9	4,25	2,09
80	" "	99	20	52	112	52,0	416	47,8	89,8 "	41,5	577,5	21,1	35,0	3,77	1,81
80	" "	33	20	52	50	50,3	503	52,2	88,0 "	43,7	576,5	20,1	45,9	4,37	2,82
80	Swintonia CMP	102	20	52	108	51,0	415	53,4	88,4 "	45,0	576,5	19,1	30,4	3,45	1,54
80	" "	58	20	52	69	50,7	445	54,3	88,9 "	46,9	576,5	18,5	35,5	3,67	1,83
80	Ceiba	145	20	52	136	50,3	346	56,3	90,9 "	50,0	576,0	15,2	20,7	2,86	0,89
80	"	156	20	52	119	50,2	375	50,5	93,5 "	49,5	576,5	16,6	20,5	2,47	0,83
80	"	53	20	52	59	52,5	383	52,5	93,8 "	50,7	577,0	14,5	23,2	2,74	1,01
90	Swintonia CTMP	99	10	52	112	51,6	410	46,1	90,8 "	42,0	577,5	22,0	36,8	4,03	1,96
70	" "	99	30	52	116	51,8	428	49,5	89,1 "	41,3	577,5	20,2	33,0	3,63	1,70
90	Ceiba	156	10	52	133	50,7	365	50,1	94,3 "	52,0	576,5	16,9	21,1	2,37	0,87
70	"	156	30	52	120	50,3	423	52,4	92,4 "	48,4	576,5	15,9	21,6	2,39	0,92
80	Swintonia CTMP	99	20	45	112	45,6	400	47,7	86,1 (45 g/m^2)	40,3	577,5	21,3	33,6	3,77	1,73
80	Ceiba	156	20	45	119	46,2	370	51,1	90,4 "	49,9	576,5	16,5	19,5	2,38	0,82

Part 2: PAPER MACHINE TRIALS

1 INTRODUCTION

This report summarizes the program of paper machine experiments, the conditions employed and the results of paper and printing tests.

2 EQUIPMENT

The pilot paper machine is a conventional Fourdrinier machine. The normal run speed is about 100 m/min and the trimmed width 700 mm. Basis weight range is 18-250 g/m^2. A picture of the paper machine is presented in appendix 1.

3 PROGRAM OF EXPERIMENTS

The paper grade to be manufactured was newsprint with the grammages of 52 g/m^2 and 45 g/m^2. The program of experiments is explained in details in appendix 2. As a reference a Finnish newsprint was manufactured from the furnish transported from a machine chest of a newsprint mill.

The paper machine trials were run in two phases. The first phase was carried out during the visit of Burmese engineers. Newsprint from furnishes containing Euca CMP/CTMP and bamboo pulps as well from reference furnish number 1 was produced. The second phase included trials with the other mechanical pulps and reference furnish number 2.

As mechanical pulps were used

- Euca CTMP (Eucalyptus)
- Euca CMP (Eucalyptus)
- Swintonia CTMP (Taung Thayet)
- Ceiba CTMP (Thinbaw Let-pan)

Mechanical pulps were made at the FPPRI's pilot TMP-plant (part 1 of this report).

As chemical pulp was used

- Bleached bamboo kraft pulp

delivered from Burma. The pulp used was refined at FPPRI.

In one trial point filler was used. It was clay of English China Clay, grade C, and the retention aid used was Percol 445 (Allied Colloids).

All the papers were on-line calendered.

Testing of water, pulp and paper samples is explained in appendix 2.

4 PULPS

Properties of the mechanical pulps used in paper machine trials are presented in appendix 3.

The freeness values were:

Mechanical pulp	CSF,ml
Euca CTMP	94
Euca CMP	57
Swintonia CTMP	99
Ceiba CTMP	156

Chemical pulp refining conditions and properties of the pulp are presented in appendix 4. Freeness of pulp before refining was 475 ml. After refining the freeness of pulp used in pilot runs of phase 1 was 220 ml and in pilot runs of phase 2 204 ml. Specific edge load was 0,4 Ws/m and specific energy consumption 15 kWh/t.

In the runs of phase 1 the fibre composition was

- 65 % Euca
- 35 % bamboo pulp

The fibre composition in phase 2 was

- 80 % Swintonia or Ceiba
- 20 % bamboo pulp

As a reference furnish was used a typical Finnish newsprint furnish brought from a newsprint mill. Two reference papers were made: the first was to refer with Euca trials and the second with Swintonia and Ceiba trials.

5 PAPERMAKING

Newsprint was produced according to the normal test running procedure used at FPPRI.

Paper machine conditions are presented in appendix 5 and properties of water samples, wire retentions and dry solids of paper web after press section in appendix 6. Analyses of all trial points were not done because of shortage of pulp.

Speed of paper machine was 60 m/min. Temperature in short circulation was about 30 ^{0}C. Linear loads of presses were 40, 50 and 50 kN/m. The points 2-9 were calendered with linear load of 35 kN/m (2 nips) and the reference points 1 and 10 as well as point 2 with 50 kN/m (2 nips).

Papers with grammage of 45 g/m^2 were manufactured in headbox consistencies between 0,23-0,29 % and 52 g/m^2 0,26-0,44 % excluding trial 8 with filler, where consistency was even higher.

Wire retention with Euca pulps was about 74 %, with Swintonia 82 % and with Ceiba 86 %.

Dry solids content after press section was with Euca pulps 44 % and with Swintonia about 41 %.

6
THE RESULTS OF PAPER TESTING

Paper physical properties are collected in appendix 7 (uncalendered) and appendix 8 (machine calendered). Paper samples were tested according to FPPRI's normal testing methods. A collection of paper samples is annexed in a separate booklet.

The main properties are roughness, density, tensile index, tear index, light scattering coefficient, opacity and oil absorption and they are presented for calendered samples graphically in figures 1-6. To compare papers with each other one has to consider the following:

- Chemical pulp amount
  - 35 % with Euca pulps
  - 20 % with Swintonia and Ceiba pulps

- Calendering conditions
  - references 50 kN/m, 2 nips
  - the others 35 kN/m, 2 nips

The Euca papers at grammage 52 g/m^2 were calendered to roughness about 150 ml. The same calendering conditions were then used with the other Burmese samples. The reference paper was also calendered to target roughness 150 ml, but calendering load needed was at higher level.

It can be seen from the pictures 1 and 2 that Swintonia CTMP paper was much easier to calender than the other papers and that density of it was also clearly higher. It has to be noticed that density of uncalendered Swintonia CTMP paper was already higher than that of other uncalendered papers.

Strength properties, pictures 3 and 4, of the Euca samples were at a very low level, clearly lower than the reference level. Tear strength of Euca CTMP sample was a little higher than that of Euca CMP sample. Tear strength of Ceiba CTMP sample was also low, but tensile index was at the same level with the reference.

Swintonia CTMP sample had good strength properties. Tear index was almost as good as that of reference and tensile index was at a very high level. The sample where filler was used had slightly lower strength properties.

Light scattering coefficient, picture 5, of all the Burmese samples was at a lower level than that of reference samples. Especially the Swintonia CTMP samples had very low light scattering values. Euca samples had the best light scattering of Burmese samples, but Ceiba sample was almost at the same level.

Opacity of the Euca CMP sample with higher grammage was at the same level as that of reference (90 %), picture 6. Ceiba sample had the highest opacity value of Burmese samples. The opacity of Swintonia samples was slightly lower than that of Euca samples.

Oil absorbency of Eucalyptus samples differs clearly from the others. It's twice as much as with the reference, Swintonia and also Ceiba samples.

7 THE RESULTS OF THE TEST PRINTING

The papers were printed in web offset printing press of the Technical Research Center of Finland.

Research results of test printing are in appendix 9 (Euca) and appendix 10 (Swintonia and Ceiba).

In both tests a different Finnish reference newsprint was used.

In appendices 9 and 10 the meaning of the sample numbers is following:

Sample number	Trial point	Mech. pulp	Grammage g/m^2
1.1	1	Reference 1	45
2.1	2	Euca CTMP	52
3.1	4	Euca CMP	52
1	6	Swintonia CTMP	52
2	7	Swintonia CTMP	45
5	10	Reference 2	45

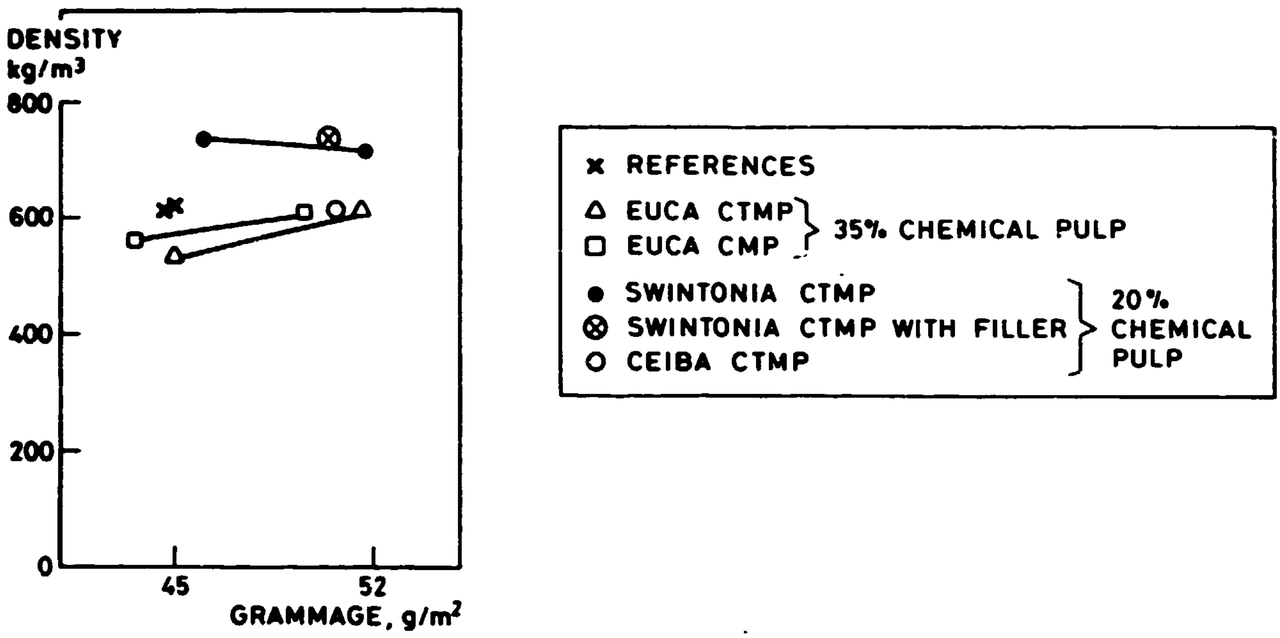
First test printing was done with newsprint made of Euca CTMP and CMP. There were several web breaks with these papers. Newsprint had heavy linting tendency.

Euca CMP sample had highest density but lowest contrast. The biggest print through was measured from Euca CTMP sample. The rub-off level of Euca samples was clearly higher than that of reference. In subjective evaluation the best in every test was reference and Euca CMP sample was the second best.

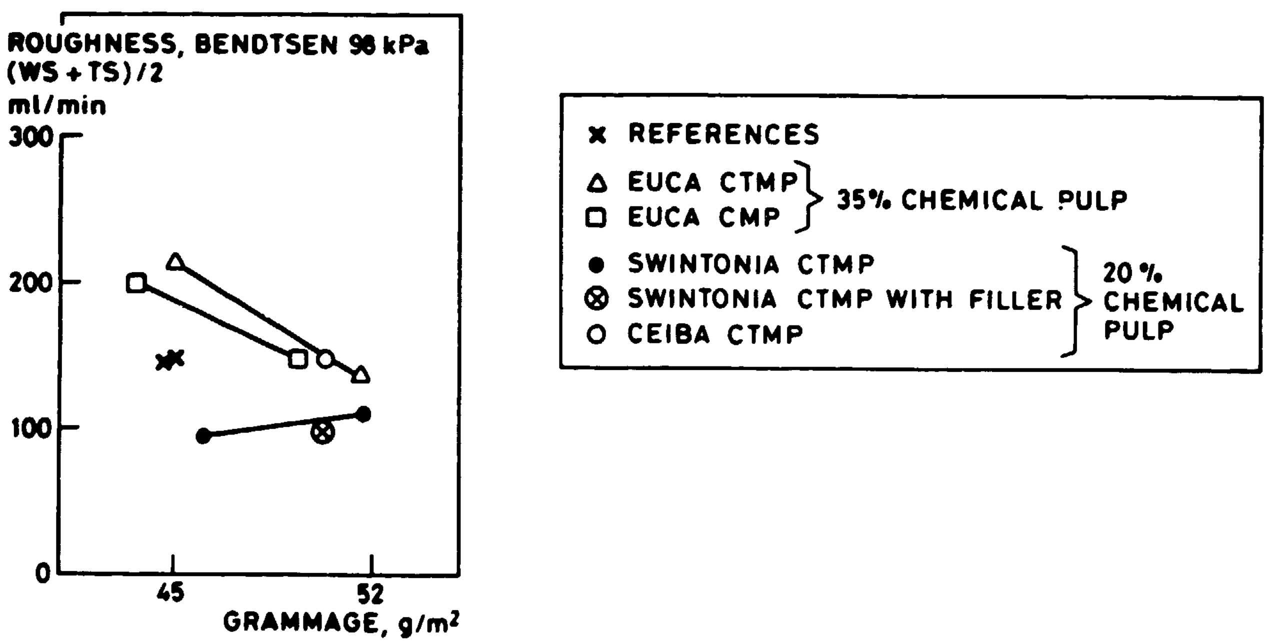
The second printing test was done with newsprint made of Swintonia CTMP with two grammages. All samples ran through the press without runability problems and linting was on a lower level than with Euca newsprint.

The densities were almost on the same level, but the contrast of Swintonia samples was lower than with reference. Swintonia samples had higher print through and rub-off than the reference.

In subjective evaluation paper made of Swintonia CTMP with higher grammage was the best when judging dark and light tones. When judging the picture, reference was the best.



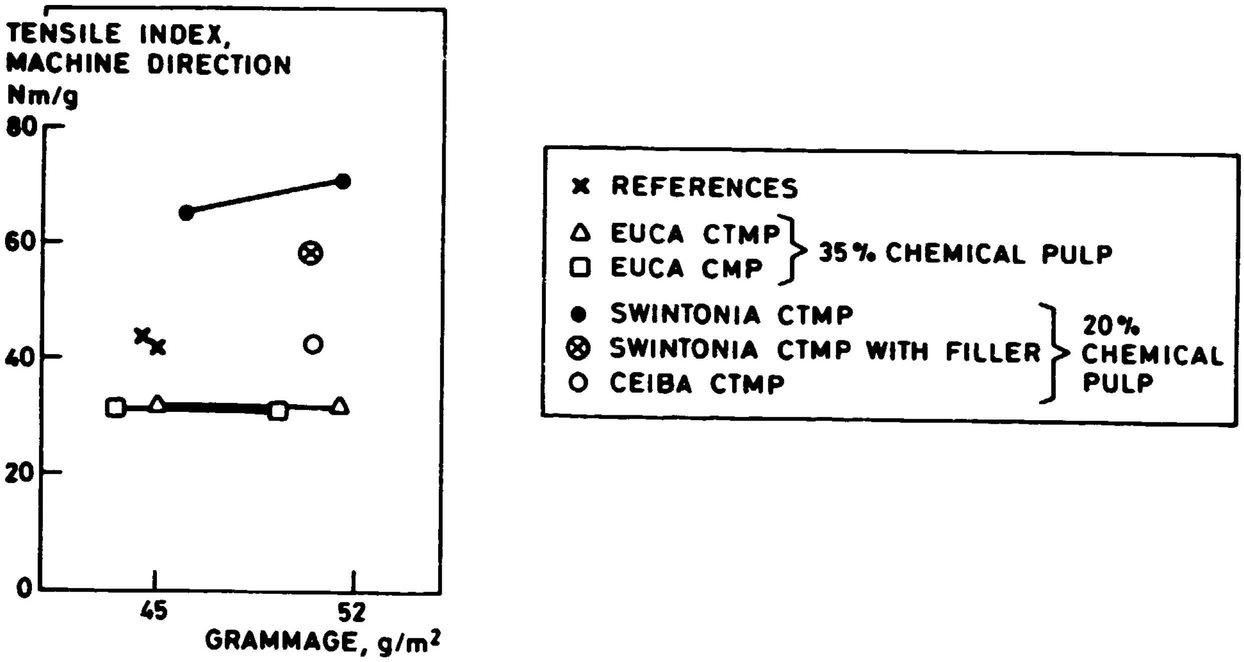
Picture 1. Density as a function of grammage.



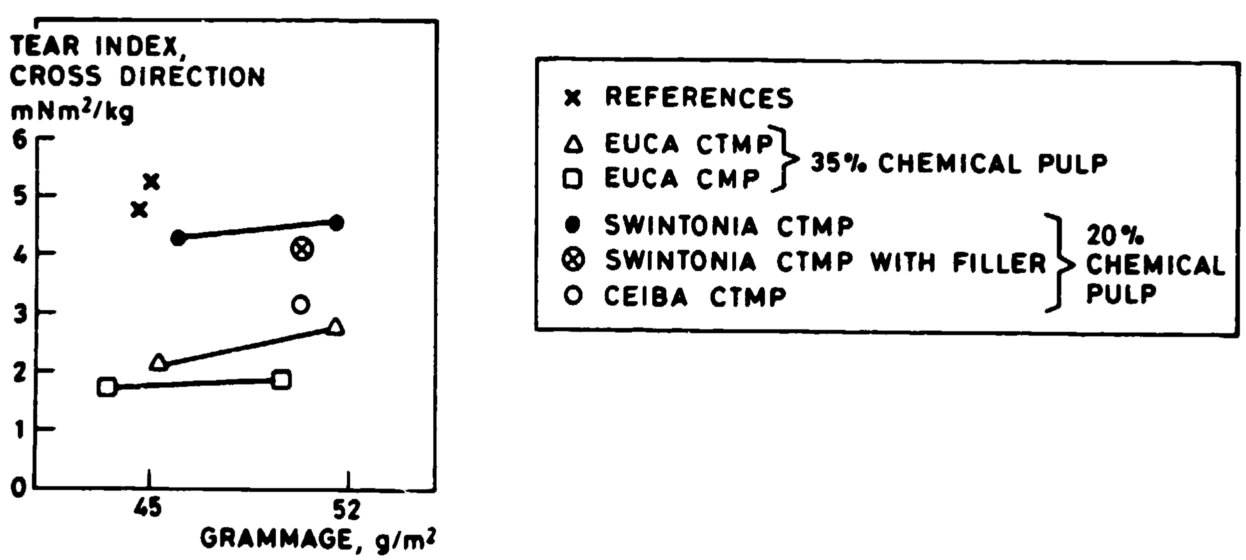
Picture 2. Roughness as a funtion of grammage.

Calendering conditions: REFERENCES 50 kN/m, 2 nips

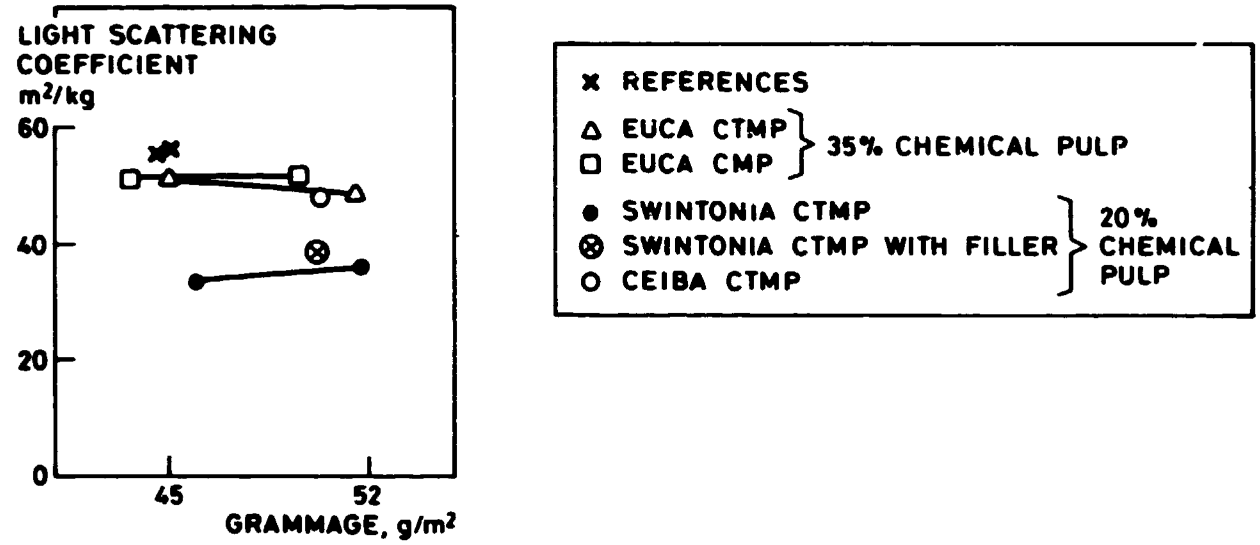
THE OTHERS 35 kN/m, 2 nips



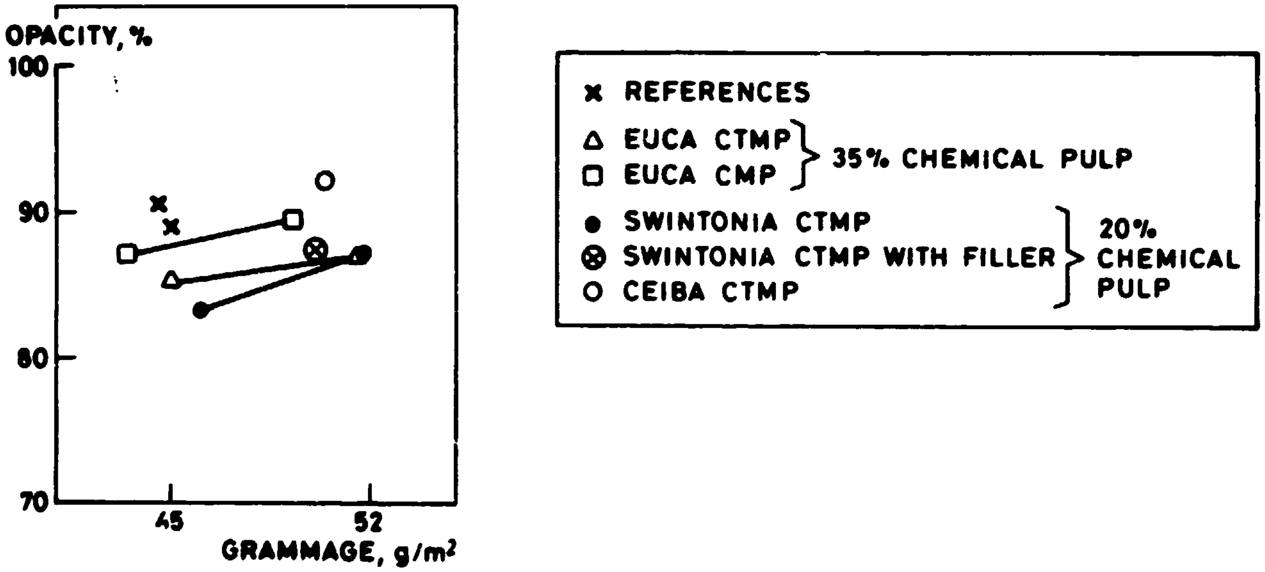
Picture 3. Tensile index as a function of grammage.



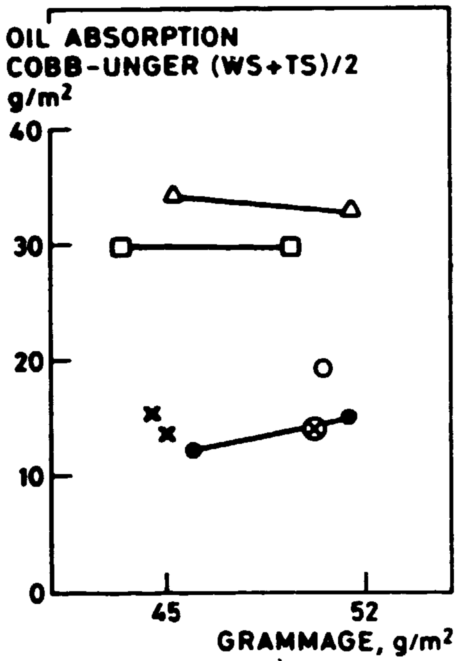
Picture 4. Tear index as a funtion of grammage.

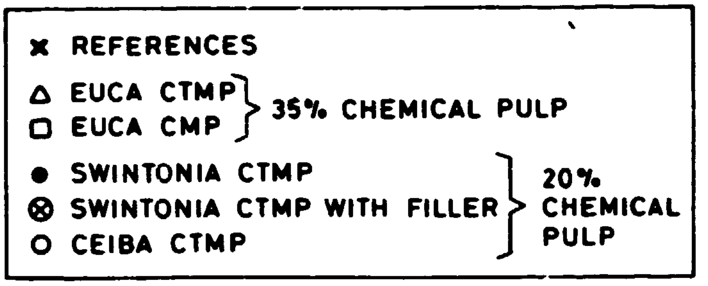


<u>Picture 5.</u> Light scattering coefficient as a function of grammage.



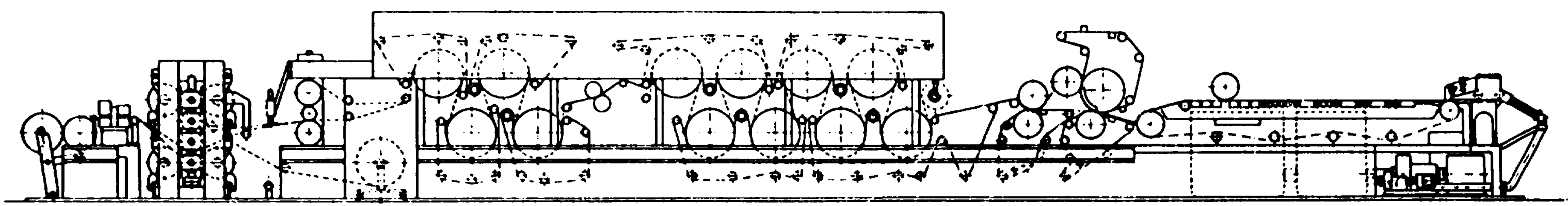
<u>Picture 6.</u> Opacity as a function of grammage.





Picture 7. Oil absorbency as a function of grammage.

Appendix 1.



TECHNICAL SPECIFICATIONS:

TRIMMED WIDTH	670 mm
CONSTRUCTION SPEED:	220 m/min
BASIS WEIGHT RANGE:	18 - 250 g/m²
NET PRODUCTION CAPACITY:	300 kg/h

MAIN PAPER GRADES:

MF-NEWSPRINT
SC-MAGAZINE PAPER
WOOD FREE PAPER
SACK PAPER
FLUTING
BASE PAPER

EXPERIMENTAL PAPER MACHINE

1984

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Appendix 2. PROGRAMME OF EXPERIMENTS C584-6

Raw materials:

Paper	Newsprint, grammages 52 and 45 g/m^2
Pulps	Euca CTMP (Eucalyptus)
	Euca CMP
	Swintonia CTMP (Taung Thayet)
	Ceiba CTMP (Thinbaw Let-pan)
	Bleached bamboo kraft pulp
Filler	Clay, grade C (ECC)
Retention aid	Percol 445

Trial runs:

Number of run	Date	Grammage %	Type of mechanical pulp	Fibre composition Mechan. pulp %	Chem. pulp %	Filler %	Retention aid %	On-line machine calendering kN/m, 2 nips
1. (1.1)*	12.9.	45		Finnish reference 1			-	50
2. (2.1)*	12.9.	52	Euca CTMP	65	35	-	-	35, 50
3.	12.9.	45	Euca CTMP	65	35	-	-	35
4. (3.1)*	12.9.	52	Euca CMP	65	35	-	-	35
5.	12.9.	45	Euca CMP	65	35	-	-	35
6. (1)*	20.10.	52	Swintonia CTMP	80	20	-	-	35
7. (2)*	20.10.	45	Swintonia CTMP	80	20	-	-	35
8.	20.10.	52	Swintonia CTMP	80	20	10	0,02	35
9.	20.10.	52	Ceiba CTMP	80	20	-	-	35
10. (5)*	20.10.	45		Finnish reference 2			-	50

*) numbers used for printing tests and for samples sent to Burma

Paper machine conditions:

White water pH	5
Machine speed	60 m/min
On-line machine calendering	35 kN/m, reference points 50 kN/m, 2 nips
Moisture content at pope	8 %

Testing procedure:

Water samples:	Machine chest Dilution tank Headbox White water Wet suction boxes Reject of cyclone cleaning
Tests of water samples:	Consistency Freeness pH (white water)
Paper webs:	Dry solids after press section
Pulps:	Tests, see appendix 3
Papers:	Rolls for printing tests, 4000 m Sheets Tests, see appendices 7 and 8

Appendix 3. C584-6

Properties of mechanical pulps produced for paper machine runs

		Euca CTMP	Euca CMP	Swintonia CTMP	Ceiba CTMP
Dry solids content, %		4,05	4,60	2,61	2,83
CSF, ml		94	57	99	156
Somerville-shives, %		0,08	0,03	0,03	0,38
Bauer McNett, %,	+28	0,3	0,04	16,6	6,6
	+48	25,0	21,7	40,4	22,5
	+100	22,7	22,5	10,6	11,5
	+200	17,0	18,1	6,4	12,3
	-200	35,0	38,0	26,0	47,1

52 g/m² hand sheets prepared with white water:

	Euca CTMP	Euca CMP	Swintonia CTMP	Ceiba CTMP
Tensile index, Nm/g	14,0	13,8	39,1	23,6
Burst index, kPam²/g	0,54	0,50	1,92	0,79
Tear index, mNm²/g	1,53	1,30	4,83	2,34
Density, kg/m³	273	295	433	371
Air permeability resistance, s	1,5	2,4	46	22
Opacity, %	91,0	94,2	92,9	96,1
Brightness, %	62,1	56,6	46,8	50,0
Light scattering coeff., m²/kg	58,4	61,9	46,3	57,5
Light absorption coeff., m²/kg	2,09	3,49	4,43	5,78

Refiner: Bauer 442M disc refiner

Pulp: Bleached bamboo kraft pulp

	Unrefined	Phase 1 PM runs numbers 2-5	Phase 2 PM runs numbers 6-9
Consistency, %	-	3,9	3,8
Specific edge load, Ws/m	-	0,4	0,4
Specific energy consumption, kWh/t	-	15	15
Freeness CSF, ml	475	220	204
SR	-	-	71
Length weighted average fiber length (Kajaani FS-200), mm	0,71	0,54	-
Hand sheets:			
Grammage, g/m^2	63,9	66,1	64,0
Density, kg/m^3	555	600	590
Tensile index, Nm/g	18,1	20	19,5
Burst index, $kPam^2/g$	0,80	0,79	0,90
Tear index, mNm^2/g	3,52	2,52	2,70
Porosity, Gurley-Hill, s	3,4	7,8	4,2
Opacity, %	83,2	83,7	82,5
Light scattering coeff., m^2/kg	36,7	37,3	37,0
Light absorption coeff., m^2/kg	0,76	0,79	0,67
Brightness, %	73,3	73,1	-

Pretrial number	1	2	3
Consistency, %	3,77	3,77	3,77
Specific edge load, Ws/m	0,5	0,5	1,0
Specific energy consumption, kWh/t	15	30	30
Hand sheets:			
Grammage, g/m^2	61,9	61,6	61,8
Density, kg/m^3	583	595	578
Tensile index, Nm/g	23,3	23,3	23,2
Tear index, mNm^2/g	2,48	2,12	2,33
Porosity, Gurley-Hill, s	7,2	11,1	7,3
Opacity, %	77,0	77,5	78,0
Light scattering coeff., m^2/kg	32,9	33,2	33,3
Light absorption coeff., m^2/kg	0,47	0,51	0,56

Number of run	1	2 & 3	4 & 5	6	7	8	10
Grammage, g/m²	45	52/45	52/45	52	45	52	45
Ash, %	-	-	-	-	-	10	-
Headbox							
- height of level, cm	14,3	13,8	14,6	13,7	14,0	14,3	13,4
- slice gap, mm	24	24	24	22	22	22	22
- pressure, mbar	11,0	11,1	11,6	9,6	9,7	9,9	9,4
- temperature, °C	30,7	28,8	31,2	28,7	32,1	27,0	31,2
Wire section							
- shaking	-	-	-	-	-	-	-
- dandy roll	-	-	-	-	-	-	-
- wet suction boxes, vacuum, mbar							
1. box	91,5	90,3	91,2	87,8	70,5	69,6	93,0
2. "	75,0	71,2	71,7	73,1	57,6	57,0	73,9
3. "	76,9	29,3	49,9	86,7	67,6	66,6	78,5
4. "	86,1	83,5	83,2	83,8	62,1	63,9	79,1
- water line *) number of suction box	2K-	4M	3M+	3M-	3M-	3M	4M-
- dry suction boxes, vacuum, mbar							
1. box	364	179	212	219	186	188	273
2. "	339	171	206	112	97	96	132
3. "	325	176	210	138	116	113	151
4. "	309	173	207	111	96	95	122
5. "	319	176	208	196	172	168	248
6. "	305	172	202	190	164	159	240
- suction roll, vacuum, mbar	250	175	180	215	190	190	235
Press section							
- presses, linear pressure, kN/m							
1. press	40	40	40	40	40	40	40
2. "	50	50	50	50	50	50	50
3. "	50	50	50	50	50	50	50
Drying section							
- groups, pressure of steam, bar							
1. group	0,31	0,25	0,29	0,36	0,26	0,24	0,37
2. "	0,50	0,43	0,44	0,59	0,36	0,51	0,67
- drying cylinders, surface temp., °C							
1. cylinder	48	48	50	50	48	52	50
2. "	54	53	57	58	57	57	59
3. "	61	60	63	66	64	61	67
4. "	65	64	68	70	68	69	70
5. "	84	84	79	85	84	85	82
6. "	91	93	95	97	96	97	97
7. "	88	89	90	97	95	97	95
8. "	83	84	85	88	86	89	86
9. "	81	80	79	79	74	75	79
10. "	102	100	101	104	100	103	107
11. "	99	98	98	100	97	100	101
12. "	64	67	69	65	61	65	64
Machine calender							
- linear pressure, kN/m	50	35	35	35	35	35	50
- number of nips	2	2	2	2	2	2	2
Speeds							
- wire, m/min	59,9	59,5	58,9	60,2	60,3	60,3	60,1
- wet presses, m/min							
1. press	60,2	60,0	60,0	60,6	60,7	60,5	61,0
2. "	60,8	60,7	60,8	61,3	61,3	61,3	61,5
3. "	60,7	60,6	60,6	60,6	60,7	60,6	61,3
- drying groups, m/min							
1. group	60,8	60,5	60,6	60,9	60,9	60,8	61,2
2. "	60,9	60,9	60,9	61,3	61,3	61,2	61,8
3. "	60,2	60,2	60,2	60,6	60,6	60,6	61,2
4. "	60,5	60,5	60,6	61,2	61,1	61,0	61,6
- calender, m/min	61	61	61	62	62	62	62
- pope, m/min	60,7	60,7	60,7	61,2	61,2	61,2	61,7

*) number of suction box K = dry suction box - = after the box
M = wet suction box + = before the box

Properties of water samples, wire retentions and dry solids of paper web after press section.

Number of run	1	2	4	6	7	8	9	10
Machine chest								
- consistency, %	2,91	2,72	3,17	2,58	2,37	3,29	2,32	3,00
- ash content, %	-	-	-	-	-	25,79	-	-
- freeness CSF, ml	80	152	110	120	112	162	150	86
Dilution tank								
- consistency, %	0,267	0,325	0,325	0,345	0,327	0,570	0,389	0,313
- ash content, %	-	-	-	-	-	37,94	-	-
- freeness CSF, ml	55	50	46	54	54	126	96	58
Headbox								
- consistency, %	0,228	0,260	0,258	0,314	0,293	0,542	0,440	0,299
- ash content, %	-	-	-	-	-	42,82	-	-
- freeness CSF, ml	44	42	36	42	42	122	84	50
White water								
- consistency, %	0,074	0,071	0,068	0,056	0,054	0,019*	0,060	0,064
- ash content, %	-	-	-	-	-	64,42	-	-
- pH	4,8	5,9	5,4	6,0	5,3	-	-	4,8
Wet section boxes								
- consistency, %	0,072	0,048	0,046	0,051	0,055	0,022	0,034	0,056
- ash content, %	-	-	-	-	-	72,53	-	-
Reject of cyclone cleaning								
- consistency, %	0,343	0,643	0,689	0,992	0,473	1,341	2,065	0,946
- ash content, %	-	-	-	-	-	22,24	-	-
- freeness CSF, ml	200	440	435	385	190	450	590	415
Retention (first-pass)								
- total, %	68	73	74	82	82	96*	86	79
- filler, %	-	-	-	-	-	-	-	-
- fibre, %	-	-	-	-	-	-	-	-
Dry solids content								
- after press section, %	39,5	44,1	44,2	40,7	40,1	42,5	-	40,3
Filler addition of production, %						43,6		
Filler content of paper, %						7,1		
Total filler retention, %						16,3		

*) retention unreliable

Appendix 7. Uncalendered samples 20 kN/m, testing at 50 %, 23 °C C584-6

Sample:		1.	2.	4.	5.	6.	7.	8.	10.
Grammage, SCAN-P 6:75, g/m^2		46,5	50,7	48,7	44,1	51,2	45,7	48,3	46,0
Bulking thickness C, SCAN-P 7:75, µm		107	110	108	100	92	82	87	108
Density, SCAN-P 7:75, kg/m^3		435	461	451	441	559	557	555	420
Roughness, Bendtsen, SCAN-P 21:67, ml/min									
- 98 kPa,	ws	1490	1200	1020	1020	840	830	890	1420
	ts	1700	1300	1230	1220	950	900	1120	1610
-490 kPa,	ws	430	530	440	420	310	340	380	580
	ts	570	570	560	550	330	420	460	760
Roughness, Parker Print-Surf, µm									
- S_{10}	ws	6,70	6,98	6,86	6,85	6,89	6,74	6,85	6,64
	ts	7,25	7,24	7,23	7,18	7,15	7,02	7,14	6,69
- S_{20}	ws	4,69	5,62	5,51	5,45	5,61	5,46	5,55	4,63
	ts	5,34	6,02	6,00	5,87	5,85	5,72	5,78	5,00
Porosity, Bendtsen, ISO 5636/3-1984, ml/min		81	1560	1170	1440	330	330	400	310
Oil absorption, SCAN-P 37:77, Cobb-Unger, CU_6, g/m^2									
-	ws	18,0	46,3	36,1	36,3	19,2	17,4	18,3	23,8
-	ts	23,9	52,5	43,2	41,2	23,8	20,9	22,5	29,0
ISO-brightness, SCAN-P 3:75, %		63,8	64,4	58,8	58,9	46,0	45,8	49,3	59,5
Opacity, SCAN-P 8:75, %		89,3	87,4	89,0	86,8	86,7	83,6	87,4	90,6
Y-value, SCAN-P 8:75, %		74,0	77,0	73,1	73,2	66,5	66,5	68,5	70,2
Dominant wave length, Elrepho 2000, nm		575,4	575,3	576,5	576,5	577,3	577,2	576,9	576,2
Excitation purity, Elrepho 2000, %		9,9	11,5	13,8	13,8	22,8	23,0	20,4	10,9
Light scattering coeff., SCAN, m^2/kg		55,0	49,9	50,0	49,8	35,7	34,8	41,0	53,2
Light absorption coeff., SCAN, m^2/kg		2,51	1,72	2,47	2,45	3,02	2,94	2,97	3,37
Tensile strength, SCAN-P 16:76, kN/m									
-	md	2,30	1,62	1,52	1,34	3,56	3,02	2,67	2,48
-	cd	0,906	0,709	0,655	0,583	1,28	1,10	0,967	0,925
Tensile index, SCAN-P 38:80, N.m/g									
-	md	49,5	32,0	31,2	30,6	69,5	66,1	54,9	53,9
-	cd	19,5	14,0	13,4	13,2	24,9	24,2	20,0	20,1
Stretch, %									
-	md	1,6	1,1	1,2	1,1	1,8	1,8	1,4	1,4
-	cd	1,7	1,7	1,9	1,7	2,9	2,6	1,9	2,2
Tear strength, SCAN-P 11:73, mN									
-	md	216	83	64	56	169	149	138	220
-	cd	297	116	102	89	240	215	192	293
Tear index, SCAN-P 11:73, mN.m^2/g									
-	md	4,65	1,63	1,31	1,26	3,31	3,26	2,85	4,77
-	cd	6,40	2,30	2,10	2,01	4,69	4,70	3,97	6,36

Appendix 8. Machine calendered samples, testing at 50 %, 23 °C

Sample:	1.	2.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Calendered kNm, 2 nips:	50	35	50	35	35	35	35	35	35	35	50
Grammage, SCAN-P 6:75, g/m^2	45,0	51,5	50,1	45,1	49,3	43,2	51,6	46,0	50,3	50,6	44,5
Bulking thickness C, SCAN-P 7:75, µm	73	85	83	83	82	78	72	62	68	81	74
Density, SCAN-P 7:75, kg/m^3	616	606	604	543	601	554	721	741	740	625	601
Roughness, Bendtsen, SCAN-P 21:67, ml/min											
- 98 kPa, ws	130	140	130	230	140	200	100	83	81	125	130
ts	190	150	150	260	200	250	130	110	115	190	180
-490 kPa, ws	38	57	56	110	71	93	46	39	37	40	41
ts	59	59	65	120	92	120	51	45	47	61	59
Roughness, Parker Print-Surf, µm											
- S_{10} ws	3,68	4,29	4,14	5,01	4,60	4,57	4,32	4,04	4,00	3,69	3,68
ts	4,06	4,54	4,62	5,33	5,11	5,04	4,60	4,34	4,41	4,26	4,13
- S_{20} ws	2,52	3,58	3,41	4,17	3,91	3,83	3,64	3,38	3,33	2,76	2,61
ts	2,93	3,84	3,93	4,42	4,31	4,18	3,88	3,58	3,67	3,18	2,98
Porosity, Bendtsen, ISO 5636/3-1984, ml/min	79	900	1000	1300	770	930	200	180	210	200	170
Oil absorption, SCAN-P 37:77, Cobb-Unger, CU_6, g/m^2											
- ws	12,6	29,4	32,7	31,9	27,5	28,8	13,2	11,3	12,4	18,1	14,5
- ts	14,9	36,6	36,4	35,4	30,9	30,9	17,0	13,5	14,2	20,5	16,5
ISO-brightness, SCAN-P 3:75, %	64,0	64,5	65,5	64,8	58,9	59,1	46,0	45,4	48,2	52,3	59,4
Opacity, SCAN-P 8:75, %	89,2	87,5	86,9	85,2	89,4	87,0	87,1	83,7	87,4	92,0	90,7
Y-value, SCAN-P 8:75, %	74,0	77,4	78,8	77,3	73,0	73,1	66,2	65,8	67,7	67,4	70,0
Dominant wawe length, Elrepho 2000, nm	575,4	575,3	575,5	575,3	576,5	576,5	577,3	577,3	577,3	576,3	576,1
Excitation purity, Elrepho 2000, %	9,6	11,6	11,8	11,2	13,6	13,5	22,5	22,9	21,0	16,0	10,8
Light scattering coeff., SCAN, m^2/kg	56,4	49,9	52,1	51,1	50,5	51,3	35,6	34,4	38,7	48,3	55,1
Light absorption coeff., SCAN, m^2/kg	2,58	1,65	1,49	1,70	2,50	2,54	3,07	3,06	2,98	3,81	3,54
Tensile strength, SCAN-P 16:76, kN/m											
- md	1,89	1,64	1,39	1,39	1,51	1,31	3,68	3,00	2,90	2,16	1,94
- cd	0,923	0,699	0,638	0,600	0,648	0,548	1,22	1,07	1,07	0,866	0,888
Tensile index, SCAN-P 38:80, N.m/g											
- md	42,0	31,8	27,7	30,8	30,6	30,3	71,2	65,1	57,7	42,7	43,6
- cd	20,5	13,5	12,7	13,3	13,1	12,7	23,7	23,2	21,3	17,1	20,0
Stretch, %											
- md	1,3	1,2	1,1	1,1	1,3	1,4	1,9	1,8	1,7	1,1	1,1
- cd	1,9	1,5	1,6	2,1	2,6	2,3	3,0	2,5	2,0	1,2	2,2
Tear strength, SCAN-P 11:73, mN											
- md	165	93	70	60	61	48	163	140	143	105	157
- cd	237	142	103	92	94	76	233	196	207	157	203
Tear index, SCAN-P 11:73, mN.m^2/g											
- md	3,70	1,81	1,41	1,33	1,25	1,10	3,16	3,04	2,85	2,07	3,53
- cd	5,28	2,75	2,06	2,03	1,91	1,75	4,51	4,26	4,13	3,10	4,57

TECHNICAL RESEARCH CENTRE OF FINLAND	**RESEARCH REPORT No.** GRA8424
Graphic Arts Laboratory	September 16, 1988 -1-

Orderer: The Finnish Pulp and Paper Research Institute, Tekniikantie 2, 02150 Espoo, FINLAND

Order: Mrs. Pirkko Tikka, August 30, 1988

Samples: 3 paper rolls delivered by the customer

Scope: Test printing in the Wärtsilä TAPA offset press at the Graphic Arts Laboratory of The Technical Research Centre of Finland

Printing conditions:

Printing speed:	9 000 r/h
Printing ink:	Rotalith 31 000, black
Dampening water:	10% Isopropanol + 3% Rosos
Blanket:	Reeves Vulcan 714
Length of the run:	500 impressions/NCI-level, 7-10 levels for each roll

Method of test printing:

The NCI-run (Normal Colour Intensity) was made on 7-10 levels of ink feed. The NCI-level is the level on which the dark halftone areas print out well, but no filling in occurs. On this level the contrast of the dark tone areas (appr. 75 % dot percentage) with the solid areas is at its maximum. The contrast curves of measured densities are shown in Appendices 1-3. The NCI-level is marked with an arrow. From that level the following measurements were made.

- Rub-off (Patra-device, pressure 20 kPa)
- Print through
- Subjective evaluation (a light tone, a dark tone and quality of the test picture)

Subjective assessment has been determined using the method of ranking order and five independent viewers. The results have been transformed to a quality number 0-100 (100 is best) and the unanimity of the viewers has been checked with Kendall's test.

Discussion about the run:

Paper 1.1 ran through the press without runnability problems. On the contrary there were several web breaks with papers 2.1 ja 3.1. The samples 2.1 and 3.1 showed heavy linting tendency: after printing there were so much dust on the blanket that the light halftone areas had filled in. The dust had also gone to the ink rollers.

Results: The results of the test printing are shown in Table 1.

Table 1. Print density, print through, contrast, rub-off and the results of subjective assessment.

Sample	NCI-dens. D	Print thr. D	Relat. contr.	Abs. contr. D	Rub-off D	Subjective assessment dark tone	light tone	picture
1.1	0,94	0,078	0,113	0,106	0,088	83	82	70
2.1	0,94	0,086	0,115	0,108	0,172	22	19	28
3.1	0,98	0,079	0,102	0,100	0,180	45	50	52
Kendall's factor of unanimity						0.83	0.90	0.46

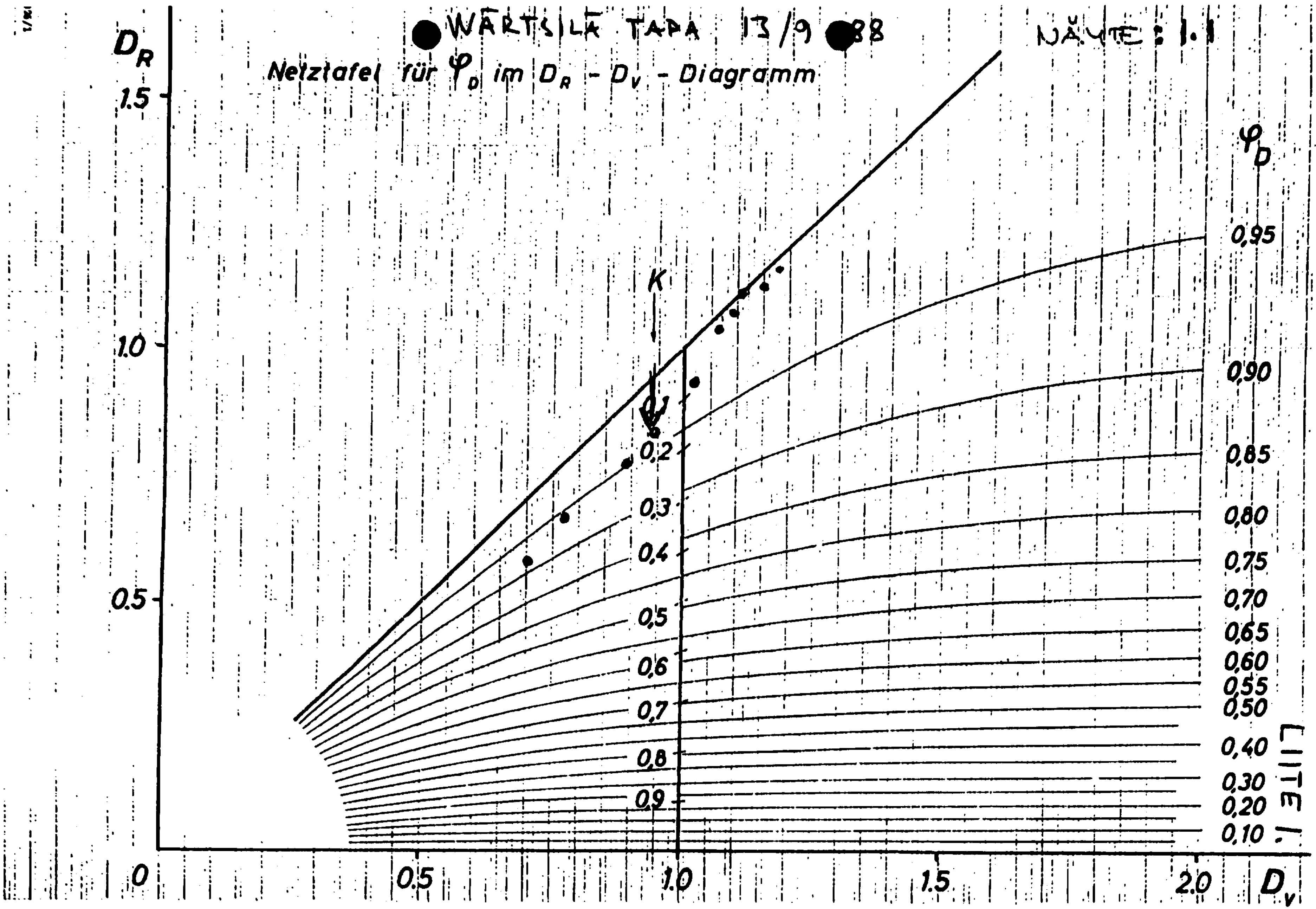
Sample 3.1 had highest density but lowest contrast. The biggest print through was measured from sample 2.1. The rub-off level of samples 2.1 and 3.1 was clearly higher than of sample 1.1.

In subjective evaluation the differences between test points resulted from print evenness of tone areas and sharpness of details in the picture. The best in every test was sample 1.1. Sample 3.1 was always second best, and sample 2.1 was last. The differences are clearest on assessment of light and dark tone; when judging the picture the factor of unanimity stayed on a moderate level.

TECHNICAL RESEARCH CENTRE OF FINLAND
Graphic Arts Laboratory

Hannu Linna
Senior Scientist

Ulf Lindqvist
Sections Manager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K
0,2
0,3
0,4
0,5
0,6
0,7
0,8
0,9
φD
0,95
0,90
0,85
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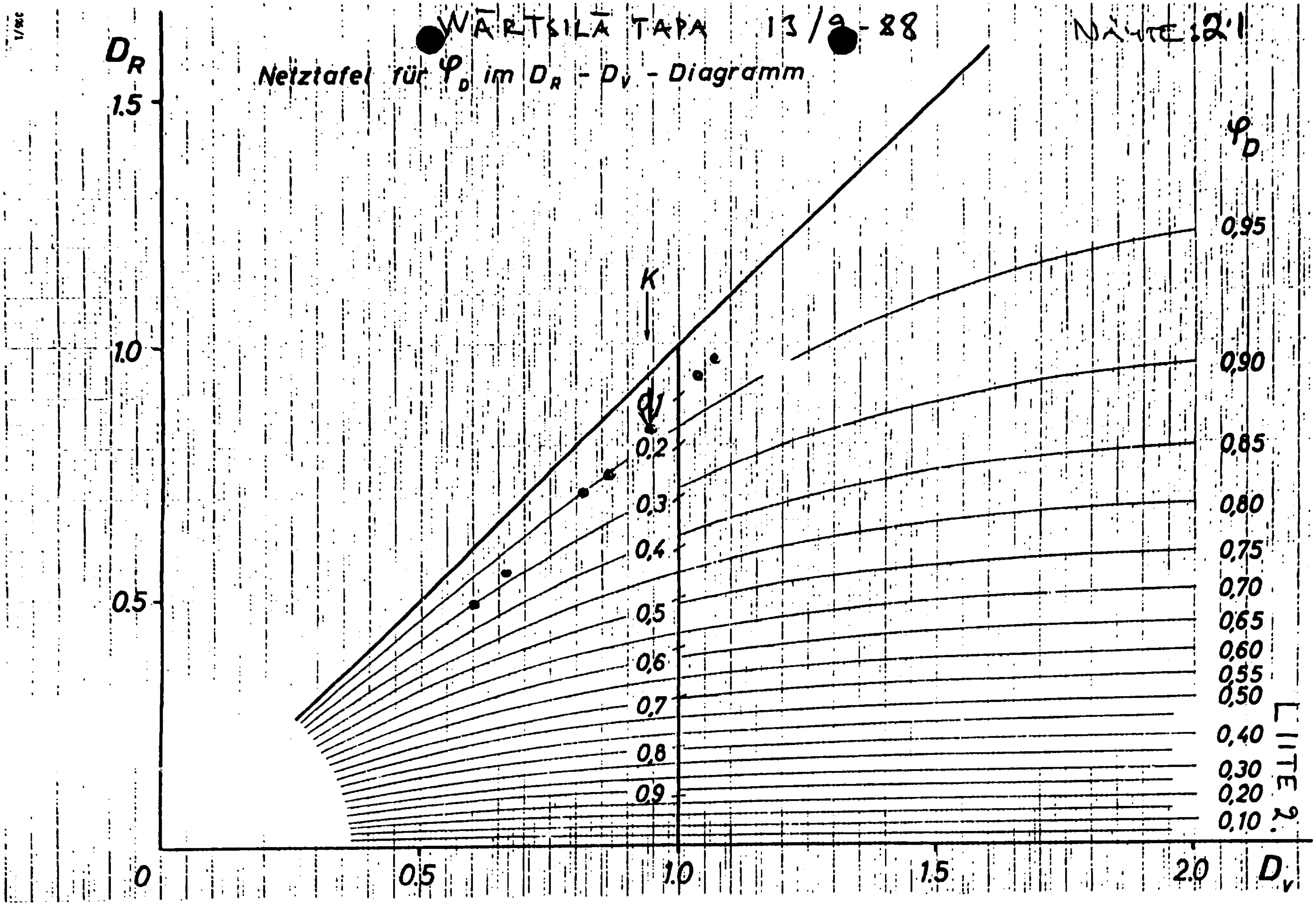
1.5
2.0
Dv
LIITE 1.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NÄYTE 21
Netztafel für φ_D im D_R - D_V - Diagramm
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0.5
0
0.5
1.0
1.5
2.0
D_V
K
ψ
0,2
0,3
0,4
0,5
0,6
0,7
0,8
0,9
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0,90
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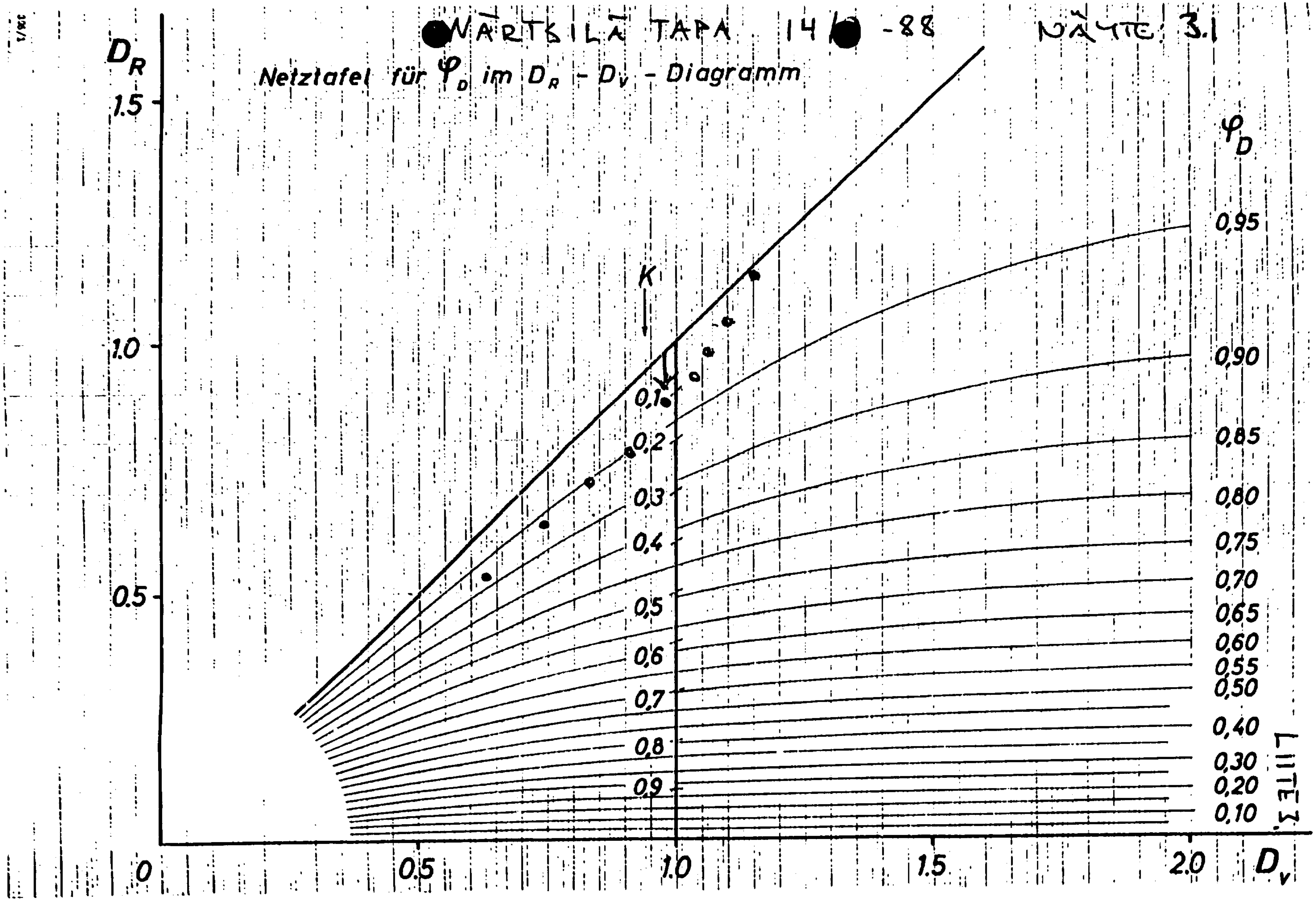
LIITE 2.

Appendix 9. (cont.)



Orderer: The Finnish Pulp and Paper Research Institute, Tekniikantie 2, 02150 Espoo, FINLAND

Order: Mrs. Pirkko Tikka, October 11, 1988

Samples: 3 paper rolls delivered by the customer

Scope: Test printing in the Wärtsilä TAPA offset press at the Graphic Arts Laboratory of The Technical Research Centre of Finland

Printing conditions:

Printing speed:	10 000 r/h
Printing ink:	Rotalith 31 000, black
Dampening water:	10% Isopropanol + 3% Rosos
Blanket:	Reeves Vulcan 714
Length of the run:	500 impressions/NCI-level, 7-8 levels for each roll

Method of test printing:

The NCI-run (Normal Colour Intensity) was made on 7-8 levels of ink feed. The NCI-level is the level on which the dark halftone areas print out well, but no filling in occurs. On this level the contrast of the dark tone areas (appr. 75 % dot percentage) with the solid areas is at its maximum. The contrast curves of measured densities are shown in Appendices 1-3. The NCI-level is marked with an arrow. From that level the following measurements were made.

- Rub-off (Patra-device, pressure 20 kPa)
- Print through
- Subjective evaluation (a light tone, a dark tone and quality of the test picture)

Subjective assessment has been determined using the method of ranking order and five independent viewers. The results have been transformed to a quality number 0-100 (100 is best) and the unanimity of the viewers has been checked with Kendall's test.

Discussion about the run:

All samples ran through the press without runnability problems. Also linting was on a lower level when compared to test printings made on 13.09.88 (Research Report GRA8424). Filling in of light halftone areas did not occur, and evenness of solid print was good.

Results: The results of the test printing are shown in Table 1.

Table 1. Print density, print through, contrast, rub-off and the results of subjective assessment.

Sample	NCI-dens. D	Print thr. D	Relat. contr.	Abs. contr. D	Rub-off D	Subjective assessment dark tone	light tone	picture
1	0,95	0,121	0,065	0,062	0,067	56,5	20	28,5
2	0,92	0,139	0,076	0,070	0,076	76,5	70	38,5
5	0,94	0,070	0,094	0,088	0,046	17	60	83
Kendall's factor of unanimity						0.84	0.60	0.74

The NCI-densities were almost on the same level; the highest contrast was reached with sample 5. Sample 1 had lowest contrast. Sample 5 had lowest print through. The rub-off level of samples 1 and 2 was clearly higher than of sample 5.

In subjective evaluation the differences between test points resulted from print evenness of tone areas and sharpness of details in the picture. When judging dark tones sample 2 was best and sample 1 was second best. The evenness of the surface of sample 5 was not good - fibres could be seen, so it was ranked last. In light tones sample 2 was again best with a small difference compared to sample 5. When judging the picture the viewers evaluated sample 5 as the best. The quality number of samples 1 and 2 was smaller because the hue of both papers was yellowish and print contrast was lower. In all tests the factor of unanimity stayed on a quite high level.

TECHNICAL RESEARCH CENTRE OF FINLAND
Graphic Arts Laboratory

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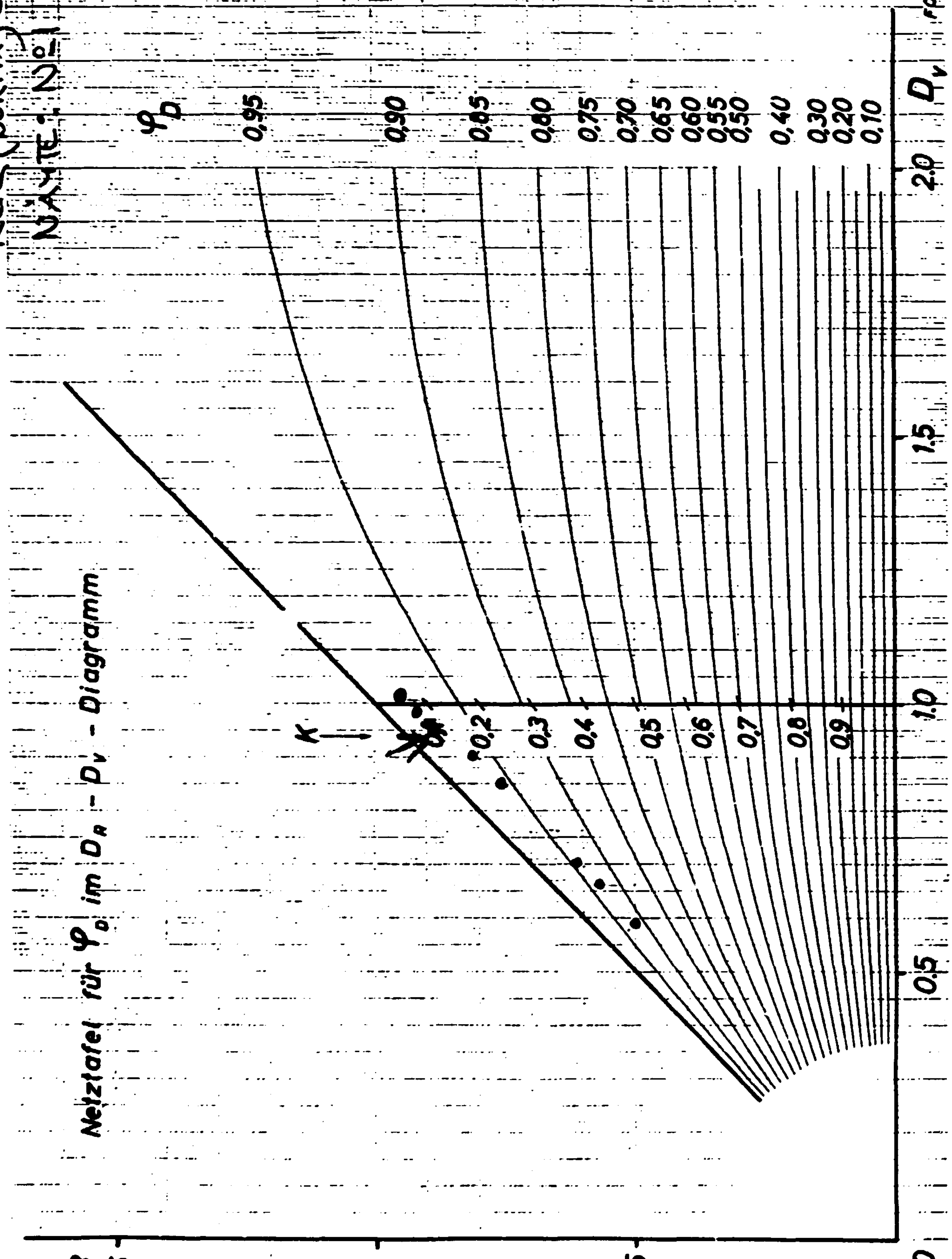
LITE I.

No 258
26/10-58
KCL (BURMA) C581-3
NAVITE No 2



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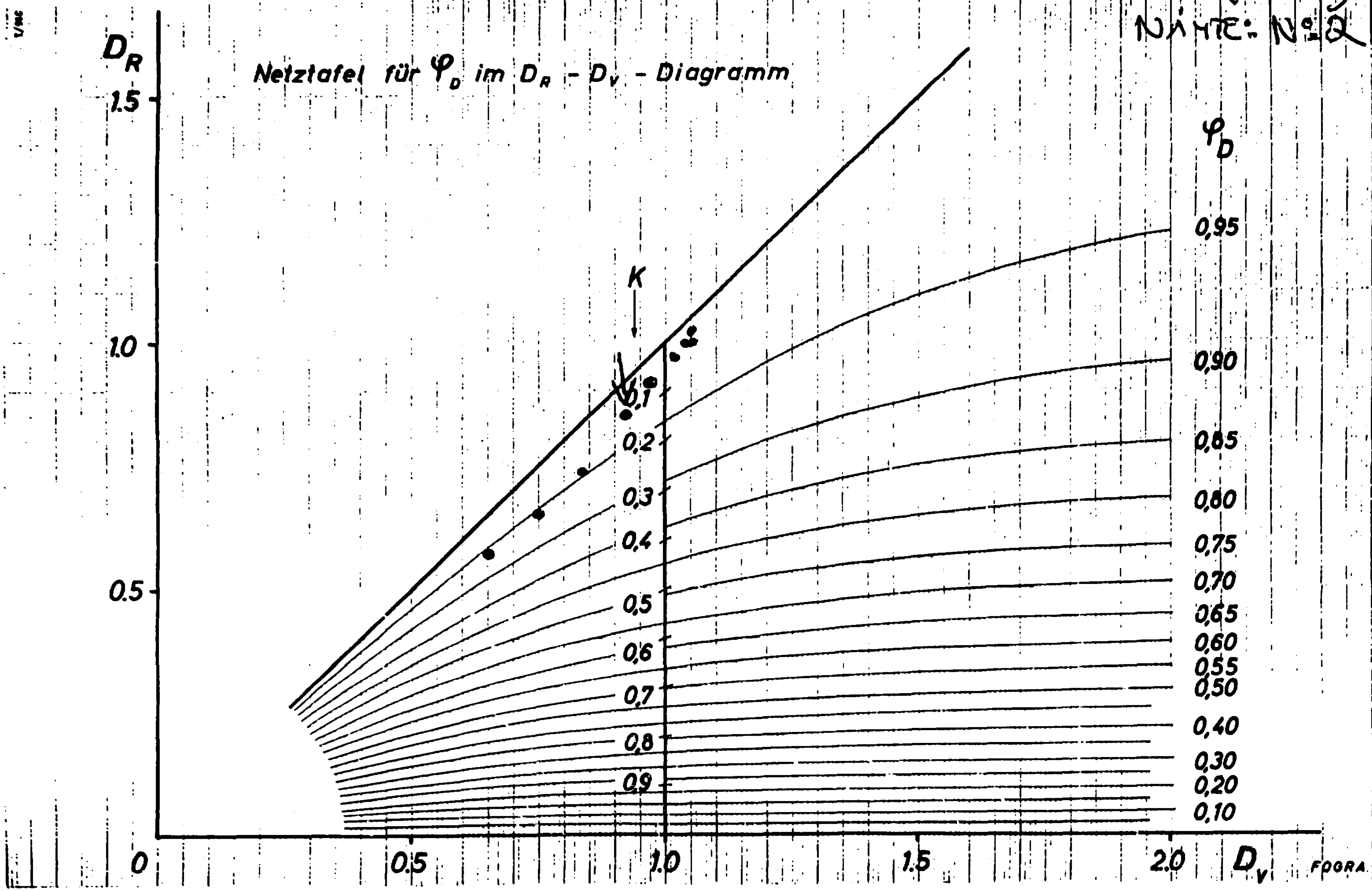

Appendix 10. (cont.)

LIITE 2.

Appendix 10. (cont.)

LHTE 3.