made very thin on purpose. Import restrictions ruled out the use of AISI 420 steel alloy for our disks, so we had to stick with our own variant of alloys and design.

However, both cost-wise and in quality of pulp treatment, we feel it is a bearable compromise.

Before we had enough time to realize dependable statistics in power savings we noticed quite an improvement in formation at the Fourdrinier. Today, power expenditure has dropped to a level of 220 to 280 kw hr/ton of paper produced which we consider satisfactory for our needs.

Disks are about 2 inches thick and can take up to 5 or 6 remachinings, representing the lowest possible investment on this type of equipment. Our 36 - inch disks work for an average of 800 to 1,000 hours producing 1,100 to 1,300 tons of paper per machining as long as work is interrupted when only 6 mm of knives have been spent.

PAPERMAKING OPERATIONS

The operation on paper machines of furnishes based exclusively on 100 per cent eucalypt fibres has some peculiar problems which can be resolved only after some experience and many failures.

Back in 1959 in our mill, we started from furnishes where eucalypt was considered more or less to be a "filler", and high percentages of long fibre were always used.

Our equipment was not designed for operation with eucalypt fibre at the speeds we were striving for. The first problems were encountered on the beating of the fibre, as explained before. After that was more or less solved we had to learn, step by step, how to operate our paper machines at levels of efficiency which could be considered acceptable, even by our standards.

Today our monthly production is close to 4,000 metric tons in 7 paper machines, 4 of them using only eucalypt kraft pulp as a furnish.

On wrapping grades, for light weight grocery bags, up to 75 per cent of the furnish is unbleached eucalypt kraft, beaten to about 65 SR and the remaining 25 per cent is unbleached araucaria kraft pulp, beaten very lightly using a brushing action, to 28-30 SR.

On duplex boards, white lined, the liner is mostly eucalypt bleached kraft pulp, to which is given a slight covering of modified starch at the calender stack, to avoid the "peel off" effect typical of the eucalypt pulps. Beating must not be carried too far as this effects the dimensional stability of the duplex board. Dennison wax surface pick test is kept around 15 to 16.

On printing and writing grades, made at speeds of 750 to 850 ft/min, only eucalypt bleached kraft pulp is used in the furnish, even for the 50 g/sq m grades, which are the most commonly made. For this grade pulp is beaten up to 50 to 55 Sr, on Hydradiscs (36 inch already described, with a power expenditure on beating, of some 240 to 290 kw hr/ton).

Over a period of two years, running efficiencies have been raised from about 60 per cent to an average of 85 per cent, occasionally reaching 95 to 98 per cent.

This paper machine was designed in 1948 for kraft and newsprint grades, with 136 in trimmed width. A lump-breaker roll and a blow roll were added to the wet part early last year.

In November (1966) a two-week shut down was programmed when more extensive changes were made on the paper machine in order to improve quality of the sheet and also the running efficiency levels.

Present average daily production is 45 tons/day. On this paper machine experimental short runs of isolated species of eucalypts have been made, using first 100 per cent *E. rostrata* syn. *E. camaldulensis* pulp, then 100 per cent *E. saligna* pulp, noticeably improving quality of paper made, but without any remarkable improvement in efficiency levels.

Many times using pulp of mixed species we attained even better operation efficiencies.

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KRAFT PULPING OF EUCALYPTS IN SOUTH AFRICA[1]

SUBMITTED BY SOUTH AFRICAN PULP AND PAPER INDUSTRIES LIMITED
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SUMMARY

This contribution reviews the historical background to the planting of eucalypts in South Africa dating from 1890. It indicates the areas involved, the species used and the climatic conditions. A short review of South African Pulp and Paper Industries' pulping experience from the commencement, when the raw material was straw and the soda process was used, right through to the present situation with eucalypt pulping, where the Kraft Process is used at Springs and at Tugela in Natal.

Some notes are provided on the sylvicultural practice and the yield of wood obtained in the particular areas of plantation; this is followed by a statement of the pulping conditions applied, pulp yield obtained and the physical strength properties of the pulps produced.

Tables are provided giving details of research laboratory pulping data of some six species from different areas and also a statement of the strength properties obtained with laboratory beatings of these pulps.

The formation of *Eucalyptus* plantations started in South Africa after the opening of the Witwatersrand goldfields in 1890 when a great demand arose for mining timber which could be quickly and cheaply produced (1)(2).

The first Government plantings occurred in 1896 and only after 1920 did the areas planted by private enterprise begin to expand rapidly. Government plantings were aimed at supplying timber for the mines (as pit props), but some plantings of eucalypts were established to provide railway sleepers.

One of the species planted for mining timber was *Eucalyptus saligna* which was introduced from Australia. In South Africa the name *E. saligna*, or saligna gum, is commonly applied to trees of the related species *E. grandis* (Hill) Maiden and *E. saligna* (Smith) and also to trees of the many transitional forms between them. Actually, the bulk of the plantings is strictly *E. grandis* or the intermediate forms, showing greater affinity to *E. grandis*. There is comparatively little true *E. saligna* (1).

The area in South Africa planted with eucalypts (all species) was 473,000 acres in 1965, of which 359,480 acres or almost 67 per cent of the total was *E. saligna*. This figure of 359,480 acres amounts in fact to 13 per cent of the total area in South Africa afforested with exotic species. 91.5 per cent of the total of eucalypts planted belongs to private enterprise.

Saligna gum has been grown with success in the warm temperate zone of the Northern Transvaal, the Eastern Transvaal Lowveld, the sub-tropical zone in Zululand and in the coastal and semi-coastal belt in Natal. All of the areas in South Africa where saligna gum has been extensively planted enjoy summer rainfall (1).

The Highveld of the Transvaal has an elevation for the most part of approximately 5,000 feet or more, with a mean annual temperature of from about 55° to about 62°F and a mean annual rainfall (predominantly summer) ranging from about 25 inches in the west to about 40 inches in the east. Severe winter frost is also experienced in this area (2). On the Highveld, species like *E. rostrata* were first established as shade trees around homesteads in the towns by the early Dutch settlers. The first Government plantations included stands of *E. viminalis, E. sideroxylon, E. maideni, E. globulus* and *E. fastigata* (2), since *E. saligna* could not stand the frost conditions.

PULPING PROCESS

South African Pulp & Paper Industries (SAPPI) commenced producing pulp from straw by the Pomilio processes.

After changing from straw, SAPPI did a lot of commercial soda pulping of eucalypt species. Due to effluent problems (the Enstra Mill near Springs, Transvaal, is not situated on a river as is customary) and pulping economics, and also to paper strength requirements, SAPPI converted to the kraft or sulphate process, and commercial kraft pulping of eucalypt species commenced at their Enstra Mill at the end of World War II.

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(1)Paper presented 21st Appita Conference.

Problems associated with the commercial kraft pulping of hardwoods have in the past taken a second place in the SAPPI organisation as an adequately strong short-fibred pulp is easily produced. Considerable attention has always been applied to the kraft pulping of the exotic South African grown pine species in order to produce the strongest possible unbleached and bleached long-fibre pulp.

SPECIES

In 1966, SAPPI's Tugela Mill in Zululand consumed 74,537 O.D. tons of *E. grandis (saligna)* or saligna gum from various private and Government plantations in Natal and Zululand for unbleached kraft manufacture. This pulp is being utilized in admixture with unbleached pine kraft in linerboard, sack, bag kraft, wrappings and fluting grades.

Only very small quantities of *E. paniculata, E. maculata* and *E. fastigata* are grown in the vicinity and are received at this mill. The very low density of *E. grandis* is an advantage in using this timber species so extensively here.

At Enstra bleached kraft mill near Springs, Transvaal, SAPPI in 1966 consumed 31,224 O.D. tons of various mixed eucalypt species for the manufacture of various grades of bleached fine writing and printing papers. Here, the following species are drawn from private and Government plantations, mainly from the Highveld regions:

E. macarthuri, E. obliqua, E. radiata, E. viminalis, E. maideni, E. fraxinoides, E. melliodora, E. sideroxylon, E. fastigata, E. camaldulensis (or *rostrata).*

SYLVICULTURAL PRACTICE AND HARVESTING AGE

E. saligna is planted on a 9 ft x 9 ft spacing, preferably on a ploughed and harrowed site. If the planting is kept clear of weeds and grass, then yields of 6 O.D. tons/acre/annum can be obtained in the hotter zones. In the cooler Natal climate the yield is lower.

After the first harvesting at 10 years, 4 or 5 coppice rotations are allowed before the stand is replanted. The yield per acre falls with each coppice rotation by approximately ½ ton/acre/annum (as is basis). For mining purposes two coppices per stump may be allowed due to the small diameter specification. In other cases only one is allowed.

The Highveld eucalypt species are mainly grown on farm woodlots.

The Natal saligna gum species are pulped at about 10 years old and the Transvaal eucalypt species at anything from 10 to 20 years of age.

PULPWOOD REQUIREMENTS

Eucalypt pulpwood is purchased down to a top diameter of 3 in in 8 ft debarked lengths. Because of high railway tariffs, timber is stored in plantations for about six weeks, by which time the moisture in the timber has dropped to about 25 to 35 per cent (net weight basis). Tests have proved that no serious fungal decay occurs under these conditions of round log storage even during warm, humid summer months to significantly affect pulp strength.

KRAFT PULPING CONDITIONS

Extensive investigations carried out by the Company's research laboratory showed that the following are the optimum conditions for kraft pulping South African eucalypt species:

Liquor to wood ratio	4.5 : 1 or 5.4 : 1 cc
Sulphidity	22% (Tappi)
Active alkali	18% as Na_2O
Maximum temperature	170°C.
Time to 170°C.	110 mins.

The Enstra Mill producing a pulp for a C-E-H-D-E-D bleaching sequence, pulps to a Kappa number of 16 to 20. The Tugela Mill producing a pulp for unbleached paper grades, pulps to a Kappa number of about 22. Both mills use a 16 to 18 per cent active alkali charge at 20 to 22 per cent sulphidity and 3.5 to 4.0 to 1 liquid to solid ratio and pulp at 170°C, with slightly different times to maximum temperature.

PULP YIELD

A feature of the saligna gum grown in Natal (mainly *E. grandis (saligna)*) is the higher pulp yield obtained, compared to the mixed and older eucalypt species grown in the Transvaal at altitudes of 3,000 - 5,000 ft above sea level. (See Table 1). This difference may be as much as 6 to 10 per cent. The species, no doubt, has something to do with this, but no extensive chemical analysis have been carried out to determine the factors affecting the cellulose content.

At Enstra Mill the commercial unbleached kraft gum pulp yield is about 44 per cent (on oven dry wood basis) at a Kappa Number of 16 - 20 while at Tugela Mill it is about 52

TABLE I.

RESEARCH LABORATORY KRAFT PULPING DATA

Timber	Age (years)	Source	% Moisture	O.D. density lb/cu ft	Time (in min) at max. temp. (170°C)	Kappa no.	Percentage yield		Tear factor at 75 burst factor	Fibre length (mm)
							Screened	Total		
1. *E. grandis* (saligna)	10-13	Natal	32.8	34.2	0	27.2	52.8	54.6	121	1.29
			,,		5	23.2	52.6	53.4	121	
			,,		10	20.7	51.4	52.0	130	
			,,		20	18.9	51.2	51.5	—	
2. **E. nitens*	10	Transvaal (Highveld)	39.0	40.0	0	30.2	47.9	48.2	79	1.85
			,,		5	23.0	46.9	47.0	82	
			,,		10	21.0	46.9	46.9	86	
			,,		15	19.7	46.6	46.6	84	
3. **E. deglupta*	8	Natal (Zululand)	59.8	30.9	15	32.5	48.0	48.7	108	1.43
			,,		45	23.3	47.3	47.3	—	
			,,		30	26.3	48.2	48.2	88	
4. *E. macarthuri*	10	Transvaal (Highveld)	41.2	40.2	5	27.6	43.3	44.1	86	1.49
			,,		15	23.1	43.4	44.3	91	
			,,		25	19.5	42.6	43.2	97	
5. *E. viminalis*	10	Transvaal (Highveld)	47.0	41.5	5	31.0	46.2	46.2	100	1.40
			,,		15	22.5	44.4	44.3	101	
			,,		25	19.4	43.6	44.7	96	
6. *E. rostrata* syn. *E. camaldulensis*	10	Transvaal (Highveld)	46.2	45.2	5	47.2	—	—	90	1.74
			,,		15	35.1	40.2	41.2	94	
			,,		25	24.7	39.8	40.8	88	

*These species are not as yet available for commercial pulping.

TABLE 2

PHYSICAL PROPERTIES OF LAMPEN EVALUATIONS OF KRAFT PULPS FROM RESEARCH PULPING TESTS

Timber	Kappa No.	Wetness °S.R. (back orifice) (2)				Metric burst factor mullen (10)				Dynamic tear factor (sq m) (6)				Breaking length (m) (6)			
		2250	9000	18000	27000	2250	9000	18000	27000	2250	9000	18000	27000	2250	9000	18000	27000
1. *E. grandis* (*saligna*)	27.2	—	20.5	30.0	38.0	—	75	91	92	—	126	125	110	—	11300	12800	13600
	23.2	15.0	20.5	26.5	35.0	51	67	80	83	127	121	120	117	9290	11600	13520	13900
	20.7	15.0	19.0	26.0	36.0	49	65	73	83	126	133	132	114	8900	10300	12000	13000
	18.9	14.5	18.5	26.5	35.0	44	60	71	73	129	124	120	112	9150	10500	11720	12600
2.* *E. nitens*	30.2	14.5	23.5	26.0	—	49	68	79	—	80	78	78	—	9390	11700	12250	—
	23.0	16.0	20.0	26.5	—	52	67	75	—	88	78	83	—	9940	11950	13190	—
	21.0	17.0	21.0	—	—	53	74	72	—	83	85	83	—	9860	11600	12760	—
	19.7	17.0	21.0	26.0	—	53	76	92	—	81	83	83	—	10100	12050	13700	—
3.* *E. deglupta*	32.5	16.0	22.0	28.0	—	57	74	87	—	114	108	113	—	10310	11770	14190	—
	23.3	18.0	20.5	29.5	—	55	64	63	—	128	99	95	—	9160	11830	12060	—
	26.3	17.0	19.0	29.0	—	54	71	73	—	119	105	93	—	9310	11710	12810	—
4. *E. macarthuri*	27.6	20.0	23.0	25.0	37.0	57	80	93	96	80	86	84	104	10070	12130	13100	13040
	23.1	18.0	24.0	31.0	34.0	60	80	87	86	96	89	86	91	9910	11250	10820	11310
	19.5	15.0	24.0	28.0	31.0	52	81	87	90	106	94	91	90	9390	12020	12370	13230
5. *E. viminalis*	31.0	15.0	19.0	27.0	29.0	42	69	79	69	88	100	99	104	8940	10550	11690	12240
	22.5	15.0	20.0	26.0	35.0	47	66	83	85	87	102	101	99	8720	10030	13580	11770
	18.4	15.0	21.0	26.0	34.0	54	75	76	71	88	96	93	93	9800	11630	12110	12520
6. *E. rostrata* syn. *E. camaldulensis*	47.2	18.0	25.0	32.0	41.0	57	72	78	79	82	86	92	88	10710	12040	13180	12340
	35.1	20.0	29.0	35.0	42.0	52	75	73	86	81	95	87	92	9560	12850	12430	14210
	24.7	20.0	30.0	38.0	40.0	53	68	76	80	90	91	87	96	10090	12480	12910	13410

* These species are not as yet available for commercial pulping.
Figures in brackets denote number of tests.

to 53 per cent at a Kappa Number of 22. In the latter mill if the Kappa Number of the pulp is allowed to drop to 17, this yield drops to 47 to 48 per cent. The lower yield obtained at the Enstra Mill is thus due to:

(i) the lower potential yield of the Transvaal mixed gum species and
(ii) the lower Kappa Number being achieved for bleachable grades of pulp.

PHYSICAL STRENGTH PROPERTIES

South African unbleached eucalypt kraft pulps compare favourably in overall physical strength properties to pulps produced overseas from eucalypt species, and are generally superior to American and Scandinavian hardwoods like birch, beech, oak, *etc.*

Pulp from Natal *E. grandis (saligna)* is superior in physical strength properties to that produced from the Transvaal species. (See Table 2). *E. grandis (saligna)* is, however, unsuitable for the cold and frosty conditions experienced during winter months on the Transvaal Highveld and cannot therefore be planted there.

Kraft pulping investigations are at present being conducted on some of the species mentioned from the Transvaal plantations (lying at altitudes varying from 3,000 to 5,000 ft above sea level).

KRAFT ODOUR

SAPPI's experience is that gum cooks yield a larger quantity of odorous compounds than cooks made on pine. Work on the odorous constituents from eucalypt pulping was already reported in 1949 by Reid (3).

CHEMICAL ANALYSIS

The following is a chemical analysis of a typical mixture of gum species used at Enstra Mill:

Ethanol-benzene extractives	4.9%
Hot water extractives	4.0%
Lignin	23.3%
Alpha-cellulose	39.6%
Pentosans	18.9%

PECULIAR PROBLEMS WITH EUCALYPT PULPS

Unbleached eucalypt kraft pulp can be successfully used in the making of packaging grades of paper (sack, bag, *etc.*), provided the amount of short-fibred pulp does not exceed 40 per cent. Other grades can use much higher percentages (plastic base, *etc.*). A high degree of refining has to be applied to achieve the necessary property development on the pure eucalypt pulp before admixture with the long-fibred portion of the furnish.

In the case of bleached paper manufacture higher percentages can be used, but trouble can arise due to vessel elements ("gum cells") picking from the sheet during solid tone letterpress printing or more especially in litho printing. This problem can be overcome by proper size press starch techniques.

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APPENDIX A

TESTING CONDITIONS FOR PULPS

Laboratory kraft pulping cycle

Time to 100°C	30 min.
Time from 100°C to 157°C	55 min.
Time to degas from 157°C to 145°C	12½ min.
Time from 145°C to 170°C	12½ min.
Maximum temperature	170°C
Time to degas from maximum temperature (170°C) to atmospheric pressure	30 min.

Laboratory digester

Kraft pulping is carried out in a 10 litre Deutsch and Neumann electrically heated rotary digester on a 1,000 g O.D. chip charge. Pulp is screened through a 14 mesh box screen and collected on another 50-60 mesh box screen.

Beating and sheetmaking

Pulp beating is carried out in a Lampen ball mill doing 275 rpm at 3 per cent consistency and 24 g charge and 60 g/sq m (O.D. basis). Sheets are made on a Rapid-Köthen sheetmachine. After pressing to British Standard conditions, the sheets are dried under 580 mm Hg vacuum for 2 min.

Conditioning

24 hr at 50 ± 2 per cent relative humidity and 73 ± 2°F.

Testing

1. *Metric burst factor:* Three sheets tested separately in a Model C burst tester. Gauge reading in lb/sq in converted by formula:

$$\text{Burst factor} = \frac{\text{Burst pressure (lb/sq in} \times 70.3}{\text{O.D. basis weight (g/sq m)}}$$

Units : Metres squared
Number of tests : 10

2. *Tear factor:* Tested in Elmendorf Dynamic tear tester (Australian Model).
6 Sheets 50 × 63 mm torn simultaneously.
Scale reading converted by:

$$\text{Tear factor} = \frac{\text{Tear reading} \times 16/6 \times 100}{\text{O.D. basis weight}}$$

Units : Metres squared
Number of tests : 6

3. *Breaking length:* Determined on sample 9 cm × 15 mm in a pendulum tester at a constant break time of 20 ± 3 sec.

$$\text{Breaking length} = \frac{\text{Tensile strength kg/15 mm} \times 1{,}000}{\text{Basis weight}}$$

Units : Metres
Number of tests : 6

4. *Wetness:* 2 g O.D. pulp suspended in 1,000 litres tap water and poured through Schopper-Riegler wetness tester at room temperature. Back orifice reading recorded.
Number of tests: 2.

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