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HIGH LEVEL ADVISORY SERVICES FOR THE BAIKALSK PULP AND PAPER MILL

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RUSSIAN FEDERATION

Technical report: Pulp and papermaking*

Prepared for the Government of the Russian Federation
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

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ABSTRACT

During the visit and the discussions the Baikalsk Pulp and Paper Mill was found to be very viable. The biggest issue, the environmental problems, can be solved in a satisfactory way.

The proposed changes carried out, the volumes and loads to the existing effluent treatment plant are so much reduced, that the plant can operate very effectively. They also make possible to reduce the consumption figures, both chemicals and energy, in the effluent plant.

The main target of the proposed process reconstructions is to cook to very low Kappa number 10-14 and reduce it by oxygen delignification to 5-6 and also by good washing to get the carry-over to the bleaching plant down to less than 10 kg COD/ADt thereby allowing the elemental chlorine to be left out (ECF-solution) and to start the designing of a TCF-solution with no chlorine chemicals.

The proposed changes to help in achieving this target are:

- new cooking
- improved washing
- closed new screening
- oxygen delignification

The bleaching is proposed to be made in the ECF-solution using the sequence D-EOP-D-P-H or D-EOP-P-P-H for the viscose pulp and for the paper grade pulp the hypochlorite can be left out. With no hypochlorite used the AOX will be 0.35 kg/ADt before the treatment and treated it will be 0.2 kg/ADt. The effluent volume from the bleaching goes down to 23-30 m3/ADt, BOD5 to 3 kg O2/ADT and COD to 22-23 kg O2/ADt

Because of the high penalty for organochlorines in the effluent these changes should be made in the 1st stage. At the same time there should be carried out studies for the TCF using ozone.The mill experiences in the world have proven that TCF is good in the paper grade production and the pilot plant tests have proven success in the hardwood viscose pulp, but softwood viscose pulp is still open. Probably there will be a good solution for that too, but the final target, the closing of the bleaching plant, is a more difficult problem. The metal and resin balances should be calculated very carefully.

Also in the 1st stage the drying machines should be inspected and the reasons for reduced capacities to be found out. The both machines should be able to dry 325 Adt/d thereby allowing at least 200 000 ADt/a , the design capacity of the mill.

In order to secure the chip production and reduce the effluent loads the present debarking should be replaced by a new one-line dry debarking drum. A new chipper and screening will help to produce high chip quality, which helps to cook even pulp and to reduce the knot percentage.

The proposed changes in the causticisation and lime kilns help to secure the white liquor quality and to make some fuel saving in the kilns.

The paper machine should produce in the future liners for example white top liner. For the top layer could be used paper grade pulp from the pulp mill and for bottom layer the reduced rejects flow from the pulp mill and 20 000 t/a collected waste paper. The new production would be 30 000 t/a. Because the price for white top liner is very good, this would be very profitable too.

There was a lot of discussions about producing birch pulp. The mill people were not very interested in using it as raw material, because they had bad experiences; production was reduced, there were breaks in the drying machines etc. There is a demand for birch paper grade pulp at the market and birch is very suitable for dissolving pulp, but according to the information received from wood supply department, the available birch would cover only 20 % of the annual wood consumption. Because of that small part and some investments needed for the birch utilisation, birch is not proposed to be used in the future.

Investments:

The investments in the first stage including the area cooking-oxygen delignification, 1st stage changes in the bleaching plant and the drying machines would be about **84 MUSD**.

The second stage investments including the woodhandling, 2nd stage bleaching , paper machine and causticisation would be **54 MUSD**

The total investment would be about **140 MUSD**.

Personnel:

In the 1st stage the reduction would be 90-100 persons in the cooking-oxygen delignification area. In the 2nd stage the reduction would be 260 persons so the total reduction would be 350 persons.

Effluent volumes:

The 1st stage reduction would be 160 m3/ADt and for the second stage the estimate is very difficult, but for the woodhandling reduction is 17 m3 and for the bleaching from 15 to 30 m3/ADt.

TABLE OF CONTENTS

V ANNEXES

INTRODUCTION

A. Background

UNIDO and PI Consulting Ltd contracted the author, Olli Jalkanen, pulping specialist to provide independent expert advice on modifications to the processes employed at the Baikalsk Pulp and Paper Mill designed to minimize/eliminate impacts of potential emergency and continuous pollutant releases on the Baikal Ecosystem.

At the same time the mill was visited by following other specialists:

- Risto Salama,	consultant on on cost/financial and market analysis
- Neil McCubbin,	consultant on environmental sciences
- Lothar Huber,	consultant on waste water treatment
- Roy King,	consultant on mechanical processing of wood

The visit in the mill was from 14th February until 28th March, 1995. A detailed job description is presented in the ANNEX 1. The senior staff of the mill is presented in the ANNEX 2 and the persons, with whom the author discussed in the mill, is given in the ANNEX 3.

B. Objectives attained

Current situation

After the visits in the mill departments and in the discussions with the mill management and with Mr. Salama and Mr. McCubbin it became clear, that the mill is still very viable after nearly 30 years of running. It also became clear, which are the main targets to be reconstructed or modified not only for the environmental reasons, but also for being mechanically finished. The comments on the present plant and machinery are given in the chapter II.

New cleaner technologies

The proposals made by the mill people for modifications were discussed in details specially with the production management, Mr. Shapkin and Mr. Tikhonov. We could agree on the targets, but for some departments the mill proposal included cheaper investment, which in the long run would not work properly. The recommendations for new cleaner technologies are presented in the chapter III.

I. DESIGN DATA AND BALANCES

A. Pulp and paper mill

A short description of the pulp and paper mill is given in the ANNEX 4.
The design capacity of the mill is as follows:

Dissolving pulp	200 000	ADt/a
- viscose	100 000	"
- cord	100 000	"
Wrapping paper	12 100	"
Tall oil	9 600	"
Turpentine	2 000	"
Fodder yeast	10 500	" (stopped 1987)

Because of the environmental reasons the pulp production is now limited to 163 000 Adt/a and and cord-pulp is replaced by bleached paper grade pulp.

The working days according to the standard (GOST) are 345 days/a.

B. Fiber balance

The wood is transported to the mill as a mixture which includes 25 % pine and 75 % larch. The wood is bought without bark so the wood volumes are measured in m3 sub (solid m3 under bark)

In the woodhandling there are following losses:

	Pine %	Larch %
Bark	7.0	15.0
Wood loss in debarking	1.4	1.3
Fines	3.0	8.0
	11.4	24.3

Using in calculations wood losses; pine 4.4 and larch 9.3 % and solid weights 486 and 594 kg BD/m3 respectively there is in the mixture going to the digesters 26 % pine and 74 % larch and an average wood content is 566 kg BD/m3.

The calculated wood consumption figures are:

- viscose	5.9	m3 sub/ADt
- cord	6.6	"
- bleached kraft pulp	4.4	"

The balance calculations are shown in ANNEX 5

C. Heat and power balance

Heat

For steam production there are following units:

- recovery boiler 1	50 t/h	40 bar and 420 C
- recovery boiler 2	50 "	"
- recovery boiler 3	50 "	"
- recovery boiler 4	50 "	"
- bark boiler	75 "	40 bar and 420 C
- bark boiler(old,oil fired)	40 "	
- coal boiler 1	160 "	100 bar and 520 C
- coal boiler 2	160 "	"
- coal boiler 3	160 "	"
- coal boiler 4	160 "	"
- coal boiler 5	160 "	"

After the turbines there are 3 different steam pressure levels for use:

- medium pressure, MP	13 bar
- low pressure, LP	6 bar
- low pressure	1.2 bar (for town heating)

Total heat consumption is 59 GJ/ADt, of which the production consumes 39 GJ/ADt which is an enormous figure. Heat balance is presented in ANNEX 6.

Power

For the electric energy production there are four turbogenerators:

- 2 turbines 12 MW each, from 40 bar to 5-6 bar
- turbine 25 MW, from 100 bar to 13 and 1.2 bar
- turbine 50 MW, from 100 bar to 13 and 1.2 bar

This capacity is enough for the mill and the town, but it is sometimes cheaper to buy from the national grid, so in 1994 the purchased energy was 71405 MWh.

The usage of power in the mill and the town is 1839 kWh/ADt of which the pulp production is 780 kWh/ADt, see ANNEX 7.

D. Personnel

The present personnel is presented in ANNEX 8. The total figure is 3521, of which a significant part works in non-industrial jobs.

E. Freash water

The present consumption is 183 800 m3/d, see ANNEX 9.

II. COMMENTS ON THE PRESENT PULP AND PAPER MILL

A. Woodhandling

The average distance for wood transport was in 1994 1300 km and this transport is made using railway wagons. In order to be more independent from the state railways the mill has purchased 50 wagons for pulpwood and 38 wagons for long logs. The problem is that those wagons go empty to fetch the wood. The railway freight cost plays a significant role in the pulp wood price. 1st of march 1995 the price averaged 102 780 SUR/m3. From that price the freight was 58 %(59 920 SUR = 13.32 USD). The used wagons and wagon loads are listed in ANNEX 10.

The mill has decided to take into the mill full length logs. The wood cutting enterprises have tendency to cut the best pieces of logs and to export them for better price. That leaves the mill without suitable material for saw mill. For the purpose the mill has purchased those 38 pieces 27-m wagons and is building a working area where long logs be cut suitable using hand chain saws.

Because of the hard financial situation of the wood cutting enterprises, a stable wood delivery to the mill cannot be quaranteed. The mill is going to purchase a own wood raw material base, which would supply 60 % of the future wood needed.

There has been a lot of discussions of using birch. The mill purchased in 1992 some birch and cooked it together with softwood. There were some difficulties with bleaching plant filters and in the drying machine wire part, so the mill people are not very eager to take birch into the mill. There were no birch during 1993 and 1994 and the planned pulp wood assortment for the 1995 does not include any birch (see ANNEX 10 for wood deliveries). Only in a case there is no other wood available, birch can be purchased, and an estimate for that case is 200-250 000 m3.

The majority of the wood and purchased chips are transported in railway wagons with walls, but no roof, which means certain difficulties in unloading and makes it slow. It also means that the unloader must climb up to the car to help with lifting wires and especially in winter time it is dangerous too. The log bundles are heavily wired and it is very important to remove those wires before lifting them on the feeder tables.

The barking drums being now about 30 years old are nearly finished, there is a lot of maintenence, which causes process disturbances and costs. The wet debarking using 400 m3 water/h (circulation open) causes heavy loading to the effluent treatment plant.

Pine and larch are debarked together and that left 5-7 % of the larch undebarked and a visual control at the conveyor gave even higher percentages. Every tenth of logs was undebarked and all of them larch.
The old chippers probably cause unnecessary fines and the diameter of wood fed to them is limiting factor.

The screens are of vibrating type with perforated plates, which means that they are not sorting the chips according to the thickness but to the length and breadth.

In the slasher feeding two drums the wood is driven by screws against the right side and in the case of short wood the right hand debarking drum is overloaded and the left one is running empty. The full capacity of the drums cannot be utilized.

The purchased chips being now 10-12 % of the wood supply seem to be of low quality. There was a lot of bark and a huge amount of fines from the screen. The mill and the chip suppliers have worked only a short time together. A good co-operation, a good control at the reception and a strict rejection when needed before mixing chips with accepted chips will help with the time.

One reason for high fines quantities is larch. It is hard and easily splitting. All strong mechanical treatments like pneumatic transport should be avoided.

The total wood yard area is 53800 m2 and 160 000 m3 wood can be stored in that area. It corresponds to 1,5 month's use and is enough.

There are 6 chip silos 600 m3 each so the capacity is 3600 m3 or 25 cooks or 10 hours. It should be bigger, at least some days, in order to give some flexibility.

Power consumption varies between 83-91 kWh/ADt, and it probably is too high. By using modern equipment and less parallel lines it could be about 40 kWh.

The platforms, steps and handrails in many places are not safe and most of the mechanical drives are uncovered.

Conclusion:

- the debarking machinery is at the end of its mechanical life
- the wet debarking causes high load to the effluent treatment
- the present system demands high manpower
- the electric power consumption is double compared to a modern plant
- the chip storage capacity is quite too small
- the working conditions in the department are not all acceptable

It is proposed that the mill invests in new debarking, screening and chip storing. This should be made in new building(s), then the present production can go on almost undisturbed during the erection. Perhaps one of the present lines could be preserved as an emergency line in a case the new line does not temporarily work.

B. Cooking

The digesters and their controls date from the sixties. It is not quite clear what is the condition of those clad digesters.
The digesters are tested normally every fourth year with 16 kg/cm2 pressure and allowed operating pressure is 12 kg/cm2, which is 1,5 times 8 kg/cm2 corresponding to the 172 C cooking temperature. It was told that the pressure vessel authorities give for each digester a permission only for one year a time. These cracks in cladding can be repaired, but doing that for 24 digesters would be expensive. So all the solutions in which the old digesters would play a part as pressure vessels should be left out.

There are difficulties with the calorisators(heat exchangers). The pipes are clogged often and the main reason is the "caramel" in the prehydrolysate and possibly calcium carbonate in the white liquor (30-40 mg/l). There are also a plenty of leaks contaminating the steam condensate with black liquor. The condensate normally returned to the power boilers is totally rejected to the effluent treatment. That is one of reasons to the lignin content in the effluent. Also the treatment of 30 t/h make-up feed water is expensive.

In order to modernize the cooking control there is a plenty of automatic valves to be installed and a new DCS-system to be bought for 24 digesters and tank farm. This would be so expensive, that it would be best to have a totally new cooking plant with fewer, bigger digesters.

The cooking degree numbers are as follow:
- paper grade pulp 95-110 Björkman units corresponding 22 - 29 Kappa Scan
- viscose pulp 65- 80 Björkman units corresponding 13 - 18 Kappa Scan

Those Kappa-numbers are already quite low, but it is possible get them lower to around 12-14 units using extended cooking.

Power and heat consumption figures for the existing cooking plant are high. Power consumption should be on the level 40 kWh/ADt and the mill announces 86 kWh/ ADt.
The heat consumption together with the washing (comsumption negligible) is 9 GJ/ADt, which is twice so high as in a normal batch cooking and about four times as high as in the modern batch cooking.

Conclusion:

- the present machinery is at the end of mechanical life
- the calorisator and other leaks cause high effluent loading
- the present blow system causes high emissions and specially with paper grade pulp
  some strength properties are lost
- the heat and power consumptions are very high

It is is proposed that the cooking department machinery is replaced by a new plant erected in a new building.

C. Washing and screening

The existing 2 lines of three Rauma-Repola pressure washers are still working relatively well. There have been some problems with the sealing between the drums and the bodies. That was solved by Sunds men coming to replace the old type sealing with new. Probably those filters will work for many years ahead.

The problem is that the washing efficiency is not good enough. So there is a need of some additional washing unit for the lowering of the carry-over to the next stage. The mill uses now evaporation plant secondary condensate for washing and the quantity is so high, that the concentration of black liquor sent to the evaporation plant is only 13 % and still the washing loss is 30-40 kg NaSO4/ADt.

The unbleached pulp screening is of open using screens of Cowan type for deknotting and screening. If the pulp is not well washed, it means that a lot of

lignin and inorganic material is going into effluent treatment or with the rejects to the paper machine.
The knots after separation are refined in two refiners and added to the other rejects.
The screening is made in three stages. The accepts from the first and second stages are fractionated in Attis-filters. The pulp from Attis goes to thickening. The filtrate including the fines or O-fibers with the resin in them goes through Waco-filters, which collect the fibers to be sent to the paper machine. Waco-filtrate goes into effluent treatment. There we have open way through which quite a lot of organic and inorganic material is lost partly on purpose and partly as a result of inefficient washing.
For the present Attis-filters are needed for the fractionation but also as prethickeners, because the capacity of the next thickening stage is not enough and the pulp concentration too low. These Attises get dirty with resinous material very easily and there a lot of work to try to keep them clean. Also the wires of filters are easily broken, which means that acceptable fibers are getting into the rejects.

According to some mill experiences, if there is a oxygen delignification after the screening the fractionation can be left out thus getting rid of these problematic filters.

By using a modern deknotter, knot washing and screens working under pressure in the concentration area of 2-5 % it is possible to do screening as a part of the countercurrent washing filtrate flow. The only losses are those in the thickened rejects.

Conclusion:

- open screening causes a lot of effluent and organic and inorganic losses
- the Attis-filters are problematic and should be left out

The deknotting should be made after the blow tank with pressurized screens and also the screening should be closed and done after the existing washing lines. The pulp concentration of in the new slotted pressure screens could be elected so that the capacity of the existing thickeners would be enough. There is enough space for the new screens in the existing building.

D. Bleaching and bleach chemical plant

The most filters are original and of drop leg type. There are some JEH-type filters delivered later by Russian supplier. According to the chief of department only 5 filters could be used later. Three of those have been in the temporary use for cold extraction in the cord pulp production. The use of filters in some new solution is very questionable.

There are some original retention towers like extraction (AISI clad) and hypo (rubber and resin) towers. All he other towers like chlorination, dioxide and acidification towers are made of titanium. These are of up-to-down type and the volume is 320 m3 each.If the tower is full it gives a retention time of 3 h +/- 20 minutes depending on the concentration.

Mostly the filtrate tanks, 10-15 m3, are made of titanium and seem to be quite OK.

Chemical mixers, one shaft and double shaft types, are made of titanium, but their use in some solutions is questionable, because the mixers needed should work under pressure and their mixing ability should be much more effective.

The heat consumption of the bleaching plant the bleaching chemical plant included is 3,8 GJ/ADt. Also there are some potential savings to be made.

Mathieson-reactors originally of mild steel clad with plumb are now made of titanium and probably they will last very long. The mill has been using only one, the other one seemed to be in the condition that it is not possible to take it into use very easily.
The maximum nominal capacity is 2,5 t ClO_2/d each, but according to the chief of the department it is possible to produce only 4,5 t ClO_2/d instead of 5 t/d. The reason is probably the low concentration of Na-chlorate. It is brought to the mill in liquid form and in the cold time the mill uses direct steam to heat it thus diluting it. Also the incoming raw materials; Na-chlorate, sulphuric acid or SO_2 seem to include some organic material, because there is a lot of "puffing" in the reactors. Those chemicals are filtered, but it does not help much.
If the future capacity of the mill will be 160-220 000 t/a and the elemental chlorine is left out, the limiting factor for the bleaching will be the ClO_2-plant capacity. With the present machinery there are available only 7-10 kg ClO_2 or 18 - 26 kg act Cl_2/ton of pulp depending on the pulp quality.

Conclusion:

- the filters are in bad condition, the outsides of the vats are strongly corroded
- the elemental chlorine should be left out in the first stage
- the chlorine dioxide production capacity must be checked

1st stage:
The beginning of each bleaching line must be changed to use only chlorine dioxide, which demands some new equipment.

2nd stage:
Chlorine dioxide and hypo should be left out.

E. Drying machines

Cowan-type screens and plastic centricleaners are working satisfactorily. They could be replaced by pressure screens, which helps to save some energy and cleaning result would be better. The capacity of the plants must be checked, if the drying machines capacities are elevated.

The design capacity of each drying machine is 300 ADt/d. But real capacities are now:

1. drying machine		2. drying machine
- cord	250 ADt(90%)/d	- paper grade pulps 270-280 ADt(85%)/d
- dissolving	250-260 ADt(90%)/d	
- paper grade pulp	270 ADt(85%)/d	

The total capacity of the drying machines varies between 500-540 ADt/d respectively 172-186 000 ADt/a. So even if they had a permission to produce more than that 163 000 ADt/a, the maximum would be about 180 000 ADt/a.

The construction speed of the machines is 200 m/min and speeds used now are 50-60 m/min. The working pressure allowed for the drying cylinders is 6 bar and the pressure of the low pressure steam is 3,5 bar (130-140 C).

Because the system is so open and the Baikal fresh water so cold, the temperature in head box is very low and that is one reason for very low capacity.

The drynesses after the press parts vary between 42-46 % for the viscose and paper grade pulp, which is quite satisfactory.

The drying air (60-65 C) water contents in (0,010-0,012 kgH2O/Kg air) and out (0,117 kg H2O/kg air) seem to be acceptable.

There are some cylinders which are not in use, but this should not be reason for low capacity.

The mill people think that after some remont the machines can again dry 2 times 300 ADt/d corresponding 207 000 ADt/a. They do not know excatly what would be the targets of repairs, because for many years they have not needed the full capacities.

<u>Conclusion</u>:

- there is something wrong , because the design capacity cannot be reached. If the dryness values after the press part are OK, the dryer part does not work properly. Possibly there are many cylinders filled with condensate.

F. Paper machine

The paper machine uses as raw material rejects from pulping process. The amount of rejects has been enough for 11 000 tons of wrapping paper. If the changes we propose for the pulp mill go through, this amount will drop significantly. So there is a need for some new solution. The mill people do not know what to do. They wait for proposals made by machine suppliers and Unido specialists.

The main idea is to produce some 2-layer board, fluting or kraftliner.
The mill has had contacts with:

- LENSNIIVBUMMASH, who has made a proposal costing 4 MUSD.
- NEECPAPCEL, LITOVEL (Tsech republic) costs 11 MUSD
  - -- second wire part
  - -- new presspart
  - -- size press
  - -- calander
- CELLI (Italy), proposal is coming, representatives were here Feb./95

We discussed about possibility to produce liner using recycled paper(OCC). I was told that the people do not like idea using old paper, but if Unido specialist proposes it, it might go through. There is enough recycled paper in the Irkutsk area, but collecting, sorting and transport are problematic.

The mill people are willing to produce writing and copy paper like the Svetogorsk paper they use now. They could make bleached softwood and hardwood pulps themselves.

One possibility is to produce wrapping paper for the pulp, but basis weight in the present machine is not high enough. Maximum is now 130 g/m2.

There is also a wish to produce Chromo-ersatz boards, specially chip board with white or grey bottom layer, basis weight 350 g/m2.

G. Evaporation plant

There is 500 t/h water evaporation capacity which is quite enough for much higher production of the pulp than the present production. If there is no more cord production, the existing white liquor evaporation equipment could be used as an additive capacity.

The present concentration after the concentrators is 67-68 %. If this could raised by up to 74-75 % by using the superconcentration (Tampella) or the heat treatment (Ahlström) or the present equipment could be finetuned to reach the level 72 %, the SO_2-emissions from the recovery boiler would be significantly reduced being less than 50 mg SO_2/flue gas m3 .

The heat consumption in the evaporation plant is 19 GJ/ADt, which is extremely high, but it must be remembered, that it includes also the the heat needed for the cord white liquor evaporation and that the incoming weak black liquor concentration is only 13-15 %.

Condensates:
- steam condensate, returned only 80 %
- contaminated condensate is treated with air in catalytic towers (some antimone bound in polyethylene pebbles, the mill people have a Russian patent for that).

The condensate:air relation is 1:4. All methylsulphide compounds are oxidised into sodium thiosulphate and sodium sulphate. Also methanol and furfural are oxidised. This method of cleaning allows the condensate to be reused , in this case 100 % as wash water in the brown stock washing plant. No stripper is needed.
The outlet from the towers go into the atmosphere and it is not clear to me , what is included in that air.

Conclusion:

The mill should ask some evaporator supplier specialist to come and see, what are possibilities to to raise the outlet concentration > 70 %. That would raise the steam production and reduce the SO2 emission down to zero level.

H. Recovery boilers

The capacity of each 4 working recovery boilers is 380 t DS/d with maximum somewhere 415-420 t DS/d. The boilers were reconstructed 1987-1994 and are working satisfactorily. There is also a fifth boiler made by Belgorodski but according to the mill people, it is out of use forever. All the boilers are equipped with 3-chamber electric precipitators. Just now there are problems with brick insulation, but they are under repair.

Conclusion:

Total capacity of the boilers is enough even when only three of them are in use, so the fourth one is a reserve. A positive thing would be the raising of the black dry solids proposed for the evaporation plant.

I. Causticisation and lime kilns

Depending on the pulp quality produced, 3400 m3 white liquor/d is enough for the production of 210-230 000 t pulp/a. The system is based on Dorr-clarifiers, after which there is 60-80 mg CaCO3/l white liquor. In order to diminish this the mill has erected two patron (sock)filters by which the amount is halved, but still it is too much. I propose a new white liquor filter and the existing clarifier can be used for green liquor. By adding some causticiers the white liquor flow could be somewhat bigger.

The dry solids in two lime kiln feeds are about 60 % and could be even lower. The production, 300 t CaO/d, is enough for the abovementioned white liquor flow, when 88 kg CaO/white liquor m3 is used. If the dry solids content of the mud is added, the capacity of the kilns could be higher. The using of the oxygen for oil burning could add some capacity.

There are some (or total) repairs to be made in the brick layers of the kilns.

The flue gases of the lime kilns are cleaned using Imatra-venturis, which wash the gases, but are not good enough. The mill has erected a system called "emulgator" by which the gases are further washed, but now the system was under repair.

Conclusion:

The capacity of this part of the recovery cycle is enough. The cleanliness of white liquor should be raised by new filter for example a Ecofilter The existing clarifier

could be used for green liquor clarification or even there is possibility to get better results by installing a new filter.
The old lime mud filters could be replaced by new filters by which the dry solids would be raised up 75-80 %. That would reduce the oil consumption and thereby the SO2 emissions. Also the possibility of using new lime mud dryers would help in the same direction.
If the "emulgator" is not working properly, there should be installed electric precipitators for the kilns.

III. RECOMMENDATIONS

A. General

Production

The present capacity is limited to 163 000 Adt/a by the authorities. The design capacity is 200 000 Adt/a, but this production can not be reached, because the drying machine can dry only about 175-185 000 Adt/a (500-540 Adt/d).
The recovery island (evaporation, recovery boilers, causticization and lime kilns) allows a maximum production of 210-230 000 Adt/a.

The future production capacity was discussed in the mill and the opinions varied a lot. The design capacity 200 000 Adt/a was proposed and also higher production has its defenders.

Recommendation

The production capacity, which the recovery island allows, should be chosen as the base for the future calculations. Depending on the pulp quality it would be 210-200 000 Adt/a, an average 220 000 Adt/a. The new proposed machinery; woodhandling, cooking, washing, screening, oxygen delignification and bleaching, should be capable for this production.

1 or 2 production lines

The present mill has two production lines and the mill people are used to it, so a proposal to have only one production line for fibre in the future and campaignwise production with it wakes some opposition. The investments would be some 30-40 % cheaper when made with one line, but in this case only some parts of the fiber line would be one lined, so because of the flexibility of the production it is proposed that production is made with two lines also on the future.

Recommendation:

The woodhandling should be 1-lined. The new cooking plant is easy to arrange in one or two lines. The washing, the new screening, the new oxygen delignification and partly new bleaching are kept two lined.

Kappa and carry-over to the bleaching plant

The recommendation for the new machinery and process solution in the cooking-washing area is based on the idea of minimizing the Kappa-number and the carry-over to the bleaching plant. Thereby will the chemical use and the environmental load be reduced.

This target can be reached using extended cooking and oxygen delignification with a good post-washing. The Kappa after cooking would be 10-14 and with 50-60 % reduction in the oxygen delignification the entering Kappa to the bleaching is 5-6 plus the effect of the carry-over, 10 kg COD/ADt, from the post-washing.

Total entering Kappa would be:

Total Kappa = Kappa(O2) + 0,278 x carry-over (Simons, 1994)

= 5-6 + 0,278 x 10

= 7-9

If the last washer is used partly oper or there will be a open washer berween the HC-tower and the bleaching, the carry-over is further reduced by 60-70 % and the entering Kappa-effect will be 6-7 units.

Compared to the present situation, Kappa 13-18 for viscose pulp, 22-29 for paper grade pulp and carry-over calculated as 30-40 kg NaSO4/ADt, this would be a real reduction and would save bleaching chemicals and allow the dismissing of elemental chlorine.

B. Woodhandling

The mill has asked during 1991-95 offerts for the modernizing of the wood debarking. The offerts given are: KONE, PSI&MORBARK, RADER and HARRIS&NICHOLSON. The first three companies offer dry debarking in bulk form and the fourth one offers also dry debarking but in unit form.

This unit debarking using Nicholson ring debarker sounds very interesting, because it is very cheap compared to the others. This type debarker is normally used in the mechanical wood industry (saw mill, plywood mill etc.), where the wood material is heavier.
There is a doubt that in a continuous use:
- designed capacity will not be reached, because the pulp wood is normally thinner and even constant feed is difficult to arrange. More equipment is needed.
- the maintenance cost will be higher
- the life time is much shorter
- wood loss is double, specially with the frozen wood

Based on the abovementioned reasons the world wood pulp industry uses nearly 100 % drum debarking.
The offerts, the mill has received from the others, are very expensive and are based on 2-line complete systems.
A cheaper solution is to use a single line, which is capable to handle both softwood and hardwood. Of course separate chip storages are needed.

Recommendation:

- separate cutting and sorting for full-length wood (Russian delivery, 0,2 MUSD). Acceptable parts are sent to the saw mill and debarked there for ex. with ring debarker.
- existing bridge crane system is utilized
- feeding to the debarking line is made by using trucks
- deicing conveyor using 30-50 C circulation water heated with steam
- dry drum debarker, dia 5,5 x 35 m, capable of handling long and short wood

- washing for logs prior to the chipper
- chipper
  -- chip length controlled, 22-25 mm, no thickness chip screen needed
  -- fines very low, about 0,7 %
  -- max. wood diameter 750 or 850 mm depending on chipper
- chip pile for 5-10 days (second pile, if birch is needed)
  -- conveyor loading, screw unloading
- screening for all chips
  -- oversized and thick chips conditioned
- water treatment
- bark presses, the existing ENSO-presses could be used

This solution gives a modem woodhandling and the investment is 50-60 % of the existing offerts.

Consumption figures:

- steam	30-60 kg/sub m3
- fresh water	40-120 m3/h, could be warm treated effluent
- power	6,7 kWh/sub m3 or 40 kWh/ADt

Effluent:

- quantity	0.1-0.3 m3/sub m3
- suspended solids(SS)	0,2-0 4 kg O2/sub m3
- BOD5	0.2-0.4 kg O2/sub m3
- pH	> 5 must be or with alkaline controlled

Personnel:

- operators	30 persons/shift (+ maintenance)

Investment:

- equipment	
- electrification	
- spares and supervising	
- trucks	
	22 MUSD
- erection, normally	3,3 MUSD
- civil works,15 000 m3	0,15 MUSD

C. Extended cooking and cold blow

The present cooking plant is now 30 years old . The modemizing would be very expensive and during reconstruction there would be a lot of production losses. The proposal is that the mill invests in a new cooking plant.

Continuous digester would be a good solution for the paper grade pulp, but for the viscose pulp it is not suitable. There are some mills which have tried to produce viscose pulp with a Kamyr-digester. The "caramel" in the prehydrolysate has caused troubles and the difficulty to achieve stable quality have made it impossible to use it
(Ahlström, Varkaus mill, Becker).

Many of the latest deliveries for sulphate cooking have been batch cooking (Enocell, Metsä-Rauma, Mörrum, Nettingsdorf, Steti, Riau Andalan etc.).

Some advantages of displacement batch cooking:
- extended cooking to a low Kappa numbers
- one washing stage already in the digester
- cold blow reduces the emissions and effluents from the cooking plant.
- heat and power consumptions are low
- prehydrolysate is neutralized already in the digester, so some difficulties are avoided
- steam prehydrolysis proven to be as good as conventional water prehydrolysis
- good yield at least with eucalypt, at Kappa 9, yield 40 %

There are three potential suppliers; VAI with Visbatch, Sunds with Superbatch and Beloit with RDH.
From Beloit there are no articles showing their interest in RDH dissolving pulps, so there remain VAI and Sunds. VAI with Lenzing has developed this Visbatch, which is proven suitable for dissolving pulp made of hardwood, eucalypt, and which will soon have an industrial solution in use in Brazil. Originally those tests were made by Sunds, but for some economical binds the tests were continued by VAI/Lenzing.

Both suppliers are capable of delivering the cooking plant needed. But both lack the know-how concerning the softwood dissolving pulp made with their new systems. Laboratory tests should be made for the mixture of larch and pine. After these tests also the consumption figures could be defined.

Consumption estimates:

Steam:	
- Visbatch	0.9 t/BDt
- Superbatch	1.2 t/ADt
Power:	
- Visbatch	45 kWh/BDt
- Superbatch	40 kWh/ADt
Hot water:	
- Visbatch	9 m3/BDt
Personnel:	
- Superbatch	1 operator/2 lines + field operator/shift

Investment (Superbatch):

- 10 pcs x 300 m3 digesters

- chip feeding
- pumps and piping
- accumulators and tanks
- motors
- field instruments and hardware(DCS)
- electrification
- engineering
- supervising, start-up and training

190 MFIM = 44 MUSD

- erection, Russian, 60 000 h
- civil works, Russian. 40 000 m3

Emissions and effluents:
- relief gas condensate 100 kg/ADt
- following gases should be collected/treated/incinerated
  -- non condensable gas from relief (60 C) 3,3 Nm3/ADt
  -- weak gases from blow and filtrate tanks 9000 Nm3/h (at 95 C)

D. Brown stock washing, screening and oxygen delignification

The idea is to use the present pressure washer lines, to add oxygen delignifications and to use pressurized screening, so that the washing can be made countercurrently.

The target is to have washing losses (carry-over) 10 kg COD/ADt from the last filter. All the rest goes into the black liquor except small losses with the rejects.

There are many alternatives to do that, two of them are presented here:

Alternative I (see ANNEX 10)

1. - pressurized deknotting between the blow tank and the 1st pressure washer (Includes a screen and knot washer/line)

2. - after 3rd pressure washer 3-stage slotted pressure screening (3rd stage could be common to both lines) Accepts from 1st and 2nd stages directly to the existing thickener.

3. - 2 stage oxygen delignification with 2-stage postwashing

This system includes following washing stages:
- displacement in the digester
- 3 pressure washers, 2 stages in each
- 1 thickener

- 2 post washer (could be DD-washer/Ahlström or press/Sunds etc)

The thickener after the screening can be a bottleneck: the pulp feed consistency can be arranged suitable, but the capacity (tons/m2 .h) drops by 50 %, because the pulp and wash water are alkaline.
Washing water is added to the last filter/press.

Alternative II (see ANNEX 11):

1. - same as in Alt.I

2. - after pressure washer there is a new washer (DD-washer/Ahlström or press/Sunds etc.)

3. - 2 stage oxygen delignification and one washer

4. - 3-stage slotted pressurized screening. Accepts directly to the thickener

Investment is about the same as in ALT. I, but the potential bottleneck is removed. The rejects from the screening are cleaner.
The washing water with DF (=dilution factor) maximum 2,5) is added to the thickener and if a part of the filtrate is removed, also to the washer prior to the screening. If this filtrate removing is used, the carry-over 10 kg COD/ADt can be reduced to 3-4 kg.

Oxygen delignification

The target of oxygen delignification is to reduce Kappa by 50-60 %. For this purpose high alkali concentration and drastic conditions are needed and then there a danger of high carbohydrate degradation. In order to have better selectivity and efficiency a 2-stage delignification without interstage washing is proposed. A chelating agent can added between the stages.

Rejects:

The cooking to low Kappa number with good control of cooking and high chip quality cause very low reject-%. The knot content would be about 1 % and the shives content about the same. Total amount of rejects would 5000 Adt/a, which is a considerable reduction compared to the present one. For the paper machine must be found a new raw material.

Investment:

	MUSD
Equipment	
- deknotting	1.2
- screens	1.2

- oxygen delignification	8.2
- oxygen plant	1.3
- white liquor oxidation	0.5
- automation	0.7
- electrification	0.5
Total	13.6
Erection (local)	0.8
Civil works (local)	xx
circa	15.0

Wash water consumption:

- wash water 5 m3/BDt

Power consumption:

- no estimate, because a lot of present machinery is taken out and fewer new but higher consuming ones installed

Chemical consumption:

- oxygen 23 kg/ADt
- sodium hydroxide 25 kg/ADt

Personnell:

- 1 operator/line + 2 field operators

E. Bleaching and bleach chemicals

The studies and the mill experiences with ECF- and TCF-pulps in the pulp bleaching are concentrated on hardwood and softwood paper grade pulps leaving the dissolving a little aside. Dissolving pulps using hardwood as raw material were studied by Sunds and later by VAI/Lenzing. The results show that it is possible to produce eucalypt dissolving pulp using OZP-sequence (SIXTA et al. 1994).
The Baikalsk combine uses softwood, pine and larch, and these have not yet been studied so well, that it would allow the mill go directly to TCF-bleaching
It is proposed that in the 1st stage is produced ECF-pulp.

If the proposed changes prior to the bleaching are carried out and the entering Kappa is 5-6 and the carry-over 10 kg COD/ADt, there will be prerequisites for low chemical consumption thus leading to low AOX.

Enzymes:

It is further possible to reduce chlorine consumption by using enzymes. The mills treating the pulps with enzymes prior to the bleaching have recorded a reduction of 20-30 % in the chlorine consumption thereby reducing the AOX by 15-25 %. With dissolving pulps the reduction is probably much smaller, because those xylanase-based enzymes effect on the xylan which is already reduced in the prehydrolysis.
The use of enzymes is very easy. It can be added into the HC-tower (also with chelate). The enzymes normally demand low pH and low temperature, 50-60 C. This low temperature and pH suits well with ozone stage in the future. Enzyme producers are developing enzymes which tolerate higher pH and temperatures. Because of the low pH the lining of HC-tower must be checked.
This is an alternative, if the AOX reduction is not satisfactory or the ClO2-production is not sufficient.

1st stage ECF

The final delignification is proposed to be made using the sequence D-EOP. The peroxide addition in the extraction improves the extraction of lignin from the pulp thereby allowing to lower the active chlorine consumption in the D-stage.

The final bleaching or brightening can be made using existing sequence thus saving some investment or D1-P-H
The new cooking and oxygen delignification will produce pulp with very stable Kappa and viscosity. By optimising the conditions in the oxygen treatment the viscosity of the pulp could be controlled so that there is little or no need for hypochlorite. Also peroxide can be used for viscosity control.

Changes

- If the proposed changes are in the bleaching plant, there will be the problem with the HC-tower consistency. The pulp must be diluted down to 3 % for outpumping and the stage D demands medium consistency.

A solution for that could be:
- new towers, 2 lines, expensive

- the existing towers will be changed to have conical/ball bottoms, may be difficult
- a filter is added. Some of the existing filters is used as thickener

This tower-filter-system can be used later for acidification/chelation of the pulp needed in the protection of the peroxide and/or ozone stages. At the same time this filter can be used as so called open washer for the reduction of carry-over.
- for new D-stage is needed a MC-pump, chemical mixer and up-flow tower. If the existing titanium C-tower or some other titanium tower can be reconstructed by adding a conical bottom and a scraper the investment would be a little cheaper
- the existing extraction stage is is reconstructed with a pressurized pretube which makes the use of oxygen and peroxide viable. A new MC-pump and a chemical mixer is needed
- possibly an existing stage could be changed to use peroxide instead of chlorine dioxide and hypochlorite.

<u>Investments/2 lines</u>

	MUSD
- equipment	
-- changing of HC-tower/filter	0.5
-- MC-pump and ClO2-mixer	0.35
-- D-tower and filter, 2,3 MUSD/line	4.65 *)
-- EOP-pretube	4.6

Total	10.10
- erection (local)	0.4
- civil works	0.5
Bleaching changes	11.00
	====

*) if the existing tower and filter can be reconstructed, the sum is considerably lower.

<u>Chemical consumptions</u>

- active chlorine in D

Total Kappa = 5-6 + 0.278 x 10 kg COD/ADt (Simons, 1992)
= 8

Chlorine multiple	0.15	
Active Cl2, 0,15 x 8	1.2	%
"	12	kg act Cl2/ADt

- active chlorine D1

Estimate	0.6	%
Active Cl2	6	kg act.Cl2/ADt

- total active chlorine	18	kg/ADt
- total ClO2	6.9	kg/ADt

- EOP(estimates)

-- sodium hydroxide	8	kg/ADt
-- oxygen	4	kg/ADt
-- peroxide	5	kg/ADt

Hypo (H):

- hypochlorite (viscose pulp)	10	kg act. Cl2/ADt
- sodium hydroxide	2	kg/ADt

Peroxide (P):

- peroxide	18	kg/ADt
- sodium hydroxide	4	kg/ADt
- chelating agent	2	kg/ADt

Sulphuric acid and SO2:

- total H2SO4	2	kg/ADt
- Acidification	9	kg/ADt

Effluents

- AOX

AOX = 0.026 (D) + 0.006 (D1) (Simons 1992)

= 0.026 x 12 + 0.006 x 6

= 0.348
=====

AOX = 0.024 (D) (Lindström,Norden, 1990)

= 0.288
=====

The latter equation finds the effect of D1 + D2 negligible. It is also 15 % lower than the value given by the Simons equation. The reason for that is maybe the alkaline hydrolysis which happens when the alkaline and acidic effluents are combined.

The effect of hypochlorite on the total chlorine sum is 0.5 x consumption in kg act. Cl2 so 0,5 x 10 = 5, but the factor for the AOX-calculation is not given in those studies. An estimate is 0.08, which gives an AOX of 0.4 kg/t. That doubles the AOX , but probably the hypo need will be less than 10 kg and thus AOX lower.

- BOD5

BOD5 = 0.4 (Kappa + 0.278 x carry-over) (Simons, 1992)

= 3.2 kg O2/ADt
===========

- Flow

- acidic effluent	11.5	m3/ADt
- alkaline effluent	11.5	m3/ADt
- total	23.0	m3/ADt
- open washer *)	7.0	m3/ADt
	30	m3/ADt

*) if the solution for HC-tower unloading is a filter and there is a need for metal-removing and/or carry-over reduction

- COD

– an estimate 22-23 kg O2/ADt (Sjödin. Norden, 1994)

<u>2nd stage</u>

The final target of this stage is TCF-bleaching. As mentioned earlier there are studies on TCF softwood dissolving pulps. VAI/Lenzing (Sixta et al) has found out that it is possible to produce eucalypt dissolving pulp using OAZP-sequence. TCF hardwood dissolving meets all quality requirements, which are necessary for the production of high quality rayon staple and rayon filament.
Probably it is suitable also for softwood added by final brightening done with P-stage/stages.
The ozone has an advantage. It can be used to adjust the viscosity provided that Kappa number and viscosity of the oxygen prebleached pulp are within certain limits, so there is no need for hypochlorite.

The estimated bleaching sequence for pulps would be: A(Q)-Z-EOP-P-P

Chemical consumptions (rough estimates):

- ozone	5	kg/ADt
- sodium hydroxide	25	kg/ADt
- peroxide	40	kg/ADt
- oxygen	5	kg/ADt
- sulphuric acid	15	kg/ADt
- chelating agent	3	kg/ADt

BOD5 and COD:

- BOD5 and COD will be about same as in the 1st stage

Effluent volume:

- depending on the closure of the bleaching plant the effluent volume will be from 0 to 15 m3/ADt. The total closure would be very interesting, but with specially dissolving pulp the metal balance and resin balance can be a serious hinder to carry it out.
The effluent is very acidic and demands a neutralization before leading into the alkaline circulation, which changes the solubility of many metals. The most TCF mills lead the water to the effluent treatment. There are three other possibilities to treat this water:
-- evaporation: condensate is reused as process water and concentrate is connected with the black liquor and damaging materials are separated from the green and white liquor
-- this low COD-water is used in the smelt dissolving or causticisation. Again the damaging material is separated from green and white liquor
-- water is treated with lime mud and pH is controlled and it is used in the process

All the alternatives lead to the same conclusion, the green and white liquor must be well clarified or better filtered.

Power and heat consumptions:

- no estimates

Personnel:

- when the reconstruction in the bleaching and bleach chemical plant are finished, the future need will be 26 persons, This means a reduction of about 90 persons.

<u>Bleaching chemicals</u>

ClO2-production:

An estimate for the future chlorine dioxide consumption is about 18 kg act.Cl2/ADt or 7 kg ClO2/ADt. The production of two dioxide plants is 4500 kg ClO2/d. Total demand is 600 Adt/d x 7 kg/ADt = 4200 kg/d, so the present capacity is enough. The design capacity of one plant is 2500 kg/d total being 5000 kg/d, so there is some reserve too.

Peroxide:

Total peroxide consumption is about 25 kg/ADt so the capacity of plant is 15 t/d. It was told that this project is already going on. It is local supply and there is no need estimate the investment.

F. Drying machines

The condition of the present machinery seems to be good, but the problem is the capacity lower than the design value. If all the cylinders are working and the informed dryness values are 42-45 % after the press part, the need to evaporate is 7 kg/m2h with 325 ADt/d production. This is significantly lower than normally used design value > 10 kg/m2h. There is something wrong in the dryer part, perhaps condensate filled cylinders etc.
Besides repairing the dryer parts there could some adding in the water removal in the wire part and in the press part (upper felts in the presses). It is very difficult to give an estimate for the reconstruction, but just to give on questimate of 2-3 MUSD.

Recommendation:

A drying machine specialist from Sunds(Rauma-Repola) is called to check the details and to give an estimate of what should be done

G. Paper machine

There will be only 5000 t/a rejects from the pulp mill. In order to utilize the capacity of 100-110 t/d, which the dryer part should dry, it needed 30 000 t/a some other raw material. Because the pulp mill produces bleached paper grade pulp, it is a natural thought that this pulp could be one part of raw material.
It is proposed that the product will be white top liner. The top layer is made of pulp and the bottom layer is made of rejects and purchased waste paper (OCC etc) from the area and Irkutsk, which is big enough to produce sufficiently waste paper.

White top liner:

- top layer	50-60 g/m2
- bottom layer	70-145 g/m2
	125-200 g/m2

Raw material:

- top layer	10 000 t/a	=	31 t/d
- bottom layer			
-- rejects	5 000 t/a	=	15 t/d
-- waste paper	21 000 t/a	=	61 t/d (10 % rejects)
	36 000 t/a	=	107 t/d
- resin			
- alum			

Investment:

	MUSD
- Equipment	
-- simple system for recycled paper	
-- additional headbox	
-- upper felts for presses or presses	
-- calander	
-- pocket ventilation	
-- water flotation	
	5 - 7
	=====

H. Causticisation and lime kilns

The proposed changes and improvements (chapter II/I) in the causticisation and lime kilns would cost as follows:

Investment:

	MUSD
- Equipment:	
-- white liquor filter	1.3
-- lime mud filters, 2 pcs	2.0
-- lime mud dryers, 2 pcs	2.6
-- electric precipitators, 2 pcs	2.0

Recommendation:

Installing a new white liquor filter and new lime mud filters should be thought.

IV. RESULTS

A. Investments

The proposed investments are summed in the following

Item:	Equipment MUSD	Erection Civil works MUSD(local)
- woodhandling	22	3.5
- cooking	44	7.0
- washing,screening and oxygen delign.	14	2.5
- 1st bleaching	11	1.7
- 2nd bleaching	15	2.3
- drying	3	0.5
- paper machine	6	1.0
- causticisation and lime kilns	3.3	0.5
	118.3	19.0

The estimate for the equipment is based on prices in Finland now.
Erection and civil works are thought to be made using local labour.
The mill people gave a price for one building-m3 = 50 000 SUR. It sounds very low, but it is used in the calculations.
The majority of the equipment is from the western suppliers, but the investment will be reduced, if for example digesters, tanks and existing titanium tower modifications are made locally (Petrozavodsk in Karelia).

B. Operation costs

Wood:

As it can be seen in the ANNEX 5 the fiber losses in the present process are very high specially in the bleaching, 15 % for the viscose and paper pulp. The training, good maintenance with the filter wires and a system to collect all the spills back into system would help to reduce extra fiber losses.

Proposed losses in the viscose and paper pulp production 1st stage, %:

- bleached pulp screening	0.5
- bleaching	5
- oxygen delignification	2.5
- brown stock screening and deknotting	2.5

The cooking yield differs: for viscose pulp 33 % and paper pulp 40 % , this means wood consumptions 5.7 and 4.7 solid m3/ADt respectively. So the lower cooking yields are compensated by lower bleaching losses and better economy in screening.

Chemicals (compared to the present situation):

- salt cake make-up	- 25	kg/ADt
- bleaching		
– ClO2	+ 0.5	kg/ADt
– oxygen	+ 27	kg/ADt
– sodium hydroxide	- 30	kg/ADt
– peroxide	+ 23	kg/ADt

Power and heat (compared to the present situation):

- cooking: power	- 50	kWh/ADt
heat	- 6	GJ/ADt

For the washing-oxygen delignification, bleaching and oxygen plant there is no estimation for power and heat. For the woodhandling there is a saving of 40 kWh/ADt, but heat consumption is about the same.

C.Personnel

The present production personnel figure , 3074 persons, is very high. The Finnish pulp mill Kaskinen produces 400 000 ADt/a bleached pulp with one line employing only 300 persons. Rauma pulp mill, 500 000 AD/a, will give jobs to 250 persons. In the future, when the salaries will go high, this high number of employees will be reduced significantly.

The mill is divided in many independent departments each of them having operators and own maintenance and what is surprising , are the numerous levels of group leaders, technicians and chiefs. In the discussions they know their own area very well, but perhaps the totality is not very clear and important.

Some proposals:

- the bosses are trained to take responsibility over the bigger areas. One boss in shift is enough for each fiber line (cooking-drying, causticisation and lime kilns included), one for recovery boilers and evaporation etc. This demands that there are good ways of communication (telephone, peepers, radios etc.).
- the maintenance is more centralised and somebody puts the works in priority order and divides the workers into different jobs. The total quantity is so reduced.
- the operators for new departments should be chosen carefully and be well trained. Perhaps younger people, which are willing to learn and they dont have the old way of thinking.

With the new investments carried-out the number of people in those new areas will be reduced.

An estimate for new departments:

	Present			New			Differ.
	Superv.	Oper.	Maint.	Superv.	Oper.	Maint	
Wood yard + room	22	225	64	7	120	15	169
Cooking-oxyg.delign.	10	81	38	5	24	5	95
Freed							264

The changes in the bleaching area come later, the reconstruction is made stages, but the target perhaps could be:

Bleaching and chemicals	10	69	40	-	16	10	93*

*) new chemical plants like peroxide,oxygen and later ozone should be controlled by the operators included in the new concept.

The role of maintenance is difficult to estimate. In order to reach low numbers the training must be good and the availability of spare parts is very important.

The estimate for the reduction from the reconstructed departments is now 350 persons.

D. Effluents

There will be significant reductions in the effluent quantities from the reconstructed areas. The dry bebarking, the cold blow, the closed screening and the simplified bleaching will help to carry this out.

Effluent volumes: (pulp lines, visc+paper pulp)	Present m3/ADt	New m3/ADt
Woodhandling	18	1.3
Cooking	8	0.1
Washing,screening oxygen del.	70	-
Bleaching, 1 stage	110	30
Others	64	64
Total from pulp production	270	95
Total	400	225

This new figure is based on the fact that there are no changes in other non-pulp production departments. With the reduced energy consumption the cooling water demand will be lower thus the new figure could be 150 m3/ADt.

Some of figures are very rough estimates, but at least it is clear that the loading to the effluent treatment plant is reduced. That gives a possibility to reduce chemical consumptions in the treatment and to use the existing plant more effectively

JOB DESCRIPTION **ANNEX 1**

SI/RUS/94/801/11-52

Post title:	consultant in pulp paper manufacturing and new cleaner technologies in pulp and paper bleaching	
Duration:	1st mission:	2,.3 w/m (split mission as follows: 1.8 field, 0.5 homebased)
Duty station:	1st mission	Baikalsk Russia home based

Duties: The consultant will in close co-operation with the mill management, other national and international consultants, govemement agencies, institutions be expected to:1st mission:

a. assess and review the current processes/methods and available equipment for: wood preparation, pulping, washing screeneng, bleaching, chemical recovery of black liquor, hypochlorite and chlorine dioxide production plants, power/steam production, units freshwater treatment facilities and papermaking unit:

b. identify opprtunities for introduction of new cleaner technologies in the areas mentioned in item a.

c. evaluate the technical viability, investment and operational costs of the actual proposal of the mill for modification of the pulp production lines including its compatibility with other production areas as for example: chemical recovery, power/steam production, fresh water treatment, hypochlorite and chlorine dioxide plants, treatment of effluents and air emissions

d. study the technical viability, investment and operational costs of other possible altemative(s) for conversion/reprofiling the mill using as much as possible the existing equipment and identify equipment locally manufactured

e. evaluate the personnel requirements at managerial and operational levels for the altemative(s) for modification of the pulp mill including identification of training requirements for the mill personnel

f. prepare a draft report on the study of altemative for modifying/reprofiling the mill including the recommendations prepared by the consultants 11-53 (consultant on waste water treatment- 1st mission report) and 11-53 (consultant on mechanical processing of wood- 1st mission report); this report should be sent to the consultants 11-51 (consultant on environmental sciences), 11-53 (consultant on waste water treatment system), 11-54 (consultant on social sciences)), and 11-56 (consultant on cost/financial and market analysis) for comments and evaluation of the impact of the modification being recommended in their area of expertise;

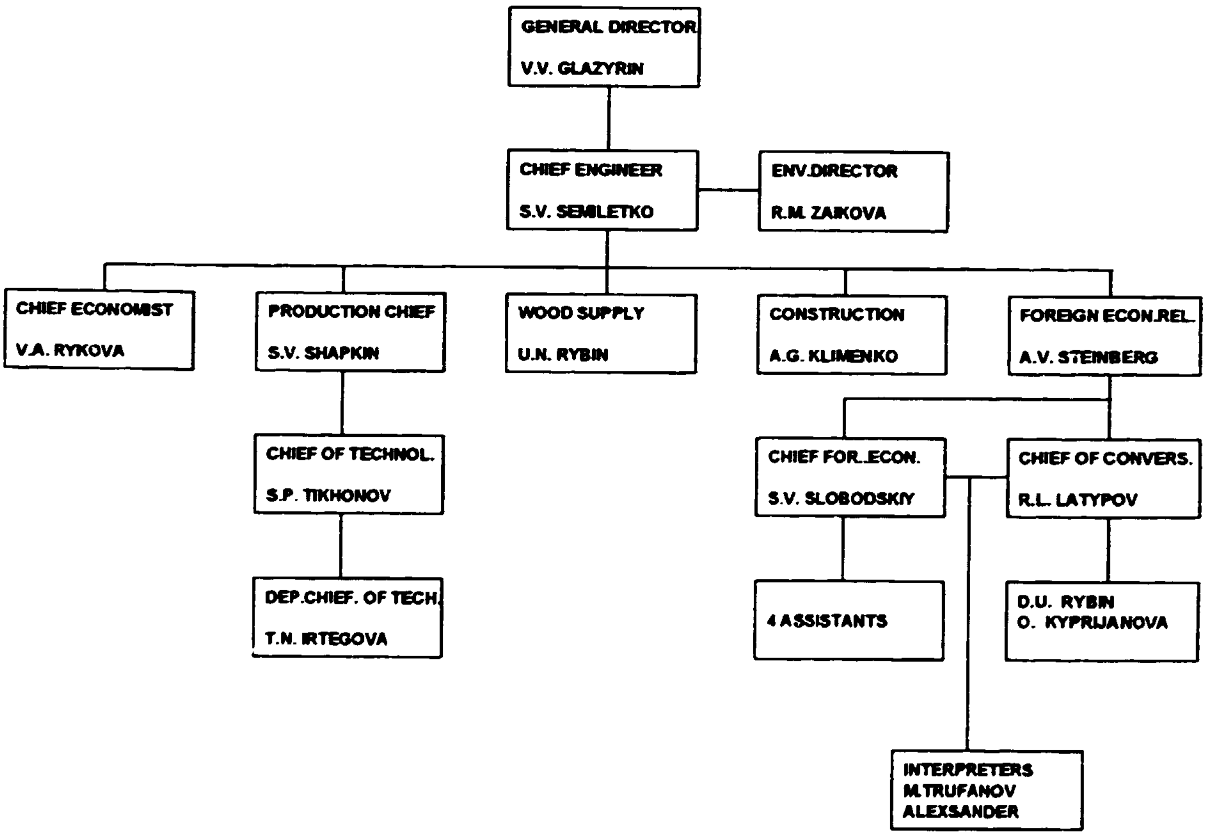
g. prepare a consolidated draft report after receiving the comments and evaluation from the consultants 11-51, 11-53, 11-54 and 11-56 to be discussed in the meeting in Vienna during the 2nd meeting

SENIOR COUNTERPART STAFF

ANNEX 2

Glazyrin, Valeri Vasiljevich, general director
Semiletko, Sergei Vasiljevich, chief engineer
Rybin, Juri Nikolajevich, deputy manager for timber supply
Shapkin, Sergei Vladimirovich, production chief
Steinberg, Anatoli Vladimirovich, vice president, foreign economical relations
Klimenko, Anatoli Grigorjevich, deputy of director, construction

BAIKALSK PULP AND PAPER MILL
ORGANISATION



ANNEX 3

LIST OF PEOPLE MET

Baikalsk pulp and paper mill:

Glazyrin, Valeri Vasiljevich, general director
Semiletko, Sergei Vasiljevich, chief engineer
Rybin, Juri Nikolajevich, deputy manager for timber supply
Shapkin, Sergei Vladimirovich, production chief
Steinberg, Anatoli Vladimirovich, vice president, foreign economical relations
Tikhonov, Gennadi Petrovich, chief technologist
Irtegova, Tamara Nikolajevna, deputy of chief technologist
Zaikova, Raisa Matvejevna, deputy of chief engineer in environmenta' protection
Latipov, Rem Lutfurahmanovich, chief of conversion division
Slobodskij, Sergei Jurevich, depart. chief of foreign economical connections
Pantuhin, Vladimir Ivanovich, chief of bleaching department
Porotov, Boris Kirillovich, chief of drying department
Trufanov, Mikhail, interpreter

Institute of ecological toxicology:

Beim, Albert Maksimovich, Dr. director
Beim, Andrei Albertovich, specialist and interpreter

TECHNICAL DESCRIPTION OF THE MILL

ANNEX 4

A. Woodhandling

Woodyard

The woodyard has 6 traversing bridge cranes, installed 1964, to unload logs from rail cars. The logs are delivered in log bundles of 15 m3. The woodlength is from 3-6 m. The storage area under the bridge crane is 16x300 m2. There is place for 30 000 m3 wood. The bundles are normally loaded directly to three infeed decks.

The wood is received as a mix of 25 % of pine and 75 % of larch. Sometimes there are some logs of birch and aspen.

Debarking

The debarking has three infeed decks. Each line has two wet debarking drums of 3.85 x 20.4 m with a capacity of 80 m3sob/h each. The drums are the originals being installed in 1964. After two drums there is a common chipper and screen. The oversize chips are fed back to chippers and fines goes to the bark.

From the screens the chips are transported with two belt conveyors to 6 chip silos of 600 m3 each. From the silos there are two belt conveyors to the digesters.

Sawmill chips are delivered by railcars and unloaded with two traversing unloaders two chip pile with a size of 10,000 m2. At the present the sawmill chips are 10-12 % of the wood consumption. From the chip pile the chips are discharged with a front loader to a discharging screw, conveyed by a belt conveyor to chip screen and on one of the two conveyors to digesters.

Bark is transported to two bark presses and then to the bark pile.

B. Fibre line

Digesters

There are two lines of digesters with 12 digesters of 140 m3 in each line. The digesters are installed in 1964.

The digesters are made of carbon steel and clad with AISI-steel with max. operating pressure of 12 bar.

The design (max. daily) capacity of the line 1 is:

- 350 ADt/d SW viscose pulp
- 330 ADt/d SW cord pulp
- 450 ADt/d SW kraft pulp

The design (max. daily) capacity of the line 2 is:

- 350 ADt/d SW viscose pulp
- 450 ADt/d SW kraft pulp

There is a blow tank of 450 m3 for prehydrolycis steam and a blow tank of 450 m3 for digester blow, two accumulators with blow heat recovery and terpentine recovery.

Gas from accumulators is treated in a washing tower.

The present process control complicates grade changes and controlled cooking conditions.

Washing

There are two lines. Each line has three two stage pressure washers 3.5x6 m each. The max. capacity is 370 ADt/d for each line.

The weak liquor from washing goes through three fibre filters.

Poor washing result.

Brown Stock Screening

In brown stock screening there are in each line two knot screens, primary and secondary screens and zero fibre separation washers. The vacuum filter is 3.x6 m. For knots and rejects there is a reject refiner and from refiner rejects go to paper machine.

There are two storage tanks 250 m3 each and storage tower of 1000 m3.

Old type of screens.

Bleach Plant

The design (max. daily) capacity of the line 1 is:

- 350 ADt/d SW viscose pulp
- 330 ADt/d SW cord pulp
- 450 ADt/d SW kraft pulp

The line has the following sequences:

C/D-E-Ecold-D-D-SO2

The size of drop leg filters is 3.5x5 m.

There are a storage tank of 270 m3 and a storage tower of 1000 m3 after the bleaching.

The design (max. daily) capacity of the line 2 is:

- 350 ADt/d SW viscose pulp
- 450 ADt/d SW kraft pulp

The line has the following sequences:

C/D-E-H-D-H-D-SO2

The size of drop leg?????? filters is 3.5x5 m.

There are a storage tank of 270 m3 and a storage tower of 1000 m3 after the bleaching.

High bleach and fiber losses.

Bleach Chemical Preparation

The chlorine dioxide plant is of Mathieson type and has a capacity of 2.5 tClO2/d each of the two lines.

The capacity is 20 m3/h ClO2 water each of two lines and at a concentration of 12-16 g act Cl2/l.

Drying Machines

Each of two line of bleached stock cleaning includes pressure screen and centricleaners. Visc washed with demineralized water. The demi plant has a capacity of 15 m3/h. For cord there a deflaker.

The two drying machines include:

max. capacity, cord	ADt/d	240
max. capacity, viscose	ADt/d	260
max. capacity, kraft	ADt/d	280
wire width mm		5,200
trim width at reel	mm	4,800
average speed	m/min	50
max. speedm/min	100	
presses	nips	3
predryers	number	5
dryer diam.	mm	1,500
dryers	pieces	88
hood and heat recovery		
air removal presses		2
pope reeler		
intermediate reel storage for 120 reels		
cutter and layboy		
wrapping and baling		

For wrapping is used:

- kraftliner of 200 g/m2 for exported cord and viscose
- own wrapping paper of 130 g/m2 for domestic cord and viscose
- bleached liner of 160 g/m2 for kraft pulp

Paper Machine

The stock preparation includes:

- 2 thickeners
- 4 refiners 125 kW each
- 1 stage centricleaner
- mixing tank
- short ciculation with two pressure screen

The paper machine includes:

paper grade	wrapping paper	
basis wegth range	g/m2	70-130
basis weigth	g/m2	90
wire width	mm	2,850
trim width at reel	mm	2,520
average speed	m/min	200
max. drive speed	m/min	300
press	nibs	2
dryiness after presses	%	38
dryers	number	40
dryerdiam.	mm	1,500
max capacity	t/d	100
hood and heat recovery		
pope reeler		
winder		
reel wrapping		

C. Recovery area

Evaporation

The evaporation has four lines with 6 stages and an evaporation capacity of 115 t H2O/h each bringing the concentration to 53-55 %. There are four concentrators with a total capacity of 40 tH2O/h bringing the black liquor concentration to 67-68 %. So the total evaporation capacity is 500 t H2O/h.

For the cord cold extraction liquor there are two lines of three stage evaporators with a total capacity of 60 tH2O/h and a six stage evaporation with a capacity of 150 tH2O/h. The extraction liquor goes back to digesters white liquor tank.

The contaminated condensate is oxidized with air in two catalytic towers and in a separator.

Soap is collected and converted to tall oil in a tall oil plant with a capacity of 30-35 t/d.

Recovery boilers

There are four recovery boilers with a capacity of 415-420 tds/d each. The pressure is 40 bar and 420 C. Each boiler is equipped with an electric precipitator with 3 chambers.

Causticizing and Lime Kilns

The causticizing has two lines with a capacity of 71 m3 white liqour/h each total being 3400 m3 /d.

White liquor composition:

- total titratable alkali	119 g Na2O/l
- active alkali	100 "
- effective alkali	88 "
- sulphidity	25 %

There are two lime kilns with a capacity of 160 t CaO/d and 136 t CaO/d (CaO 80 %). Each kiln has scrubber.

D. Power boilers and turbogenerators

There are five coal fired boilers with capacity of 160 t steam/h each at 100 bar and 520 C. Each boiler is equipped with an electric precipitator with 3 chambers.

There are a fluidized bed bark fired boiler with a capacity of 75 t steam/h 40 bar and 420 C . The boiler was installed 1990. An old bark boiler can be used as reserve oil fired boiler with a capacity of 40 t steam/h.

The pressure levels are 100 bar, 40 bar, the medium pressure 13 bar (in reality 10 bar and 210-230 C), the low process pressure 6 bar (in reality 4-4.5 bar and 180 C) and the steam for municipal heating is 1.2 bar. For the municipal heating there 4 heat exchangers.

There are two back pressure turbines of 12 MW each from 40 bar to 6 bar and 1.2 bar.

For 100 bar there are two condensing turbines of 50 MW and 25 MW with extractions at 13 bar and 1.2 bar.

E. Effluent treatment

The effluent treatment has two activated sludge treatment lines. The line for "black" effluent with a capacity of 60,000 m3/d treats effluent from woodroom, cooking, washing and causticizing. After the mixing tank there are preaeration for malodous gases and aeration with total retention time of 20 h. It has two secondary clarifiers, each 24 m diameter.

The line for "white" effluent with a capacity of 200,000 m3/d treats effluent from bleach plant, drying machine, paper machine, cooling waters, roof drains, surface water runoff and the town sanitary sewage. pH is controlled by using caustic. After the mixing tank there are preaeration for malodous gases and aeration with total retention time of 3 h. It has 5 secondary clarifiers, each 40 m diameter.

The combined effluent from to lines is further processed by precipitation assisted by alum and polyacrylic polymer. pH is controlled by sulphuric acid before clarified in 6 flocculating clafiers, each 54 m diameter.

Sand filters were installed by the time of mill construction, but they are not currently used.

For spills there is a emergency pond of 200 000 m3.

Before discharge there are 3 polishing basins 200 000 m3 each to allow any residual settleable solids to precipitate.

The discharge pipe goes 150 m offshore and 40 m deep.

All sludge from the biological and physical treatment are thickened by flotation, 4 centrifuges, in 2 hot gas rotating dryers and incinerated by 2 fluidized bed incinerators.

The system has been designed for capacity of 120 t /d sludge, but there are only approximately 40 t/d sludge to process.

FIBER BALANCE **ANNEX 5**

		VISCOSE	CORD	BSKP
DRYER PRODUCTION	T AD(88%)/D	240	240	240
LOSS IN POSTSCREENING	%	1,5	1,5	1,5
PROD. AFTER BLEACHING	T AD(88%)/D	244	244	244
LOSS IN BLEACHING	%	15	20	15
PROD.AFTER SCREENING	T ad(88%)/D	287	305	287
LOSS IN SCREENING	%	4,5	4,5	4,5
PROD.AFTER COOKING	T AD(88%)/D	300	319	300
COOKING YIELD	%	36	34	46
COOKING LOSS	%	64	66	54
WOOD TO DIGESTERS	T AD(88%)/D	834	938	653
WOOD TO DIGESTERS	T BD(100%)/D	734	825	574
WOOD MIXTURE DENSITY	KG BD/SM3	566	566	566
WOOD TO DIGESTERS	SM3/D	1 296	1 458	1 015
WOOD CONSUMPTION	SM3/T AD	5,40	6,08	4,23
WOOD LOSSES IN DEBARKING	%	8,026	8,026	8,026
WOOD CONSUMPTION	SM3 SUB/T AD	5,87	6,61	4,60

HEAT BALANCE

ANNEX 6

HEAT CONSUMPTION 1994 prod. 120 400 ADt	GJ	GJ/ADt	COND.RET. %
Woodhandling	45 960	0,38	
Cooking+washing+screen	1 079 930	8,97	0
Bleaching+bleach chemicals	456 626	3,79	
Drying	772 011	6,41	80
Evaporation	2 320 196	19,27	80
Causticisation+lime kilns	20 057	1.70	
TOTAL, process	4 694 780	40.52	
Effluent treatment+sludge	105 249	0,87	
Paper machine 2 t/t paper	41 141	0,34	
Town	1 267 202	10,52	
Heating +ventilation+hot water	891 904	7,41	
Other departments	42 156	0,35	
Losses	88 262	0,73	
TOTAL	7 130 694	60.74	

POWER BALANCE **ANNEX 7**

POWER BALANCE	kWh/ADt
1994, production 120400 ADt	
Woodhandling	84
Cooking	98
Washing+screening	100
Bleaching+bleach chem.prep.	123
Drying	237
Evaporation	71
Causticisation+lime kilns	70
Total pulp process	783
Water supply	102
Effluent treatment+sludge	490
Compressed air station	164
Paper machine 630 kWh/t paper	46
Lighting+ventilation+maintenance	172
Other departments	64
Losses	18
TOTAL	1839

PERSONNEL AT THE PRESENT TIME **ANNEX 8**

LOCATION	SUPERVISORS	OPERATORS	MAINTENANCE	
WOOD YARD	11	120	29	
WOOD ROOM	11	105	35	
DIGESTERS	10	50	38	
WASHING AND SCREENING		31		
BLEACH PLANT AND	10	42	40	
BLEACH CHEMICALS		27		
DRYING AND BALING	12	96	36	
PAPER MACHINE		33	15	
EVAPORATION	4	46	28	
RECOVERY BOILERS	4	40	26	
POWER BOILERS+TURBIN.	2	29	8	
HEAT+POWER PLANT	47	207	153	
CAUSTICISATION+KILNS	8	36	25	
EFFLUENT TREATMENT	11	90	34	
WATER SUPPLY	4	28	47	
SLUDGE TREATMENT	9	43	24	
	143	1023	538	1704
MECH+ELECTR.MAINTE.	47	156	240	
ADMINISTRATION	130	12		
RAILWAY SERVICE	17	159		
AUTOTRANSPORT SERV.	12	176		
FURNITURE MANUFACT.	4	9	6	
TEL.+DSC	19	32	23	
GAS RESCUE,ELECTR.DRI.	2	9	6	
DESIGN OFFICE	11	2		
STORE ROOM	1	4		
STORE OF IMPORT EQUIP.	2	45		
FLEET		12		
TERRITORY CLEAN.SERV.	1	5		
CONSTRUCT.MAINTEN.	4	64		
GUARDS	8	54		

PROD.MAN.MAINTENAN	31	67		
	432	1829	813	3074
(Continued)				
NON-INDUSTR.GROUP:				
NEWSPAPER	4			
MEDICAL SERVICE	13	4		
AFTER-WORK SANATOR.	1	12		
CHILDRENS CAMP	2	4		
CONSTRUCT.MAINTENA N.	16	135		
SPORT COMPLEX	24	30		
COMMERCIAL COMPANY	27	119		
HOSTELS	6	32		
HOTEL	6	10		
AIRTRANS AGENCY	2			
	533	2175	813	3521

ANNEX 9

FRFSH WATER CONSUMPTION

	m3/d
Wood handling	600
Cooking and washing	26 000
Bleaching and bleach.chem	35 000
Drying and baling	7 000
Evaporation	50 000
Recovery boilers	20 000
Boilers and turbines	40 000
Causticisation and lime kilns	1 300
Effluent treatment + sludgeh.	700
Town	2 400
Paper machine	800
Total	183 800

ANNEX 10

WOOD WAGONS AND DELIVERIES

WAGON TYPES USED

	Length m	Load m3
- open wagon	12	5.5
- pulpwood wagon	18	65
- full length wagon	27	70
- chips wagon	18	35

DELIVERED LOGS

	Minimum	Average	Maximum
Length	1.2 m	3.5 m	6.5 m
Diameter	60 mm	220 mm	400 mm

WOOD DELIVERED TO THE MILL IN 1994

Sort	Total sm3	Pine sm3	Larch sm3	Birch sm3
1	200 000	154 000	46 000	-
2	482 000	337 000	145 000	-
3	112 000	80 000	32 000	
4	6 800	4 800	2 000	-
Total	802 800	575 800	225 000	

Chips 48 000 m3.

WOOD TO BE DELIVERED IN 1995

- short pulpwood (1.2-3 m)	150 000 sm3
- pulpwood(3.5-6.5)	1 000 000 sm3
- full length wood (24 m)	50 000 sm3
- chips	100 000 m3

WOOD TO BE DELIVERED IN 1995 BY SORT

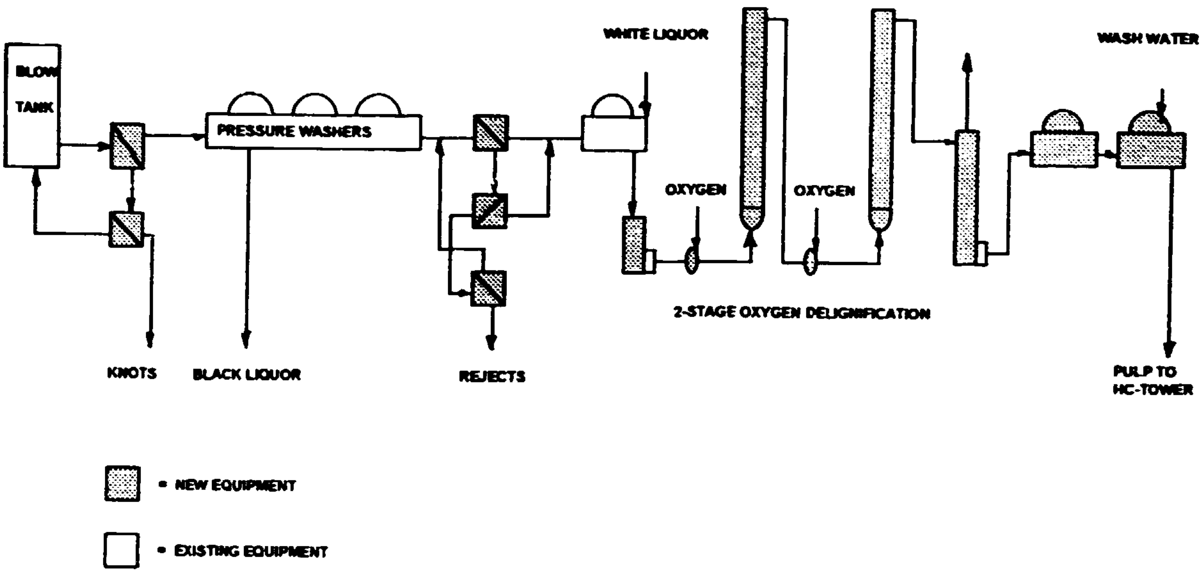
Sort	Total sm3	Pine sm3	Larch sm3	Birch sm3
1	265 000	195 000	55 000	-
2	600 000	450 000	150 000	-
3	140 000	115 000	25 000	-
4	10 000	10 000	- -	
Total	1000000	770 000	230 000	-

ANNEX 11

BAIKALSK PULP AND PAPER MILL

WASHING-SCREENING-O2-DELIGNIFICATION

ALTERNATIVE I



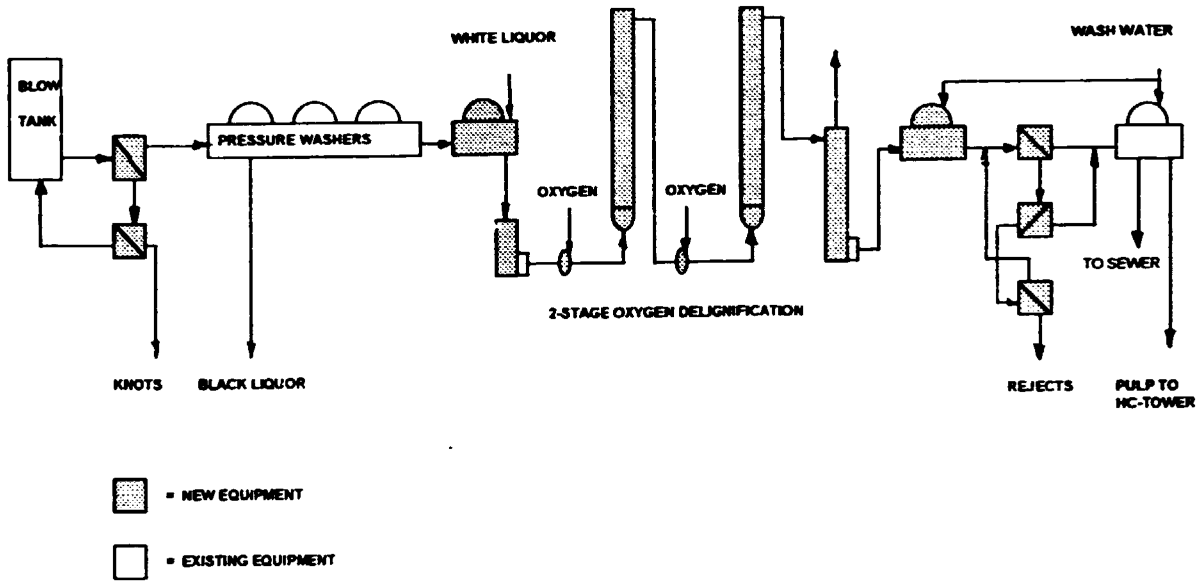
PI-CONSULTING LTD
20.04.1995 O.JALKANEN

ANNEX 12

BA!KALSK PULP AND PAPER MILL

WASHING-SCREENING-O2-DELIGNIFICATION

ALTERNATIVE II



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ABBREVIATIONS.

A	acidification in the bleaching
Adt/a	air dry metric tons pulp per annum
Adt/d	air dry metric tons pulp per day
AOX	adsorbable organic halogens
Bdt/d	bone dry metric tons per day
BOD5	biological oxygen demand in 5 days
BSKP	bleached softwood kraft pulp
C	chlorine stage in the bleaching
COD	chemical oxygen demand
D	chlorine dioxide stage in the bleaching
E	extraction stage in the bleaching
EOP	extraction stage with oxygen and peroxide
ECF	elemental chlorine free
H	hypochlorite stage in the bleaching
HC	high consistency
MC	medium consistency
M3 sub	solid cubic meter of wood under bark
MSUR	millions of rubels
MUSD	millions of US dollars
P	peroxide stage in the bleaching
Q	chelation in the bleaching
SUR	Russian rubel
TCF	total chlorine free
USO	US dollar

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