Gunns Limited
Bell Bay Pulp Mill Project
TASMANIA

In the matter of the Bell Bay Pulp Mill Project: A project of State Significance Resource Planning and Development Commission inquiry
Proponent: Gunns Limited

EXPERT WITNESS STATEMENT MR. KARI TUOMINEN
EXPERT OF GUNNS LIMITED

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1 NAME AND ADDRESS

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2 AREA OF EXPERTISE

I am an engineer with expertise in pulping process technology.

My academic qualifications and a detailed summary of my experience are set out in Appendix 1.

I have managed Pöyry’s involvement in the Bell Bay Pulp Mill project (‘the project”) since August 2005. Before assuming this role I was managing Pöyry’s pulping division in Helsinki and overseeing the provision of assistance to the project team.

I have extensive academic and practical experience in pulp mill technology.

I have a Master’s degree in Pulping Technology from the Helsinki University of Technology and have spent the last 15 years designing pulp mills and giving advice about a range of issues, including technological and environmental improvements in the pulp mill industry.

I am fluent in Finnish, Swedish, German and English and use these languages in my professional work, although my mother tongue is Finnish. In preparing this report I have been assisted by the legal advisers briefed by Gunns to ensure that this written report clearly and accurately expresses my opinions in English.

3 INTRODUCTION

Volumes 6 and 7 of the Draft Integrated Impact Statement ("Draft IIS") set out the conceptual design of Gunns’ proposed pulp mill. I adopt Volumes 6 and 7, which should be read in conjunction with this witness statement.

Although not personally responsible for all of the detail contained in those volumes, I adopt their content for the purposes of this witness statement and make the following general statements:

– Pöyry was commissioned in 2004 to undertake initial feasibility work;

– Based upon the initial feasibility work, Gunns commissioned Pöyry to undertake a pre-engineering study. The scope of that pre-engineering work was to design a cost-effective, state-of-the-art, single-line pulp mill based on available wood resources;
The purpose of the pre-engineering study was to develop the technical concept and to define the best available production and environmental technology of the mill to comply with:

- the *Development of new environmental emission limit guidelines for any new kraft pulp mill in Tasmania* Volumes 1 and 2 (the “Emission Limit Guidelines”) issued by the Tasmanian Resource Planning and Development Commission (RPDC); and
- the BAT level environmental guidelines stipulated in the EU and North America; and

The pre-engineering work was also used to provide a basis for initial impact modelling that was to be commissioned by GHD, the lead environmental consultants.

I was engaged in August 2005 to coordinate the work of the Pöyry expert team that provided the conceptual engineering for the pulp mill.

This team consisted of several experts in various fields working together in order to provide a complete technical concept for the Pulp Mill process including woodhandling, fibreline, drying plant, chemical recovery, non condensible gas (“NCG”) -handling, bleaching chemical preparation, water and effluent treatment, power and steam distribution and the lay-out of the mill.

Over 80 people have been involved in the project team. The following people have had the main role in the Pöyry team:

- **Mr. Kari Tuominen** – Millwide technical concept and the drying machine. Project manager since August 2005;
- **Mr. Esa Vakkilainen** – Evaporation, recovery boiler, power boiler, turbine, steam distribution, air emissions, NCG-handling;
- **Mr. Hannu Jäppinen** – Water treatment, effluent treatment, cooling towers, demineralised water, condensate treatment, emissions;
- **Mr. Tuomo Niemi** – Mill wide technical concept and project manager until July 2005;
- **Mr. Peter Ryder** – Fibreline, recausticizing/lime kiln, bleaching chemical preparation, NCG-handling

The process description and final technological concept contained in the Draft IIS is subject to detail design and final selection of main machinery suppliers. The purpose of the design concept was to provide a design basis to demonstrate that a pulp mill of the kind proposed can achieve the established environmental parameters.

Pöyry’s involvement was to provide the results of its work as a basis for other consultants to undertake their respective impact assessments and for GHD to write the Draft IIS. Pöyry was not responsible for the content of the Draft IIS.

Pöyry did not have responsibility for the design of the following infrastructure items:

- Water intake and water pipeline
- Effluent pipeline and the ocean outfall (diffuser)
- Landfill
- Wharf
TRANSPORTATION AND LOGISTICS OUTSIDE THE MILL SITE
- Power supply and connection to the national grid
- Gas supply

POyry was not commissioned to produce a document that specifically responded to the RPDC Scope Guidelines, although those Scope Guidelines were provided to POyry. In designing the pulp mill, POyry had regard to the Emission Guidelines.

As the project manager I have allocated tasks to the relevant experts in each field and co-ordinated the preparation of their expert reports.

I have discussed the inputs and results of the reports with the authors and I have reviewed their work.

4 SCOPE

In this witness statement I have been instructed to:
- Present an overview of the proposed pulp mill that addresses:
  - basic objectives and design parameters of the proposal; and
  - the wood handling, fibre line and drying stages of the pulp mill process; and
- Respond to issues raised in submissions made to the public exhibition of the Draft IIS that are within my area of expertise, in particular, to respond to the comments and criticisms raised by Beca AMEC in its report to the RPDC.

5 OVERVIEW OF PULP MILL OPERATIONS

I have prepared a power point presentation which will form the basis of my oral evidence. Attached at Appendix 2 is a complete set of the slides that comprise that presentation.

The presentation is divided into the following sections:

- Project Objectives and Main Design Criteria: the purpose of this part of the presentation is to summarise and explain the key design considerations influencing the concept that are contained in Volumes 6 and 7 of the Draft IIS;

- Presentation of Process Areas – Woodhandling, Fibreline and Drying: It is intended that POyry will provide an oral presentation of the process areas within the mill at the hearing. While I am familiar with the overall design concept and operation of the proposed pulp mill, I will concentrate my discussion upon the process of pulp production, leaving others in the team with more specialised knowledge to comment upon detailed aspects of the pulp mill such as the recovery plant (including evaporation plant, the recovery and power boilers, lime kiln, recausticizing plant, the malodorous gas destruction systems chemical plants) and the water and effluent treatment; and

- Chemical Plant: the design concept includes the possibility of an integrated chemical plant at the mill. My presentation includes the basic concept and options available for the inclusion of a chemical plant, but detailed evidence will be given by Erco about the technical aspects of the plant and its ability to achieve environmental guidelines.
6 RESPONSE TO SUBMISSIONS

I have reviewed the submissions made in this case that are related to my area of expertise and have identified those submissions that raise issues that require further substantive explanation or clarification beyond what is included in Volumes 6 and 7 of the Draft IIS. I deal with those matters in this section of my statement.

In addition, to submissions raising substantive matters, many submissions raising incidental issues or drafting queries were referred to me for comment, often arising from the text of Volumes 1 to 4 of the Draft IIS. I have considered these matters and provided my comments and understand that these matters will be dealt with by others.

6.1 Selection of Bleaching Process

A number of submissions have raised the question of whether it is appropriate for the proposed mill to be designed using Elemental Chlorine Free (“ECF”) technology as opposed to Totally Chlorine Free (“TCF”) technology.

In designing the pulp mill Pöyry considered both the ECF and TCF technology.

The main factors behind the selection of the bleaching process were described in Volume 7, Annex XV of the Draft IIS “Assessment and Selection of the Pulp Bleaching Process”.

I include in this statement some additional material that was not included in the Draft IIS to further support the recommendation made by Pöyry for selection of an ECF bleaching process.

6.1.1 Environmental Aspects

(a) Impacts upon aquatic environment

There are no significant differences between TCF bleaching and ECF bleaching with regard to the impact upon the aquatic environmental impact. This is supported by the detailed studies undertaken by the RPDC to evaluate Accepted Modern Technology.¹

Available studies investigating the acute and chronic toxic effects for aquatic ecosystems do not yield any indication of differences between the effects of effluent from ECF and TCF pulp production. Both production processes require a modern fibre line combined with biological purification of the effluent.

The biggest difference in environmental performance between the two processes is that the AOX in effluent in TCF mills (whether closed loop or not) is normally below 0.05 kg/ADt, where for ECF mills the range is between 0.10-0.20 kg/ADt after biological treatment in the effluent treatment plant.

The important issue is whether the levels of AOX produced by ECF mills are within acceptable environmental parameters. At the moment, there is no evidence available to indicate that reductions of effluent AOX from the average level of 0.5 kg/ADt would result in any demonstrable environmental benefit.
The AOX concentrations in the waters receiving effluent from TCF or ECF pulp mills in Scandinavia are of the same order of magnitude and comparable to the background levels of AOX in water bodies receiving no bleached pulp mill or other AOX-containing effluents.  

(b) **PCDD / PCDF concentrations**

The concentration of PCDD and PCDF generated from ECF mills are of the same order of magnitude as those generated from TCF mills, which are both well below the limits set by regulatory bodies and in this way are often referred to as “non-detectable” or very low.

The final effluent at mills employing AMT (Accepted Modern Technology) or BPEM (Best Practice Environmental Management) is non-toxic, regardless of whether ECF and TCF bleaching processes are used.

(c) **Chemical oxygen demand**

The chemical oxygen demand from effluent is slightly lower for ECF mills than for TCF mills.

(d) **Heat and power requirements**

The heat and power requirement of TCF pulp is higher than for ECF pulp.

(e) **Supporting Studies**

These conclusions have been reached based upon Pöyry’s industry experience and are supported by extensive and reliable studies and reviews that include:

- a comprehensive study on published data prepared by the Institute for Papermaking at Darmstadt Technical University, Germany, 2003, Comparison of the aquatic environmental impact resulting from the production of ECF and TCF sulphate pulp, Udo Hamm and Lothar Götschinger, Institut für Papierfabrikation, TU Darmstadt (Institute for Papermaking, Darmstadt Technical University). Concise assessment of current knowledge, VDP – INFOR project (No. 19); and

- a Beca AMEC Ltd literature review prepared for the RPDC entitled “Review of ECF and TCF bleaching processes and specific issues raised in the WWF report on Arauco Valdivia” dated May 2006.

Beca AMEC summarises the main conclusions of the literature review done by TU Darmstadt as follows:

- Treated wastewater from well-managed pulp and paper mills employing ECF bleaching is virtually free of dioxin and persistent bioaccumulative toxic compounds.

- The other chlorine-containing organic compounds resulting from ECF bleaching have a composition similar to that of natural compounds, degrade naturally, do not persist in the environment and present a negligible environmental risk to aquatic ecosystems.
- The toxicity of the whole mill effluent from modern mills is generally very low and shows no correlation to the levels of AOX from ECF bleaching.

- There is no evidence available to indicate that further reductions of effluent AOX from the average level of 0.5 kg/ADt (in 2002) would result in any demonstrable environmental benefit.

- There is no international consensus on appropriate AOX discharge limits.

- In global terms, if mills currently using molecular chlorine were to switch to ECF bleaching, a greater reduction in AOX would be achieved than if mills currently using ECF bleaching sequences switched to TCF sequences.

- There is no systematic difference in effect intensity or effect pattern between the whole mill effluents from mills employing ECF or TCF bleaching.

- There is no indication of a difference between ECF and TCF bleaching in terms of acute and chronic toxic effects on aquatic eco-systems.

- Biological toxicity tests carried out at the Mercer International Rosenthal BKP mill in Blankenstein, Germany, while producing both ECF and TCF pulps, indicate no difference in ECF and TCF effluent quality.

- The remaining environmental effects of modern mills (e.g. sub-lethal toxicity to aquatic organisms) cannot be predicted from the bleaching sequence alone. Future evaluations of these environmental effects should focus also on other unit operations within the mill (e.g. wood handling, cooking, washing, screening, spill and foul condensate handling).

- A secondary effluent treatment is a prerequisite for both ECF and TCF wastewaters to minimise long term toxic impacts on aquatic ecosystems.

- The ECF and TCF bleaching processes are considered BAT in [IPPC BREF, 2001].

- Organic halogen (OX) content of pulp is a suitable parameter for assessing the aquatic eco-friendliness of ECF pulp production.

- ECF pulps have better paper-making properties than TCF pulps.

- TCF bleaching offers no advantage over ECF bleaching in terms of reducing or eliminating an effluent discharge.
The following studies have addressed the issue of toxicity of ECF and TCF effluents particularly well:

- Nelson, Stauber et al. compared the toxicity of ECF and TCF effluents from bleaching of eucalypt kraft pulps using a suite of marine bioassays developed by the National Pulp Mills Research Program (Australia). The untreated TCF effluents were more toxic than the ECF effluent, possibly due to residual peroxide in the TCF effluents. While secondary treatment reduced toxicity, both the ECF - D(EO)DD - and the TCF - (XQ)(EOP)(EPN) P - effluents were still found to be toxic in the sensitive sea urchin fertilisation and scallop larval abnormality tests [Nelson, 1995], [Stauber, 1996].

- More recently, Mounteer et al. found that for activated sludge treated ECF - D(EO)DD - and TCF - O(OP)(ZQ)(PO) - bleaching effluents of Brazilian eucalypt kraft pulp, Microtox® toxicity was consistently eliminated from both effluents, whereas chronic toxicity to uni-cellular green freshwater alga Selenastrum capricornutum was reduced but not removed during treatment [Mounteer, 2002].

In addition, Pöyry conducted a further literature survey to source any other reliable material on the subject, limiting the search to the years between 2001 and April 2006 and using the Paperbase International Database (a database produced by a joint venture of four European research institutes CTP, KCL, Pira International and STFI). The additional Pöyry review of the literature did not reveal any change to the German conclusions.

6.1.2 Quality Related Reasons

TCF bleaching technology principally relies on either ozone and peroxide in combination, or peroxide alone as the main bleaching chemicals.

The peroxide process alone produces brightness reversion because it does not effectively oxidise the lignin leaving a considerable amount of lignin in the pulp, affecting the brightness and brightness reversion of the final product.

To achieve improved brightness it is necessary to use ozone in the bleaching stage.

The ozone attacks the fibres and weakens the pulp. TCF pulp is not usually as strong as ECF pulp when bleached to the same brightness level. This applies particularly to softwood.

1 Xylanase/EDTA; oxygen alkali extraction with peroxide; alkali extraction with peroxide and nitrilamine; peroxide.
The following figures and tables illustrate these points.

Figure 6/1. Strength of TCF pulps vs. ECF pulps

Table 6-1. Physical properties of Eucalyptus pulp at 60 N.m/g tensile

<table>
<thead>
<tr>
<th>Property</th>
<th>ECF</th>
<th>ECF light</th>
<th>TCF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refining Energy, W.h</td>
<td>20</td>
<td>19</td>
<td>24.5</td>
</tr>
<tr>
<td>Drainability, SR</td>
<td>27</td>
<td>33</td>
<td>38</td>
</tr>
<tr>
<td>Opacity, %</td>
<td>72</td>
<td>72.3</td>
<td>72.8</td>
</tr>
<tr>
<td>Bulk, cm³/g</td>
<td>1.65</td>
<td>1.60</td>
<td>1.47</td>
</tr>
<tr>
<td>Tear Index, mN.m/g</td>
<td>11.1</td>
<td>8.1</td>
<td>8.4</td>
</tr>
<tr>
<td>Viscosity, mPa.s</td>
<td>24.8</td>
<td>10.5</td>
<td>8.7</td>
</tr>
</tbody>
</table>

* 0.6 kg/t of chelant logosperse 1241 was added in (PO) and (PO/P) stages
6.1.3 Industry Experience on TCF

The industry experience of pulp mills using TCF bleaching technology demonstrates that the related quality issues are serious problems. Some recent examples of this industry experience are referred to below:

Press release by Rottneros AB, May 2006:
- The mill stopped producing TCF at the end of 2005 because sales had been falling significantly for a number of years.

ENCE in the Cumulative Impact Study – Uruguay Pulp Mills:
- ENCE has found that pulp using the same TCF method that they use in the Pontevedra mill in Northern Spain could not reach the necessary market brightness, and that the final brightness reduces during transportation of product (a phenomenon called reversion). If ozone was used in the sequence, full brightness can be made but the pulp has much reduced papermaking properties, especially strength, that renders it unacceptable for market.

Announcement by Botnia 09.03.2006 (conversion of the Rauma mill to produce ECF pulp):
- The advantages of ECF bleaching include higher pulp brightness and better runnability on the paper machine, both of which are important from the point of view of papermaking and the final paper products. The ECF bleaching process is less energy-consuming than the TCF process. Wood consumption per tonne of pulp produced is also smaller than with the TCF process. Greater production efficiency will raise the mill’s production capacity by 10%.
- The technology behind ECF bleaching has undergone considerable development in recent years. It involves the use of chlorine dioxide alongside oxygen bleaching chemicals. In terms of environmental impact, there is little difference between the ECF and TCF bleaching processes.
6.1.4 Wood Consumption

The ECF alternative produces a higher yield of pulp because it doesn’t destroy the fibre, e.g.: 0.5 % in overall yield equals 30 000 m³/a – 35 000 m³/a wood depending on the raw material quality:

![Selectivity of delignification](image)

**Figure 6/3. Selectivity of Delignification**

6.1.5 Australian and International Guidelines:

Pöyry commenced this process by seeking a design concept that was in accordance with the recognised guidelines and parameters.

ECF is considered AMT by the RPDC documentation for “Development of new environmental emission limit guidelines for any new Bleached Eucalypt Kraft Pulp in Tasmania”.

ECF bleaching is in line with the best available techniques for *Minimising or eliminating the formation of* 2,3,7,8-TCDD/TCDF *in wood and non-wood bleaching processes as specified in the United Nations Environmental Programme draft guidelines on best available techniques and provisional guidance on best environmental practices relevant to Article 5 and Annex C” of the Stockholm Convention, 31 January 2005 which states that:

“When the ClO2 substitution level is higher than 85 % in CI2 bleaching, or if ECF bleaching is used, or if TCF bleaching is used, emissions of 2,3,7,8-TCDD and 2,3,7,8-TCDF to water are lower than the limit of quantification (US-EPA Method 1613)”.

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The bleaching process to be used in the proposed mill will achieve these outcomes.

In addition to the chlorine arising from the bleaching process, the proposal includes the establishment of an integrated chlorine dioxide chemical plant which is intended to use technology for the chlorine dioxide production that limits the Cl\(_2\) in the chlorine dioxide to less than 0.2 g/l. Further information on the achievable level of Cl\(_2\) content in the ClO\(_2\) solution will be provided by the chemical plant equipment_process expert.

ECF is considered BAT (Best-available technology) by the European Union.

It is also considered BAT (Best available technology economically achievable) in the USEPA Cluster Rule ³

> "After re-evaluating technologies for mills in the Bleached Papergrade Kraft and Soda subcategory, EPA has determined that the model technology for effluent limitations based on best available technology economically achievable (BAT) should be complete (100 percent) substitution of chlorine dioxide for chlorine as the key process technology, along with other in-process technologies and existing end-of-pipe biological treatment technologies”.

ECF is an accepted bleaching system by the World Bank as defined in the Pollution Prevention and Abatement Handbook 1998.

### 6.1.6 Effluent Volumes and Closed Loop Bleaching

There is sometimes a perception that the use of TCF bleaching will allow pulp mills to have a closed loop water system, which will mean that there will be no effluent discharges into the marine environment.

There are no paper grade bleached kraft mills, with either TCF or ECF bleaching, which operate with a closed loop water system.

Attempts in this direction have been made, but have led to several operational problems both in TCF and ECF mills including increased operating cost.¹¹ This is highlighted by the fact that equipment vendors guarantee higher chemical consumptions at a lower water consumption.

The water usage and closed loop bleaching is discussed in further detail below.

### 6.2 Water Usage and Closed Loop Bleaching

A number of submissions assert that the water usage of the mill is high and that the mill should be based on complete closed loop technology.

**Closed Loop Technology in General**

Completely closing the water loop system in pulp mills means that all the organic and inorganic compounds eventually end up at the recovery boiler. This leads to a build up in the concentration of elements, some of which include chlorine and potassium from the wood, which eventually results in plugging of the recovery boiler.

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³ 18514 Federal Register / Vol. 63, No. 72 / Wednesday, April 15, 1998 / Rules and Regulations
The consequences of very low water consumption are highlighted by Botnia in the Cumulative Impact Study for the Uruguay Mill:

“The lowest water use and effluent flow for a bleached kraft pulp mill known to the CIS project team was achieved by Botnia at the Rauma mill. Rauma found that low water usage in bleaching was accompanied by detrimental effects such as bleach plant scaling, increased chemical consumptions, and specific effluent loadings of COD increased. The evaporators also had difficulty with scaling (as some bleach filtrates were recycled) and production was stopped (for evaporator cleaning) more often than normal. This also resulted in additional black liquor losses. The water use was subsequently increased, to provide better washing and purging of inorganic chemicals (such as calcium and oxalate), and effluent flow is now about 18 m3/ADt. This has resulted in lower chemical usage and lower mill effluent organic loadings (COD) at Rauma.”

The effluent flow for the proposed mill will be about 20.3 m$^3$/ADt.

Recycling waters and filtrates is undertaken in both ECF and TCF mills in order to minimise water and heat consumption by partially closed systems. However, the lower the water consumption in washing and bleaching, the larger the amount of chemicals required for bleaching in general. Therefore, the degree of closure needs to be a compromise between minimising equipment corrosion, reducing scaling and deposits, minimising the level of bleaching chemicals used and maintaining the pulp quality.

The historical perspective, perceptions and actual results on closed loop technology are presented in the Beca AMEC report on Arauco Valdivia, which reached the following conclusions:

*Both ECF and TCF bleaching offer paths to process closure. Based on current knowledge, the degree of closure in TCF mills can be only partial whereas ECF mills are more likely to offer full bleaching closure.*

*As of Q2 2006 there are no paper grade bleached kraft mills that operate fully closed on a continuous basis, more specifically there are no bleach plants in paper grade BKP mills that operate fully closed on a continuous basis.*

*The principal impediment to closure in a BKP mill is the recycle of bleach plant effluents, which typically comprise about half of the total effluent volume. For ECF mills the prime concern has been the build-up of chloride in the chemical recovery cycle, with secondary concerns with pulp quality and mill operability. For TCF mills the prime concern has been pulp quality (strength and brightness) with secondary concerns in operability, and potassium and chloride build-up in the recovery system.*

*Both ECF and TCF bleaching closure can cause operating difficulties with increased chemical consumptions, poorer pulp quality and provide challenges in minimising deposition and scaling on equipment.*
The Bell Bay Pulp Mill is designed with the capacity to be partially closed, the degree of closure depending, at any one time, upon a number of factors which have already been discussed.

The proposed mill will recirculate all the white water from the pulp drying machine through the bleach plant in a counter current manner.

Additionally, the system enables the recirculation of the alkaline filtrate back to the last stage of brown stock washing.

A small volume of hot water that can partially be replaced by secondary condensate will be used at the EOP stage washer.

**Water Usage**

The proposed pulp mill has been designed for a low water usage, incorporating all of the AMT technologies for the reduction of emissions to the marine environment, including:

- Closed brown stock screening and washing (i.e. return of all filtrates to chemical recovery (Volume 6, pages 49-52, Volume 7 line diagram 16B0104-02034);

- Effective control, containment, recovery and storage of all spill, leakages and releases of process liquids and solids and avoidance of any loss of these materials prior to their re-introduction to the process or their disposal in an approved manner (Volume 6, Chapters 3 & 4, Volume 7 line diagram 16B0104-02036);

- Stripping and appropriate reuse of foul condensates, (Volume 6, pages 52, 73,79, Volume 7 line diagram 16B0104-02034, 02030). All the secondary condensates from the evaporation plant will be used in the process. Depending on the return rate of the EOP filtrate to the brown stock washing some of the wash water used in the bleaching will be clean secondary condensate from the evaporation;

- Collection and reuse of clean cooling and sealing waters, including those from cooling towers (Volume 6, pages 85-87, Volume 7 line diagram 16B0104-02026);

- Partial bleach plant closure (Volume 6, pages 52-55, 115-116, Volume 7 line diagram 16B0104-02026);

- Efficient washing of pulp (Volume 6, pages 52-55, 115-116, Volume 7 line diagram 16B0104-02026); and

- Recirculation to a cooling tower and reuse of indirect cooling water (Volume 6, pages 85-87, Volume 7 line diagram 16B0104-02026).

With an average estimated effluent volume of 20.3 m$^3$/ADt the Bell Bay Pulp Mill will be among the lowest pulp mill consumers of water in the world. This is illustrated in the following graph.
The low water usage in the bleach plant is made possible by recent improvements and developments in the washing equipment that can be used. The washing stages are described at section 3.8.2 of Volume 6 of the Draft IIS.

### 6.3 Hexenuronic Acid Removal by Hot Acid Stage or Hot D stage. HCl vs. H₂SO₄ as pH Control Chemical

Beca AMEC and some government agencies have stated that utilising a Hot acid stage in the bleaching process to remove hexenuronic acids (“HexA”) from the pulp should not be regarded as accepted modern technology:

“The proponent intends to use an A<sub>hot</sub> stage upstream of the D<sub>0</sub> stage. It is noted that the 2004 Emission Guidelines for any new bleached eucalypt kraft pulp mill in Tasmania consider hot acid stages (A<sub>hot</sub>), combined hot acid and hot D stage (A<sub>D</sub>)hot and high temperature D stage also called hot D stage (designated DHT or Dhot) to be emerging technologies and not AMT.

The proponent should provide a description of the relative merits of including a hot acid stage together with any known risks, or disadvantages associated with including the emerging technology.”
6.3.1 Status of the Technology

Although the Emission Guidelines identify the Hot acid stage (A) or Hot D stage as “emerging technology” this technology has rapidly become the dominating technology in new pulp mills producing pulp from hardwoods, and eucalyptus in particular.

The technology has been in use since 1996 and there are at the moment nearly 30 bleach plants operating or under construction which incorporate a Hot acid stage (A) or (Hot D).

The following table illustrates that 8 out of 10 major recent pulp mills designed for producing purely eucalyptus pulp include a similar stage:

Table 6-2. Bleach plant concept of recent major pulp mills (sw = softwood, hw = hardwood)

<table>
<thead>
<tr>
<th>Large Pulp Mills</th>
<th>Supplier</th>
<th>Capacity, ADt/d</th>
<th>Bleach sequence</th>
<th>startup date</th>
<th>Hot D or A/D stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ence, Uruguay</td>
<td>Kvaerner</td>
<td>1600</td>
<td>D^*-EOP-D</td>
<td>2008</td>
<td>yes</td>
</tr>
<tr>
<td>Orion, Uruguay</td>
<td>Andritz</td>
<td>2860</td>
<td>ADO-Eop-D1n-D2</td>
<td>2007</td>
<td>yes</td>
</tr>
<tr>
<td>Santa Fe, Chile</td>
<td>Andritz</td>
<td>2400</td>
<td>ADO-Eop-D1n-D2</td>
<td>2006</td>
<td>yes</td>
</tr>
<tr>
<td>Arauco, Itata, Chile</td>
<td>Kvaerner</td>
<td>1520</td>
<td>D^*-EOP-D-D</td>
<td>2006</td>
<td>yes</td>
</tr>
<tr>
<td>Arauco, Itata, Chile</td>
<td>Kvaerner</td>
<td>1520</td>
<td>D(-EOP)-D-D</td>
<td>2006</td>
<td>no (sw)</td>
</tr>
<tr>
<td>Veracel, Brazil</td>
<td>Andritz</td>
<td>2830</td>
<td>ADO-Eop-D1n-D2</td>
<td>2005</td>
<td>yes</td>
</tr>
<tr>
<td>Mondi, SA*</td>
<td>Kvaerner</td>
<td>1877</td>
<td>D^*-EOP-(DD)</td>
<td>2005</td>
<td>yes</td>
</tr>
<tr>
<td>Hainan, China</td>
<td>Kvaerner</td>
<td>3030</td>
<td>D^*-EOP-D-D</td>
<td>2004</td>
<td>yes</td>
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<td>Valdivia, Chile</td>
<td>Metso</td>
<td>2200</td>
<td>D-EO-D-D</td>
<td>2004</td>
<td>no (sw/hw)</td>
</tr>
<tr>
<td>Stendahl, Germany</td>
<td>Metso</td>
<td>1700</td>
<td>O-(PO)-D-(PO)</td>
<td>2004</td>
<td>no (sw)</td>
</tr>
<tr>
<td>Suzano, Brazil</td>
<td>Metso</td>
<td>1700</td>
<td>D-PO-D</td>
<td>2003</td>
<td>no</td>
</tr>
<tr>
<td>Aracruz C</td>
<td>Andritz</td>
<td>2205</td>
<td>ADO-Eop-DnD</td>
<td>2002</td>
<td>yes</td>
</tr>
<tr>
<td>VCP, Jacarei, Brazil</td>
<td>Metso</td>
<td>2200</td>
<td>A-(ZE)-D-P</td>
<td>2002</td>
<td>no</td>
</tr>
</tbody>
</table>

sw = softwood, hw = hardwood

Acid Used for pH control

The acid selected for pH control depends on the availability and cost of the acid. This in turn is dependent upon whether or not there is an integrated chemical plant at the mill site.

Various acids can be used to set the pH. The final selection of the type of acid in the Bell Bay Pulp Mill case will depend on the final selection of the chlorine dioxide production method. If an integrated chemical plant is chosen, the most likely acid to be used will be hydrochloric acid (“HCl”) as it will be produced as a by-product at the mill. If chlorine dioxide is produced in a non-integrated plant without a chlor-alkali and HCl plant the acid used for pH control will be sulphuric acid H₂SO₄.
The selection of the acid has been raised by BecaAMEC in the “Peer Review of the Draft Integrated Impact Statement, Revision 1”, October 13, 2006 as a concern:

“The statement “From the last brown stock wash press after the brown stock storage tower, pulp will be transferred to an MC pump feed chute, where sulphuric acid or hydrochloric acid will be added. Whether sulphuric or hydrochloric acid will be used has no impact on the bleach plant effluent” is incorrect.”

“The use of an HCl solution (hydrochloric acid) for acidification in the bleach plant can lead to a substantial additional load of chloride (Cl-) ion.”

The use of 5 kg/ADt of HCl will increase the Cl- ion content to approximately 650 g/m$^3$ from the level of 400 g/m$^3$ where no HCl is used. In Pöyry’s opinion this difference is insignificant in terms of chloride increase in the effluent as the recipient (Bass Strait) has a chloride content of well over 10,000 g/m$^3$.

6.3.2 Relative Benefits of the Hot Acid/Hot D Stage

Introduction

HexA is a constituent formed in cooking that, especially in bleaching of hardwood, chemically consumes ClO$_2$. The loss of efficiency in the use of ClO$_2$ as a bleaching agent must be compensated by the use of additional ClO$_2$ to account for the demand generated by the presence of HexA.

The inclusion of a HexA removal stage in the bleaching of hardwood pulp has the potential to decrease the total ClO$_2$ charge in the proposed mill by up to 15-20 % and would lead to a similar decrease in AOX and chlorate content in the effluent.

The degree of reduction depends upon the HexA content of the pulp.

The presence of HexA in hardwood pulp also contributes to higher levels of brightness reversion. The usual way to counteract this problem is to bleach to a higher brightness.

By removing the HexA at the beginning of the bleaching sequence the chemical load required to minimise the effect of brightness reversion is also reduced and creates a further potential for reducing the levels of AOX and chlorate in the effluent.

HexA removal also removes metals and diminishes oxalate scaling.

Removal of HexA in Bleaching - Generally

The use of an acid stage before the bleaching can reduce the kappa number by up to 50 %. ¹²

In the acid stage, the most important process conditions are temperature, pH, retention time, consistency of pulp, and acid charge. Usually the temperature is over 85 °C and pH ranges from 3.0 to 4.0 for hardwood. The duration of the treatment depends on the pH value, temperature, and wood material but is typically 120 minutes in an atmospheric reactor.
The intention is to remove as much Hex A as possible, probably between 75–90 %. However, the HexA’s should not be removed completely in order to prevent excessive carbohydrate degradation. Viscosity loss depends on the reaction time and yield loss on the maximum temperature.

**Brightness reversion**

The brightness reversion is an important issue for pulp mills. With high pulp brightness, less optical additives are needed in the papermaking process. These additives often cause more environmental problems than some extra bleaching chemicals in the pulping process. The easiest way to diminish the brightness reversion problem is to bleach the pulp to a somewhat higher final brightness. This means that even after brightness reversion has occurred, the pulp brightness will still be above the target. However, it is not always easy to predict in advance how great the reversion will be. In addition, bleaching to a higher target brightness also means an extra cost and higher chemical load. Therefore other methods of fighting brightness reversion should be considered.

An acid stage diminishes the brightness reversion problem (see figure 6). With a hot acid/Hot D stage in the mill, brightness reversion decreases considerably, and the pulp target brightness can be lower than in a normal ECF sequence. The amount of HexA in bleached pulp has a direct influence on brightness reversion as shown in the following graph.

![Figure 6/5. The effect of HexA on brightness reversion](image-url)

---

**Figure 6/5. The effect of HexA on brightness reversion**

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16B0 104-E0072
Efficient metals removal

The efficiency and selectivity of bleaching chemicals derived from oxygen (H₂O₂, O₃, peracids) are negatively influenced by the presence of transition metals (Mn, Cu, Fe, Co, etc.) in pulp. The acid stage solubilizes these metals.

The amounts of metals removed by an acid stage are significant. This will considerably reduce the deposit build-up at the bleaching plant as well as the decomposition of hydrogen peroxide in bleaching. Manganese is considered the most difficult metal to remove from the pulp. Its removal is important especially to avoid peroxide degradation in the EOP and P stages. According to the literature, an acid stage is as efficient as normal chelation in manganese removal. On the other hand, the acid stage preserves Ca and Mg better than chelation treatment. This is beneficial when the sequence includes a peroxide treatment stage. Mg and Ca stabilize the alkaline hydrogen peroxide solutions.

6.3.3 Potential Disbenefits Considered

It is true that a Hot Acid stage/Hot D stage has the potential to result in:

- Increased yield loss;
- Decreased pulp viscosity/strength;
- Decreased refinability; and
- Increased COD content in bleach plant effluents.

Despite the potential impact upon yield, strength and refinability, the HexA removal is still considered to be the preferred technology due to the reduction of chlorine dioxide demand in the bleaching and the reduced brightness reversion.
Although the inclusion of the HexA removal stage has the potential to increase the COD content of the effluent, it is, on balance a better result than an increase in the chlorate and AOX content of the effluent.

The following table indicates the effluent parameters of a recently built eucalyptus pulp mill in Brazil utilising a similar bleaching sequence and a HexA removal stage as the one proposed for the Bell Bay pulp mill.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Veracel Annual average*</th>
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</thead>
<tbody>
<tr>
<td>AOX</td>
<td>kg/Adt</td>
<td>0.1</td>
</tr>
<tr>
<td>BOD</td>
<td>kg/Adt</td>
<td>0.7</td>
</tr>
<tr>
<td>COD</td>
<td>kg/Adt</td>
<td>11.0</td>
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<tr>
<td>Flow</td>
<td>m³/Adt</td>
<td>24</td>
</tr>
<tr>
<td>N total</td>
<td>kg/Adt</td>
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</tr>
<tr>
<td>P total</td>
<td>kg/Adt</td>
<td>0.01</td>
</tr>
<tr>
<td>TSS</td>
<td>kg/Adt</td>
<td>N/A</td>
</tr>
<tr>
<td>Colour</td>
<td>kg/Adt</td>
<td>N/A</td>
</tr>
</tbody>
</table>


6.3.4 Proposed Technology Options

There are two alternative concepts that have been considered for the removal of Hex A in the proposed mill:

- An A/D stage followed by washing:
  - A hot acid stage with a retention time of 120 minutes in a separate tower followed by a D0 stage (chlorine dioxide stage).

- HotD or DualD followed by washing
  - A common hot acid and chlorine dioxide stage in one up-flow reactor or a combined up-flow/down-flow reactor with a total retention time of 120 minutes
6.3.5 Conclusion

Based on the above, it is Pöyry’s opinion that the proposed Hex A removal system either by the A/D or Hot D/DualD system and with either HCl or H₂SO₄ as the type of acid to be used is an accepted bleaching method for hardwood which reduces the need for bleaching chemicals, including chlorine dioxide in particular, that will be required for the pulp mill.

6.4 Different Operational Modes

The proposed mill has the ability to make pulp from both hardwood and softwood.

Some submissions have raised queries about the consequences for mill operations when soft wood is being processed. In the following sections I set out the relevant process differences.

6.4.1 Bleaching Generally

The basic sequence for the bleach plant includes the following sequence:

D EOP D D

The materials and equipment will be selected so that it will be possible to operate the last D stage as a peroxide stage. The use of peroxide instead of chlorine dioxide in the last stage will be dependent on the required pulp properties.

6.4.1.1 Bleaching of Eucalyptus Pulp

When bleaching eucalyptus pulp the first D will be operated as a A/D (HotD) stage.

This is not necessary for the production of soft wood pulp because it does not have the same concentration of HexA as hardwood.

In hardwood pulping it is also possible for the final D stage to be operated as a P stage.

The following table summarises the expected effect of the variations of the bleaching sequence on the effluent AOX and chlorate levels.
Table 6-4. Effect of operating mode of bleaching on the AOX and chlorate content of effluent. Eucalyptus production.

<table>
<thead>
<tr>
<th>Sequence</th>
<th>ClO₂ Kg/ADt</th>
<th>Raw Effluent Load</th>
<th>Final Effluent Load</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>AOX, kg/ADt</td>
<td>ClO₃, kg/ADt</td>
</tr>
<tr>
<td>D EOP D D</td>
<td>15.2</td>
<td>0.46</td>
<td>1.52</td>
</tr>
<tr>
<td>A/D EOP D D</td>
<td>12.2</td>
<td>0.43</td>
<td>1.22</td>
</tr>
<tr>
<td>A/D EOP D P</td>
<td>11.4</td>
<td>0.41</td>
<td>1.14</td>
</tr>
<tr>
<td>A/D EOP DP*/</td>
<td>9.5</td>
<td>0.40</td>
<td>0.95</td>
</tr>
</tbody>
</table>

* Plantation eucalyptus with increased peroxide charge, ** as ClO₃-Cl, *** As equivalent chlorate, removal efficiency in WWTP 98 %, effluent flow 20.1 kl/ADBt

6.4.1.2 Bleaching of Pine Pulp

As stated above, the Hot acid stage will not be used for pine and the D0 stage will be operated at lower temperature.

In the two reactor system (A/D), the pulp would be pumped through the A-tower. Some acid may be added to the pulp to control pH, but the pulp will not be heated. The chlorine dioxide will be added to the D0 stage after the A-tower.

In a HotD or DualD system the chlorine dioxide (and some acid for pH control) is added to the pulp before the up-flow tower. To reduce the reaction time, the down-flow tower will be operated with a lower level.

The final D stage can be operated also as a P stage.

The following tables summarise the expected effect of the variations of the bleaching sequence on the effluent AOX and chlorate levels.

Table 6-5. Effect of operating mode of bleaching on the AOX and chlorate content of effluent. Pine production.

* as Cl₅O₃-Cl, ** As equivalent chlorate, removal efficiency in WWTP 98 %, effluent flow 24.3 kl/ADBt
6.4.2 Washing of Pine

The following issue has been raised:

“The Draft IIS has not discussed washing, other than indicating in the Digester, washing etc section that the dilution factor will be 2.5 t/ADt. Considering the large difference in production rate, potential challenges could be expected in operating the washing units effectively both with eucalypt and pine pulp runs. The optimal production ranges are washer dependent and vary with the washing units chosen. Furthermore, pine pulp usually requires more washing units or stages and a higher washing efficiency ahead of the oxygen stage. Consequently, it is recommended that the proponent clarify the assumptions made for this important AMT.”

The washing result is a combination of the efficiency of the machinery and the volume of wash water to be used. The combination of washing equipment (i.e the washing sequence) will be designed to provide good operating conditions for the oxygen delignification stage to achieve high level of delignification, good recovery of cooking and oxygen delignification chemicals, and a low carry-over of these chemicals to the bleach plant to minimise the chemical demand and the environmental load from the bleaching.

Additionally, when running pine there will be a possibility to increase the dilution factor in the brown stock washing by at least 1 m³/ADt. This can be done because the pulp production through the fibreline is reduced leaving excess capacity in the evaporation plant. The increased dilution factor of 1 m³/ADt corresponds to an increase in washing efficiency (measured as E10) by 3 units prior to O₂-delignification (figure 9), by approximately 1 unit after oxygen delignification. (figure 10) and results in a clear improvement of the washing result.

The retention time in the washers with lower loading (when running pine) will also improve the washing efficiency of the individual washing equipment.

---

Figure 6/9. Digester based COD into O$_2$-delignification

Figure 6/10. COD carry-over to bleaching

The final washing sequence and type of washers is supplier dependent and will include separate guarantees for pine.
DECLARATION

I have made all the inquiries that I believe are desirable and appropriate and no matters of significance which I regard as relevant have, to my knowledge, been withheld from the Commission.

Kari Tuominen 13.12.2006
ENDNOTES


3 The Aquatic Environmental Impact of Pulping and Bleaching Operations – An Overview, Tana et al., Finnish Environment Institute, 1996, p. 34.


5 The Aquatic Environmental Impact of Pulping and Bleaching Operations – An Overview, Tana et al., Finnish Environment Institute, 1996, pp. 44-78.


7 “Bleaching”, Papermaking Science and Technology, Section 16.3.4.

8 Almeida, Colodette 2001. Strategies to Decrease Cost and Improve Quality of ECF-light and TCF Bleached Eucalyptus Kraft Pulps


11 Papermaking Science and Technology, Section 22.3.4.


14 Pikka, O., Vehmaa, J., “Ozone bleaching and AHL-stage acid treatment in a modern multichemical bleach plant”, in: ABTCB Annual Pulp and Paper Congress & Exhibition, São Paulo, Brazil, 2002

15 Blekning – Infoblad, bleaching information brochure, Kvaerner AB, 2001


18 Gullichsen, J., Fogelholm, C-J., “Papermaking Science and Technology – Chemical Pulping”, vol 6A, Fapet Oy, Jyväskylä, Finland, 2000
Attachment 1
Curriculum Vitae
KARI TUOMINEN

Born in 1966, citizen of Finland

Education
M.Sc. (Eng), Pulp and Paper Technology
Department of Forest Products Technology at University of Technology, 1991

Current Position
Vice President
Pöyry Forest Industry Oy, Pulp Technology Division

Languages
Finnish, English, Swedish, German

Specialty
Mill concepts, Fibre line

Pöyry Experience

Mr Tuominen joined the Jaakko Pöyry Group in 1995 as a Process Engineer in the Pulp Process Department of the Pulp Technology Division. In August 2000 he was nominated to Department Manager and Technology Manager for Pulping Processes. In February 2005 he was nominated to Deputy Division Manager of the Pulp Technology Division. He has participated in the following main projects:

2005-2006 Gunns Limited, Australia
Engineering Manager. Preparatory engineering phase for a new greenfield pulp mill.

2005 Aracruz Celulose S.A., Brazil
Audit of Master Plan.

2004 Confidential Client
Project Manager. Development plan for two pulp mills.

2003-2004 April Group, Pec-Tech, Kerinci, Indonesia
Process Manager. Pre-engineering of a new pulp mill.

2003 Confidential client, Canada
2002-2003 Mondi Ltd, Group Technical Services, South-Africa
Project Manager. Pre-Engineering for the capacity increase of the Richards Bay Pulp Mill.

2002 Pec-Tech, Riaupulp, Kerinci, Indonesia
Process Specialist. Third-party monitoring of guarantee runs.

2001 Oy Metsä-Botnia Ab, Kemi, Finland
Process Specialist. Washing concept development.

2001 APRIL, Riaupulp, Kerinci, Indonesia
Project Manager. Benchmarking and Gap Analysis of the Pulp Mill.

2001 Dunapack Paper and Packagings Ltd, Hungary
Project Manager. Technical assessment of a romanian pulp mill.

2001 StoraEnso, Celbi Mill, Portugal
Project Manager. Strategic investment plan. Pre-feasibility study.

2001 Sappi Ngodwana, South-Africa
Project Manager. Product development study.

2001 UPM-Kymmene Group, Finland
Project Manager. Pre-feasibility study.

2000 StoraEnso, Celbi Mill, Portugal
Project Manager. Strategic investment plan. Conceptual Study.

2000 Fletcher Challenge Canada, Crofton Mill, Canada
Project Manager. Energy reduction in the Bleach Plants and the Drying Machines.

2000 StoraEnso, Skutskär Mill, Sweden
Process Engineer. Pre-feasibility study for capacity increase.

2000 RAIZ/University of Coimbra, Portugal
Lectures for MSc Course on Pulp and Paper Technology.

1999 Conox Ltd. Finland/Shandong Huajin Group Corp., Sishui Pulp and Paper Mill, China
Project Manager. Pre-engineering study for improving the brown stock washing of a straw pulp mill.

1999 UPM-Kymmene Oyj, Wisaforest, Finland
Process Engineer. Dimensioning and conceptual studies.

1999 Yun-Jing Forestry and Pulpmill Co. Ltd, Simao, China
Process Engineer. Check-out and start-up assistance for a new fibre line including digester plant, washing, screening, oxygen delignification and bleaching.
1999  Zellstoff- und Papierfabrik Rosenthal GmbH, Germany  
Project Assistance. Pulp drying machine.

1998  Peterson Moss AS, Norway  
Process Engineer. Check-out and start-up assistance for washing and screening plant.

1998  Yun-Jing Forestry and Pulpmill Co. Ltd, Simao, China  
Process Engineer. Check-out of a new fibre line including digester plant, washing, screening, oxygen delignification and bleaching. Training of personnel.

1998  Oy Metsä-Botnia Ab, Kemi, Finland  
Consulting services. Improvement of brown stock washing and screening.

1998  Celuloza Swiecie, Poland  
Project Engineer. Study on personnel requirements and manning plan.

1997  Texmaco Pulp Mill Project, Irian Jaya, Indonesia  
Process Engineer for the fibre line and Co-ordinator for the basic engineering project.

1997  Texmaco, Pulp Mill Project, Irian Jaya, Indonesia  
Project Engineer. Engineering before dismantling of second-hand machinery. A mill-wide inventory and assessment of the suitability of the equipment for a new kraft fibre line to be built in Indonesia.

1997  Oy Metsä-Botnia Ab, Joutseno, Finland  
Process Engineer. Debottlenecking. Balance calculations aiming for reduction of the environmental load (COD) of the existing fibre line.

1997  Andhra Pradesh Rayons Ltd, India  
Process Engineer. Start-up of a new brown stock washing, screening and bleaching plant for dissolving pulp production (330 ADt/d).

1997  PT Marga Buana Bumi Mulia, Indonesia  
Process Engineer. Basic engineering of the pulp drying plant.

1996  Kymmene Oy, Kaukas, Finland  
Process Engineer. Start-up of a new pulp drying plant including post screening, approach system and pulp drying machine.

1996  Sappi Tugela, RSA  
Process Engineer. Start-up of a new brown stock washing and oxygen delignification plant.

1996  Kymmene Oy, Kaukas, Finland  
Previous Experience

1994-1995  A. Ahlström Oy, Ahlström Machinery
Check-out and start-up of a new ECF bleaching plant (980 ADt/d) for dissolving pulp production for Sappi Saiccor, RSA.

1994  Valmet - Karhula Inc,
Check-out and start-up of a new pulp drying plant (980 ADt/d) for Sappi Saiccor, RSA.

Process Engineer. Participated in several projects at the Richards Bay mill including modification of the bleaching plant for ECF production. Participated also in several projects at the Felixton mill (bagasse based fluting) to improve the bagasse cooking and refining and reduce overall water consumption.

Professional Affiliations

The Finnish Paper Engineers’ Association (PI)
Attachment 2
Bell Bay Pulp Mill General Presentation
Project Objectives and Main Design Criteria

Contents

- Project Objectives and Main Design Criteria
- Presentation of the Process Areas
  - Woodhandling
  - Fibreline
  - Drying
- Chemical Plant – options
### Pulp Mill Project – objective

- The target of the project is to build the most cost-competitive large-scale pulp mill in the world, in accordance with the relevant environmental laws, regulations and guidelines.
- The pulp mill will produce high quality ISO 90% market pulp.
- The following main objectives were set for the mill design:
  - Full advantage will be taken of the effect of scale. The pulp mill will be designed for the highest possible capacity in a single-line operation.
  - The pulp mill will represent state-of-the-art technology. The latest and best available technology will be used in the design and the mill will be highly automated and efficient, with low maintenance costs.
  - The mill will produce net sellable electricity and fully utilise forest biofuel to generate electricity.
  - The pulp mill is designed to comply with both the “Emission Limit Guidelines” and with the BAT-level guidelines applied to new bleached kraft pulp mills in the EU and North America.

### Pulp Mill

- Generally:
  - The fibreline processes in the mill are concerned with separating and refining the fibre from the other substances (mainly lignin and water) naturally occurring in the woodchip to produce a pulp product at the end.

### Pulp Mill

- The recovery system is concerned with:
  - recycling the chemical products used in the process of separating fibre from lignin; and
The recovery system is concerned with:

- Using the lignin removed from the fibre to power the various components of the mill.

Generally:

- The waste products generated by these processes are:
  - Minimised to the greatest extent possible by recycling and reusing those products in the mill process; and
  - Managed and treated in preparation for emission in accordance with accepted environmental parameters.

The raw material to be used for pulp production will be Native Eucalyptus, Plantation Eucalyptus Nilotans and Radiata Pine arriving debarked to the mill.

The design capacity of the recovery boiler and recovery liquor circuit will ultimately dictate the mill’s capacity:

- In the first years of operation the raw material of the mill will comprise primarily native eucalyptus. Native eucalyptus has a lower cooking yield and a higher cooking chemical charge than plantation eucalyptus. At the design capacity of the cooking chemical recovery system the annual production is 820 000 ADt/a.

- In the later years when the production is utilising plantation the annual production will increase to 1 million ADt/a due to the higher cooking yield and lower cooking chemical charge per tonne of pulp.
Pulp Mill Concept – Raw Material and Capacity

- Material that dissolves in cooking
  - Lignin + hemicellulose
- Material that dissolves in chemical recovery
  - Cellulose + hemicellulose

Increased yield = More fibre & less dissolved material = lower load on recovery – higher pulp production

- With gradual operational improvements and optimization the production could increase to 1.1 million ADt/a when operating on 100 % plantation eucalyptus.

- The mill design and environmental modelling has assumed the absolute maximum capacity of the mill at a daily production capacity of 3492 ADt/d corresponding to 1.1 million ADt/annum at 100 % plantation eucalyptus raw material and 100 % eucalyptus pulp.

- The mill also has the capacity and equipment to process Pinus radiata wood chip. The production of pulp from pine employs a higher chemical load in both cooking and bleaching. It follows that as the proportion of pine production per annum increases, the overall pulp production for the mill decreases. An example to demonstrate this principal is to assume pine pulp production of 100 000 ADt/annum. When this amount of pine pulp is produced the total annual production for the mill will not reach 1.1 million ADt but will be approximately 1.05 million ADt.

Pulp Mill Concept – Capacity

<table>
<thead>
<tr>
<th>Process Line</th>
<th>Planned</th>
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<th>Calculated</th>
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<td>- Chip screening m 3l/h</td>
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<tr>
<td>Fibre Line</td>
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<td>- Bleaching ADt/d</td>
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<td>2274</td>
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<tr>
<td>- Drying ADt/d</td>
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<td>2321</td>
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<td>Power and Recovery</td>
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<td>- Evaporation t H 2O/h</td>
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<td>- Recausticising m 3 WL/d</td>
<td>10000</td>
<td>9338</td>
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<td>- Lime kiln t lime/d</td>
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<td>55</td>
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<td>Chemical Plant</td>
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<td>- Chlorine dioxide plant t ClO 2/d</td>
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<td>- NaClO3 plant t/d</td>
<td>200</td>
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<td>- Hydrochloric acid plant t/d</td>
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<td>- O2 plant t/d</td>
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</table>

Summary of table 3-2, Volume 6, page 26
Pulp Mill Concept – Overall Operating Efficiency

The pulp mill has been designed to acknowledge that it may not operate every day of the year to produce an annual maximum amount of 1.1 MADt. The design of the mill has taken account of this possibility by assuming that pulp production can only occur on 350 days of the year and that of those 350 days it will only operate at 90% efficiency to arrive at design maximum capacities.

<table>
<thead>
<tr>
<th>Source</th>
<th>Plantation Eucalyptus</th>
<th>Pinus Radiata</th>
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<tbody>
<tr>
<td>Wood loss in chip screening</td>
<td>2.0</td>
<td>2.0</td>
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<tr>
<td>Knots</td>
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</tr>
<tr>
<td>Brown stock rejection</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>1% delignification</td>
<td>2.5</td>
<td>3.0</td>
</tr>
<tr>
<td>Bleaching</td>
<td>3.0</td>
<td>3.5</td>
</tr>
<tr>
<td>Bleached stock screening rejects</td>
<td>0.2</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Losses

Average daily production, bleached pulp ADt/d: 3,143
Efficiency factor: 90%
Design maximum capacity, bleached pulp ADt/d: 3,492
Annual operating days: 350

<table>
<thead>
<tr>
<th>Source</th>
<th>Plantation Eucalyptus</th>
<th>Pinus Radiata</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water consumption</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Pulp Mill Concept - Water Consumption

Water for the mill processes is drawn from the Trevallyn Dam. As capacity increases the volume of water and effluent per ADt decreases.

<table>
<thead>
<tr>
<th>Production</th>
<th>Water</th>
<th>Effluent load</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADt/a</td>
<td>m³/ADt</td>
<td>m³/d</td>
</tr>
<tr>
<td>Bell Bay</td>
<td></td>
<td></td>
</tr>
<tr>
<td>820,000</td>
<td>27.4</td>
<td>64</td>
</tr>
<tr>
<td>1,100,000</td>
<td>25.4</td>
<td>79</td>
</tr>
</tbody>
</table>

Energy Balance Summary

The pulp mill will produce an excess of power that can be sold to the grid or used for production of incremental amounts of merchant chemicals.
Pulp Mill Concept - Auxiliary Components

- The chemicals required for the pulp mill processes are capable of being produced on site at an integrated chemical plant eliminating much of the need for the transportation and handling of large volume of chemicals imported from outside the side.

- Wood fines from the screening of chips, saw mill residues and waste wood from the wood catchment area is burnt in the power boiler.

- Natural gas is used for start-up and the Lime Kiln.

Process control

- The degree of automation will be in accordance with modern industrial practice. There will be several process control and mill systems:
  - Distributed Control System (DCS)
  - Optimisation Packages (in DCS) for different process systems
  - Quality Control System (QCS)
  - Closed-Circuit TV System (CCTV)
  - Process Information Management System (PIMS)
  - Maintenance Management System (MMS) and Enterprise Resource Planning (ERP)
  - Programmable Logics (PLC) as integrated part of some machines.

Introduction
Introduction

- The detailed evidence concerning the various key parts of the proposed pulp mill will be given by those most expert in each respective field:
  - Woodhandling and fibreline – Kari Tuominen
  - Recovery/Power – Esa Vakkilainen
  - Water and Effluent – Hannu Jäppinen
  - Chemical production – Erco

- In addition to dealing with Woodhandling and fibreline, I (Kari Tuominen) will also deal briefly with:
  - chemical plant alternatives;
Introduction

Presentation of the Process Areas

Woodhandling, Fibre line and Drying

This section is divided into the following subsections:

- Woodhandling
  - General
  - New Chipping line
  - Modifications to the existing plant
  - Screening

- Fibreline
  - General
  - Cooking
  - Screening
  - Oxygen Delignification
  - Washing
  - Bleaching
Presentation of the Process Areas

- Drying
  - Bleached stock cleaning
  - Wire and Press section
  - Drying
  - Cutter-layboy
  - Baling

Woodhandling - General

- Chip silos
- Chip screening
- Biofuel storage
- From chip mill

Wood Handling - General

- The pulp mill will use the existing chip mills at the site to supply wood chips to the site.
- The logs will be received debarked at the existing North and South Mill of the Longreach Chip Mill facility of Gunns Ltd

<table>
<thead>
<tr>
<th>Wood Handling</th>
<th>Production Area</th>
<th>Mass Balance</th>
</tr>
</thead>
<tbody>
<tr>
<td>wood density</td>
<td>kg 80m³ sub 495/520</td>
<td>360/420</td>
</tr>
<tr>
<td>bark content of wood</td>
<td>% 0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>work up time</td>
<td>h/d 24</td>
<td>24</td>
</tr>
<tr>
<td>bark content of chips, max</td>
<td>% 0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>storage times</td>
<td>d</td>
<td>existing operations</td>
</tr>
</tbody>
</table>

Wood density for native wood is 520/600 kg BD/m3 (min/max)

Table 3-4, page 27, Volume II
Woodhandling - General

- The wood chips are mixed using the existing drag chain reclaimers from the existing chip piles. The reclaimers are continuously filled from the chip piles by the bulldozers.
- Chips are reclaimed to a collecting belt conveyor and transferred to two chip silos with a storage capacity of 12 hours.
- A new chip screening system will be installed to promote high chip quality.
- The design of the conveyor system will pay special attention to noise dissipation.
- Pine will also be processed using the same equipment and stock piles as for the eucalypt.

Woodhandling - New Chipping line

- A new chipper will be installed for plantation and pine wood chipping.
- A new chip pile will be located between the existing chip piles.
- The new chipping line will comprise a log washing stage where the log washing water will be recycled.
- A small amount of make-up water will be required (reclaimed storm water will be used and when that is not available, fresh water). The respective amount of effluent will be sent to the pulp mill effluent treatment plant.
Woodhandling – New Chipping line

- New railroad in the log yard
- Relocation of the maintenance workshop and the refuelling station
- Relocation of the incoming weighbridge
- New weighbridge
- Relocation of the waste conveyor from infeed log deck
- Removal of the unused log conveyors
- Demolition of the unused log conveyors
- Removal of the unused burner
- New chip truck unloading station

Woodhandling – Modifications to the existing plant

- Particles that are unsuitable for processing will be removed and excessively long chips will be rechipped and returned to screening.
- Oversize particles will be removed with a scalper screen prior to chip screening operations.
- Oversize chip fractions from scalper screen and chip screening will be fed to a rechipper.
- Rechipped wood material will be fed back to screening. Fines from screening will be fed out from the process to be burned in the power boiler.
Fibreline - General

- The main objective of the fibreline design concept is:
  - Highest quality pulp from a single line mill producing at maximum efficiency.
- This objective must be achieved within acceptable environmental parameters – set by international and state guidelines and regulations and/or supported by detailed research and impact analysis.
- While the final selection of machinery suppliers (and therefore machinery specifications) has not been completed, conservative assumptions have been made about the operation of the machinery to model the performance of the proposed mill against established environmental parameters.

Fibreline - Chips to Pulp

The main processes in the fibreline are:
- Cooking
- Washing and Screening
- Oxygen Delignification
- Bleaching

Fibreline - Cooking

- In chemical pulp production chemicals (white liquor) and heat are used to remove the lignin that binds the fibres in the woodchip together without destroying the cellulose or strength properties of the pulp.
• Chemicals that dissolve as much lignin and as little cellulose as possible are used in pulping.
• The amount of lignin in the fibre is expressed as a kappa number. The kappa number gradually decreases as the fibre moves through the fibre line as the lignin is removed.
• The objective is to produce a pulp quality prior to bleaching that does not require excessive use of bleaching chemicals. This approach produces both economic and environmental benefits – bleaching chemicals are expensive, and the reduction in their use means less emissions.
• The aim of the cooking process is therefore to remove as much lignin as possible from the fibre during the cooking process, without risking the ultimate quality of the pulp.
• Caution must be exercised because "overcooking" the pulp increases cellulose degradation and decreases pulp strength and yield.
• The sulphate process selected here uses white liquor, which is a mixture of sodium hydroxide (NaOH) and sodium sulphide (Na2S). Sodium hydroxide degrades lignin and sodium sulphide increases the rate of cooking reactions and decreases cellulose degradation caused by sodium hydroxide.

The table shows the design basis for the cooking stage.
The purpose of screening is to remove the uncooked particles such as knots, fibre bundles and sand from the pulp. The knots will be returned to cooking and the uncooked fibre bundles (rejects) are washed and disposed of. The rejects are collected as primary sludge in the effluent treatment plant and subsequently burned in the power boiler.
In this case, before oxygen delignification there is a washing stage that removes the lignin and chemicals (black liquor) from the brown stock.

The washing methods used at this stage of the process are comparable to the washing that occurs before bleaching and will be described separately.

The process of screening and washing is shown generally in the following diagram.
Fibreline - Oxygen Delignification

- Oxygen delignification continues the process of delignification that started in cooking, i.e. the removal of lignin. Delignification with oxygen is a more “gentle” way of reducing the kappa number than extended cooking.
- In oxygen delignification the lignin is oxidised and then broken down into parts that dissolve in alkali. In addition the coloured groups in lignin are destroyed and impurities such as resin are removed.

Oxygen Delignification - White Liquor Oxidation

- Oxidized white liquor is used to provide the alkaline conditions required for the reaction, because the sulphur contained in the unoxidised white liquor would otherwise consume too much oxygen, thus compromising the quality of the pulp.
- During oxidation of white liquor, the sulphur in the white liquor (sodium sulphide) oxidizes into sodium thiosulphate as well as sodium sulphate.
- In the Bell Bay Pulp Mill the oxidation is done with oxygen.

<table>
<thead>
<tr>
<th>Delignification degree</th>
<th>Plantation Beta</th>
<th>Pulp Nitable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kappa</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>Alkali charge (wt. % as NaOH)</td>
<td>18.5</td>
<td>20</td>
</tr>
<tr>
<td>Oxygen charge</td>
<td>kg/ADt</td>
<td>18</td>
</tr>
</tbody>
</table>

Table 3-7, page 28, Volume 6
The black liquor created in the cooking, which contains dissolved wood material and chemicals, is separated from the pulp in the brown stock washing process.

- Pulp is cleaned by washing to:
  - Recover the chemicals used in cooking and O2-delignification as effectively as possible
  - Recover the dissolved wood material and use it as fuel to generate power
  - Minimize the consumption of bleaching chemicals
  - Minimize the environmental effect of the bleaching effluents
  - Minimize pulp strength loss in oxygen delignification
  - Improve the efficiency of the following process stages.

Clean wash water is used at the last stage of washing when the pulp is its cleanest. The filtrate from that stage is then used in the preceding stage where it replaces a dirtier filtrate in the pulp at that stage.
Fibreline
Washing - Closed Wash Water System /Countercurrent Washing

Fibreline
Washing - Design Basis

<table>
<thead>
<tr>
<th>Washing</th>
<th>Plantation Eucalyptus</th>
<th>Plansee Redcell</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dilution factor</td>
<td>VAD</td>
<td>2.3</td>
</tr>
<tr>
<td>Washing loss to bleach plant</td>
<td>COD</td>
<td>8.0</td>
</tr>
</tbody>
</table>

Table 3-6, page 28, Volume 6

Fibreline
Washing - Pine Production: Pre Oxygen Washing

- The washing result is a combination of the efficiency of the machinery and the volume of wash water to be used
- When running pine there will be a possibility to increase the dilution factor in the brown stock washing by at least 1 m3/ADt because there is both spare production capacity throughout the fibreline (ie. lower production) and enough capacity in the evaporation plant. The increase in the dilution factor would correspond to an increase in COD before oxygen delignification. Additionally, the retention time in the washers with lower loading (when running pine) will improve the washing efficiency of the individual washing equipment.
**Fibreline**

**Washing - Pine Production: Post Oxygen Washing**

Figure: COD carry-over to bleaching

![Graph showing COD carry-over to bleaching](image)

- COD in pulp, Pine
- COD values:
  - 0,0
  - 2,0
  - 4,0
  - 6,0
  - 8,0
  - 10,0
  - 12,0
  - 14,0
  - 16,0
  - 18,0
  - 20,0

**Fibreline**

**Bleaching – Purpose of Bleaching**

- The objective of bleaching is to improve the brightness and cleanliness of pulp. This occurs either by removing or brightening the coloured substances in the pulp. Residual lignin is a major contributing factor in colour.

- Chemical pulps are typically bleached using lignin-removing chemicals. Brightness with lignin removal bleaching is more stable i.e. the brightness reversion (yellowing) is less.

**Fibreline**

**Oxygen delignification - Equipment**

- The target brightness cannot be achieved in only one bleaching step without sacrificing pulp strength. Therefore pulp is bleached in several steps, and the pulp is washed between them.
In this case it is proposed that the bleaching sequence will be ECF and not TCF.

This selection has been the basis of a number of submissions to the RPDC, which are answered in the main body of the witness statement.

This section of the presentation simply sets out the basic method and design basis for the chosen bleaching sequence.

The target brightness is 90+ ISO.

The bleaching sequence is D0 – EOP – D1 – D2.

This sequence involves:
- At D0 ClO2 is added to the pulp arriving from the post oxygen washing;
- At EOP sodium hydroxide, oxygen and hydrogen peroxide is added and further oxidation takes place. The reaction products are extracted from the fibre;
- At D1 ClO2 is added to the pulp a second time;
- At D2 ClO2 is added to the pulp for a third time and sodium hydroxide is used for pH control.

Following each stage in the sequence the pulp is washed to remove the reaction products.

The first D stage is capable of operating at high temperature and under strong acid conditions. This method is only applicable to hardwood pulp and has the advantage of removing the hexenuronic acids from hardwood pulp thus reducing the requirement for ClO2 later in the bleaching sequence.

The D2 stage can be operated as a peroxide bleaching stage.

All effluents loads have assumed the D0 – EOP – D1 – D2 sequence, which represents the worst case operating conditions of the proposed mill.
### Fibreline Bleaching – Chemical Charges

<table>
<thead>
<tr>
<th>Bleaching</th>
<th>Per cent Basis</th>
<th>Pulp Riverside</th>
</tr>
</thead>
<tbody>
<tr>
<td>Target Brightness</td>
<td>90 + ISO 90</td>
<td>90</td>
</tr>
<tr>
<td>Sequence</td>
<td>D-EOP-D1-D2</td>
<td>D-EOP-D1-D2</td>
</tr>
<tr>
<td>Chemical charges: (tentative)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ClO$_2$ (or ClO$_2$) kg/ADt</td>
<td>12.2</td>
<td>17.9</td>
</tr>
<tr>
<td>HCl kg/ADt</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>NaOH kg/ADt</td>
<td>15</td>
<td>25</td>
</tr>
<tr>
<td>O$_2$ kg/ADt</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>H$_2$O$_2$ kg/ADt</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>NaHSO$_3$ kg/ADt</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

Summary of Table 3-8, page 28, Volume 6

### Fibreline Bleaching – Other Features

- The system has been designed so that EOP filtrate can be recycled back to the brown stock washing stage (ie possible partial closure of the bleach plant as referred).

- All vent gases will be cleaned in an efficient scrubber using alkaline sodium sulphite water to absorb the residual ClO$_2$ from the vent gases.

### Fibreline Bleaching – Process Diagram
Fibreline - Summary

- The cooking operation assumed for the purposes of the report consists of a continuous digester system, including a chip pre-steaming bin, a chip feeding system, a separate vessel for impregnation, a digester vessel, liquor feeding and circulation arrangements, a digester discharge system and heat recovery system.
- The screening room consists of knot separation, knot washing and knot returning system to the digester, pressurised screening in three stages and a reject dewatering system.
- Brown stock washing takes place in the digester washing zone and in two washers in series. Washing can be by displacer drum or press drum types of washers or pressure diffusers.
- Oxygen delignification consists of two pressurised oxygen reactors, a blow tank and white liquor oxidation system. Before bleaching, there are two washers in series with a brown stock storage tower between the washers.
- Bleaching is conducted as a four stage sequence D-EOP-D-D with the option of converting the last D stage to peroxide and operating the first D stage at high temperature in combination with acid for hardwood pulping.

Drying

- Bleached stock cleaning
- Wire and Press section
- Drying
- Cutter-layboy
- Baling
Drying - Bleached Stock Cleaning

- Particles that are darker than bleached pulp and large enough to be visible to the naked eye are known as dirt particles. They are classified, based on their size, into different categories.
- The aim of bleached stock screening is to remove dirt from pulp as efficiently and with as little fibre loss as possible.
- The cleaning system consists of four stages – screening with slotted screens followed by two stage forward and two stage reverse cleaning for both heavy and light reject removal.
Drying

- Wet end after press section % 52
- Dryer inlet design value % 50
- Dryer outlet design value % 90
- Steam pressure before control valve bar (a) 4
- Dryer design steam pressure bar (a) 14

Table 3-10, page 29, Volume 6

Drying - Airborne dryer

Drying - Cutter Layboy
Harbour

- The mill wharf located approximately 1,500 m from the pulp mill is planned to be used mainly for shipment of pulp for export and as a route for import of solar salt and the import of caustic soda. The wharf could also be used for transport of equipment and materials during the construction period.
General Presentation, KPT82

Harbour
Bale handling – Ship loading

- Pulp will be mainly shipped using purpose-built pulp carriers – OHBC (Open Hatch Bulk Carriers). These pulp carriers have a deadweight of about 45 000 tons and can carry about 40 000 tons of pulp.

Chemical Plant

Options

Chemical Plant – Design basis

- The dimensioning of the chemical plant is based on the estimated maximum consumption of chemicals used in bleaching and other areas of the mill.
- The final dimensioning of the departments will depend on the selection of the chemical plant concept and extent of the merchant operation

<table>
<thead>
<tr>
<th>Plantation type</th>
<th>Chemical Plant</th>
<th>Design value</th>
<th>Process module</th>
<th>Design value</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Chlorine dioxide plant</td>
<td>1 DCl</td>
<td>51</td>
<td>39</td>
<td></td>
</tr>
<tr>
<td>- NaClO3 plant</td>
<td>0.4</td>
<td>200</td>
<td>72</td>
<td></td>
</tr>
<tr>
<td>- Hydrochloric acid plant</td>
<td>0.4</td>
<td>100</td>
<td>69</td>
<td></td>
</tr>
<tr>
<td>- Chloralkali plant</td>
<td>0.4</td>
<td>50</td>
<td>31</td>
<td></td>
</tr>
<tr>
<td>- O2</td>
<td>0.4</td>
<td>200</td>
<td>80</td>
<td></td>
</tr>
</tbody>
</table>

(1) based on merchant sodium chlorate of 137 t/d & merchant oxygen production of 110 t/d

Extract of table 3.2, page 26, Volume II.
Chemical Plant - Context

- The expert from the chemical plant supplier will give evidence about the technology – this section is defining the general design basis and describes the options within the proposed pulp mill.

Base case: Integrated Chemical Plant

- Produces as many chemicals as possible on site.
- Import of salt + small amount of caustic

Imported caustic (25% of total)

Salt

Brine Preparation

Chlor-alkali Plant

Caustic Handling

Hydrochloric Acid Plant

Chlorine-Dioxide Plant

Chlorate Plant

Caustic to Bleach plant

Hydrochloric acid to Bleach plant

Chlorine dioxide to Bleach plant

Hydrogen Gas

Base case: Integrated Chemical Plant

- South East Asian mills typically have this concept

- Reasons:
  - Low operating cost
  - Logistics to import chemicals
  - Excess power from mill
Alternative 1 - Integrated Chemical Plant

- Produces as many chemicals as possible on site.
- Import of salt + small amount of caustic
- Produce Chlorate for sales

Alternative 2: Non-Integrated Chemical Plant

- Mill imports caustic, sulphuric acid, methanol or peroxide (small amount)
- The mill generates chlorate and chlorine dioxide

Alternative 2: Non-Integrated Chemical Plant

- South American mills often have this concept

  - Reasons:
    - lower investment cost
  
  - Risk:
    - mill is subject to caustic price fluctuation