



Study report for
**Independent advice on
the development of
environmental guidelines
for any new bleached
eucalypt kraft pulp mill
in Tasmania**

EXECUTIVE SUMMARY



*Aracruz Celulose bleached eucalypt kraft pulp mill in Barra do Riacho, Espírito Santo, Brazil
Largest in the world*

Prepared for

Resource Planning and Development
Commission

TASMANIA



Rev	Compiled	Reviewed	Approved		Issued by		Issue date
4	See Appendix A in report	See Appendix A in report	JAW		RM		6-Aug-04

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EXECUTIVE SUMMARY

This executive summary should be read in conjunction with the accompanying “Study report for independent advice on the development of environmental guidelines for any new bleached eucalypt kraft pulp mill in Tasmania”.

TERMS OF REFERENCE

General

The Tasmanian Government wishes to develop environmental guidelines for any new bleached eucalypt kraft pulp mill in Tasmania (Tasmanian Guidelines).

The Tasmanian Guidelines are to use the broad framework of the *Environmental Guidelines for New Bleached Eucalypt Kraft Pulp Mills, Commonwealth of Australia (1995)* (1995 Commonwealth Guidelines).

To this effect, the Tasmanian Minister for Primary Industries, Water and Environment has asked the Resource Planning and Development Commission (RPDC) to review the 1995 Commonwealth Guidelines, taking account of changes in technological capability since 1995 and the Tasmanian legislative and policy framework.

Beca AMEC has been appointed to undertake the role of independent adviser to the RPDC for the review of the 1995 Commonwealth Guidelines and development of the recommended Tasmanian Guidelines.

The recommended Tasmanian Guidelines are based on a review of state-of-the-art kraft mill technologies and management practices aimed at minimising the environmental impact of pollutants released from the production process of any new bleached eucalypt market kraft pulp mill employing either the elemental chlorine free (ECF) or the totally chlorine free (TCF) bleaching process and whose treated liquid effluent is discharged into the marine (ocean) environment. The review includes wood handling, pulping, chemical and energy recovery, bleaching, bleaching chemical preparation and associated pollutant treatment technologies. Particular emphasis is given in the report to technology changes and developments that have occurred since the 1995 Commonwealth Guidelines were developed.

Selected pulping process

The Terms of reference for the report are confined to the bleached eucalypt kraft pulp (BEKP) non-integrated production process whose treated liquid effluent is discharged into the marine (ocean) environment.

It is noted that:

- The kraft¹ process is the dominant chemical pulping process worldwide (90% of the world chemical pulp production and 70% of the world pulp production) due to its superior pulp strength properties, suitability for all wood species and efficient chemical recovery system.

¹ After the German and Swedish word for strength.

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- Bleached kraft pulp presently accounts for over 50% of the wood pulp produced for papermaking and is globally traded.
 - Bleached kraft pulp demand is predicted to grow by over 50% over the next 15 years and the highest growth rate is expected for bleached hardwood kraft pulp, mainly from eucalypt.
 - Continuous process development has resulted in very low discharges to the atmosphere and the aquatic environment from pulping and bleaching in bleached kraft pulp mills when state-of-the-art technologies and environmental management practices are employed.
 - Discharge into the marine (ocean) environment ensures the maximum possible dilution of the liquid effluent resulting in the minimum possible environmental impact at the edge of the mixing zone.

Key terminology

In its Consultant's brief, the RPDC has instructed Beca AMEC to use the terms accepted modern technology (AMT) and best practice environmental management (BPEM) in the report to describe minimum environmental impact technologies and management practices.

AMT is defined in the *Tasmanian State Policy on Water Quality Management 1997 and Draft Environment Protection Policy (Air Quality) and Regulatory Impact Statement 2001* as a "technology which has a demonstrated capacity to achieve the desired emission concentration in a cost-effective manner, takes account of cost-effective engineering and scientific developments and pursues opportunities for waste minimisation."

The AMT included in the report are technologies that have a demonstrated track record of being technically effective and economically viable on an industrial scale for minimising the discharge of pollutants from bleached eucalypt kraft pulp (BEKP) mills to the environment. These technologies have been accepted as integral part of worldwide supra-national, national and sub-national environmental guidance.

BPEM is defined in the *Tasmanian Environmental Management And Pollution Control Act 1994* as "the management of an activity to achieve an ongoing minimisation of the activity's environmental harm through cost-effective measures assessed against the current international and national standards applicable to the activity".

BPEM includes practices like:

- High standards of maintenance.
- Environmental management systems carried out to an international standard and independently audited.
- Process control monitoring and optimisation.
- Training, education and motivation of personnel.

The combination of these technologies and practices (collectively called "techniques" or "measures"), or subsequently developed alternate techniques which produce similar or superior results, should be included in any new bleached eucalypt kraft pulp mill proposed to be built in Tasmania.

AMT and BPEM are conceptually similar to the generally accepted accounting principles (GAAP) of financial accounting which provide assurance to outsiders, who usually have no choice but to accept financial information as a company provides it, that the financial statements are prepared in accordance with a mutually understood set of ground rules. GAAP provide these common ground rules in financial accounting. Likewise, the AMT and BPEM practices listed in this report provide these common ground rules in bleached eucalypt kraft pulp production. These AMT and BPEM practices, if fully employed, allow cost-effective production of market BEKP with emissions to air and water that have minimum environmental impact.

Key terminology used by supra-national and national environmental guidance

European Union

The European Union (EU) has a set of common rules on setting of environmental permits for industrial installations. These rules were set out in the Integrated Pollution Prevention and Control (IPPC) directive 96/61/EC issued in 1996. The directive requires all installations covered by Annex I of the directive in each of the Member States, to have a permit from the State authorities. The permit shall include emission limits for pollutants likely to be emitted from a certain installation. Such limits are to be based on best available techniques (BAT) [IPPC directive, 1996].

Best available techniques are defined as "...the most effective and advanced stage in the development of activities and their methods of operation which indicate the practical suitability of particular techniques for providing in principle the basis for emission limit values designed to prevent, and, where that is not practicable, generally to reduce emissions and the impact on the environment as a whole".

- "Best" means most effective in achieving a high general level of protection of the environment as a whole.
- "Available" refers to those techniques developed on a scale which allows implementation in the relevant industrial sector, under economically and technically viable conditions, taking into consideration the costs and advantages, whether or not the techniques are used or produced inside the Member States in question, as long as they are reasonably accessible to the operator.
- "Techniques" include both the technology used and the way in which the installation is designed, built, maintained, operated and decommissioned.

These BAT include also general measures of best environmental practice.

United Nations Environment Programme

Persistent organic pollutants (POP) are chemical substances that persist in the environment, bioaccumulate through the food chain, and pose a risk of causing adverse effects to human health and the environment. With the evidence of long-range transport of these substances to regions where they have never been used or produced and the consequent threats they pose to the environment of the whole globe, the international community has, on several occasions, called for urgent global action to reduce and eliminate releases of these chemicals.

The Stockholm Convention on POP was adopted in 2001 in response to this need for global action. The Convention is an international treaty adopted in Sweden by 151 countries aimed at restricting and ultimately eliminating the production, use, release and storage of all intentionally produced POP (i.e. industrial chemicals and pesticides). It also seeks the continuing minimisation and, where feasible, ultimate elimination of the release of unintentionally produced POP (UPOP) such as dioxins and furans.

The 90-day countdown to the treaty's entry into force was triggered on 17 February 2004 when France became the 50th state to ratify the treaty. Australia ratified the treaty on 20 May 2004.

The Convention came into force on 17 May 2004 and the first meeting of the Conference of the Parties will be held in May 2005 [UNEP/POPS/EGB.2/3, 2003], [www.pops.int].

In June 2002, an expert group on best available techniques (BAT) and best environmental practices (BEP) was established to develop guidelines on BAT and provisional guidance on BEP directed towards the reduction or elimination of releases of unintentionally produced persistent organic pollutants (UPOP) like polychlorinated dibenzo-p-dioxins (PCDD), polychlorinated dibenzofurans (PCDF), hexachlorobenzene (HCB) and polychlorinated biphenyls (PCB).

The most recent relevant publication of this programme is the "Draft guidelines on best available techniques (BAT) for pulping processes", which was tabled at the 2nd Session of the expert group on BAT and best environmental practices (BEP), Villarrica, Chile, December 2003 [www.chem.unep.ch/pops], [www.pops.int], [UNEP, 2003]. In addition to the BAT identified by the European Union, UNEP considered additional techniques to be BAT for the reduction or elimination of UPOP by a bleached kraft pulp mill.

These BAT and BEP include all the EU BAT and general measures of best environmental practice.

USEPA Final Water Cluster Rule

The U.S. Environmental Protection Agency (USEPA) in April 1998 promulgated the Final pulp and paper cluster rule to protect human health and the environment by reducing toxic releases to the atmosphere and aquatic environment from U.S. pulp and paper mills [USEPA, 1998].

These guidelines are widely known as the "Cluster Rule", because they were designed to coordinate air and water discharge rules.

The final water rule includes best available technology (BAT) limits from mills in Subpart B, bleached papergrade kraft and soda and best management practice (BMP) requirements.

BAT is defined as the best control and treatment measures that have been or are capable of being economically achieved.

BMP include requirements such as recovery furnace capacity and the implementation and cost of pulping liquor spill prevention and control programs.

ACCEPTED MODERN TECHNOLOGY FOR BLEACHED EUCALYPT KRAFT PULP MILLS

The main environmental issues in kraft pulping are wastewater effluents, emissions to the atmosphere (including odorous gases), energy consumption and solid waste.

The main raw materials are renewable resources (wood and water) and chemicals for cooking and bleaching.

Emissions to the aquatic environment are dominated by organic compounds. Effluent from an ECF bleach plant contains chlorinated organic compounds, measured by the bulk analytical parameter AOX. Effluent from a TCF bleach plant still contains chlorinated organic compounds, although their quantity is much lower. Some compounds discharged from kraft mills are toxic to aquatic organisms. Emissions of coloured compounds may adversely affect biota in the environment. Emissions of nutrients (nitrogen and phosphorus) can contribute to eutrophication in the environment. Metals extracted from the wood are discharged in low concentrations but due to high flows the load can be of significance. A significant reduction of both chlorinated and non-chlorinated organic compounds in the effluent of kraft mills has been achieved to a large extent by the adoption of in-plant measures and techniques.

The measures and techniques listed below are a consolidation and expansion of those included in the international initiatives mentioned previously. They have been demonstrated to be technically effective and economically viable on an industrial scale for minimising the discharge of pollutants from bleached eucalypt kraft pulp (BEKP) mills to the environment.

The report includes a list of BEKP mills in Brazil, Portugal, South Africa and Spain in Appendix B - Selected bleached eucalypt kraft pulp mills. This list includes mill name, location, country, latitude, ownership, type, year of start-up, bleaching method, bleaching sequence, target brightness, daily production, effluent treatment type, effluent destination, comments and references. The European BEKP mills have not fully employed AMT. The Mondi Kraft mill in Richards Bay, South Africa is also believed to have not fully employed AMT. It is believed that the recent expansions at the Brazilian BEKP mills have employed most of the AMT presented in the report.

GENERAL MEASURES FOR BEST PRACTICE ENVIRONMENTAL MANAGEMENT

Table 1 includes general measures for BPEM aimed at achieving ongoing minimisation of emissions.

Table 1 General measures for best practice environmental management

High standards of maintenance	<ul style="list-style-type: none"> To maintain the efficiency of the unit operations of pulp mills and the associated pollution abatement technologies at a high level
Emissions monitoring	<ul style="list-style-type: none"> Development and implementation of protocols for monitoring the performance of pollution abatement facilities and compliance with environmental permits
Environmental Management System (EMS)	<ul style="list-style-type: none"> A system which clearly defines the responsibilities for environmentally relevant aspects of a mill. It raises awareness of issues and includes goals and measures, process and job instructions, check lists and other relevant documentation The EMS needs to be independently audited to an international standard and include environmental monitoring and a response mechanism The reporting framework of the EMS needs to be open and transparent Community consultation is recommended to ensure interested communities are informed and involved in any new kraft mill development and its impact on them
Planning	<ul style="list-style-type: none"> Investment planning/ cycles, co-ordination of process improvements to reduce technical bottlenecks and to introduce AMT
Process control monitoring and optimisation	<ul style="list-style-type: none"> To be able to reduce different pollutants simultaneously and to maintain low emissions Raw materials specification and monitoring of raw materials for precursor materials
Substitution	<ul style="list-style-type: none"> Identification and substitution of potentially harmful compounds with less harmful alternatives Use of a detailed inventory of raw materials used, chemical composition, quantities, fate and environmental impact

**Table 1 General measures for best practice environmental management
(Continued)**

Training, education and motivation of personnel	<ul style="list-style-type: none">• Pulp and paper mills are operated by people. Training of staff can be a very cost-effective way to reduce environmental impact and use of resources
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ACCEPTED MODERN TECHNOLOGY FOR THE REDUCTION OF EMISSIONS TO THE AQUATIC ENVIRONMENT

Table 2 includes technologies that are considered AMT for the reduction of emissions to the aquatic environment.

Table 2 AMT for the reduction of emissions to the aquatic environment

Topic or mill area	Description of AMT
Avoidance of synthetic dioxin precursors	<ul style="list-style-type: none"> • Exclusion of wood chips produced from wood treated with polychlorinated phenols • Exclusion of defoamers containing more than 10 ppb dibenzo-p-dioxin and 40 ppb dibenzofuran by weight • Exclusion of polychlorinated phenols in paint, cutting oils and other inadvertent inputs to the process
Optimised wood handling	<ul style="list-style-type: none"> • Optimisation of raw material storage, seasoning period, chipping process, chip storage and chip dimensions • Dry debarking
Pulping and brown stock processing	<ul style="list-style-type: none"> • Modified batch cooking or modified continuous cooking • Closed brown stock screening and washing (i.e. return of all filtrates to chemical recovery) • Oxygen delignification followed by efficient washing (99% overall recovery of dissolved wood solids and pulping chemicals from the pulp)
Chemical recovery and handling of accidental discharges	<ul style="list-style-type: none"> • Effective control, containment, recovery and storage of all spills, 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 • Adequate size of black liquor evaporation plant and recovery boiler to handle additional liquor and dry solids loads due to collection of spills and possible recycle of selected bleach plant effluents • Stripping and appropriate reuse of foul condensates • Collection and reuse of clean cooling and sealing waters, including those from cooling towers • Efficient washing of lime mud

Table 2 AMT for the reduction of emissions to the aquatic environment (continued)

Topic or mill area	Description of AMT
Bleaching	<ul style="list-style-type: none"> • ECF or TCF bleaching • Extraction stage reinforced by either oxygen (EO) or hydrogen peroxide (EP), or both (EOP) • High shear chemical mixing (i.e. with high power dissipation) • Partial bleach plant closure, i.e. increased recycle of filtrates within the bleach plant and possibly recycle of some bleach plant filtrate to the brown stock area and to chemical recovery • Efficient washing of pulp
Bleaching chemical preparation	<ul style="list-style-type: none"> • On-site generation of chlorine dioxide with low contamination of elemental chlorine (methanol or hydrogen peroxide processes)
Effluent treatment	<ul style="list-style-type: none"> • Primary and secondary (biological) treatment of all process effluent, excluding uncontaminated cooling water¹ • Anoxic selector for chlorate reduction • Provision of containment basin(s) to temporarily store, for subsequent treatment, untreated process effluent that has sufficiently high levels of contamination to adversely affect the operation of the effluent treatment plant
Cooling water	<ul style="list-style-type: none"> • Recirculation to a cooling tower and reuse of indirect cooling water
<p>Notes:</p> <p>1. Low-loaded activated sludge plants with an F/M ratio below 0.15 kg BOD/d/kg MLSS and typical hydraulic retention time in the aeration basin of about one day (up to 2 days) are regarded as AMT. Any other treatment system with comparable emission levels and cost is also regarded as AMT.</p>	

Emission levels to the aquatic environment for BKP mills employing AMT/BPEM

Depending on the type of the specific process-integrated measures implemented, the following emissions to the aquatic environment associated with the use of AMT/BPEM can be generally achieved [IPPC BREF, 2001].

Table 3 Long term average emission levels to the aquatic environment generally achieved by new BKP mills employing AMT/BPEM

Parameter	Units	Min emission value	Max emission value
Wastewater flow ^a	m ³ /ADt	30	50
COD	kg/ADt	8	23
	mg/L	270	460
BOD ₅	kg/ADt	0.3	1.5
	mg/L	10	30
TSS	kg/ADt	0.6	1.5
	mg/L	20	30
AOX	kg/ADt	Non detectable	0.25
	mg/L	Non detectable	5.0
Total nitrogen (N) ^b	kg/ADt	0.1	0.25
	mg/L	3.3	5.0
Total phosphorus (P) ^c	kg/ADt	0.01	0.03
	mg/L	0.3	0.6
Notes:			
a. Cooling water and other clean water discharges are not included in the wastewater flow value.			
b. Any nitrogen discharge associated with the use of chelating agents should be added to the figure of total N.			
c. Due to the higher content of phosphorus in eucalypt, some BEK mills will not be able to achieve the emission value of P if P exceeds the need of the biological treatment plant.			

The emission values quoted in Table 3 are long term averages. Maximum emission values calculated on shorter averaging times (e.g. daily and monthly) can be obtained from these values by multiplying them by appropriate variability factors (see Section 4.7 - Effluent variability factors in the report).

The report presents selected emissions to the aquatic environment from BKP mills in Appendix C - Reported emissions from secondary effluent treatment of bleached kraft pulp mills. This table also includes the emission values of Table 3 and the emission limits to the aquatic environment of the recommended Tasmanian Guidelines. Of the mills included in Appendix C, the European BEKP mills have not fully employed AMT. It is believed that the recent expansions at the Brazilian BEKP mills have employed most of the AMT presented in the report. The Alberta-Pacific BKP mill in Boyle, AB, Canada is considered to have employed AMT for the reduction of emissions to the aquatic environment.

ACCEPTED MODERN TECHNOLOGY FOR THE REDUCTION OF EMISSIONS TO THE ATMOSPHERE

Table 4 includes technologies that are considered AMT for the reduction of emissions to the atmosphere.

Table 4 AMT for the reduction of emissions to the atmosphere

Pollutant(s)	Description of AMT
Inorganic chlorinated compounds¹	<ul style="list-style-type: none"> • Collection and scrubbing in the bleach plant scrubber, which uses alkaline scrubbing media • Collection and scrubbing in the chlorine dioxide plant environmental scrubber, which uses alkaline scrubbing media
Total reduced sulfur (TRS)	<ul style="list-style-type: none"> • Collection and incineration of concentrated non condensable gases (CNCG) in either the recovery boiler or a standalone low-NO_x incinerator² • Backup system for the CNCG - which is activated during upsets, maintenance or other downtimes of the main system - consisting of: <ul style="list-style-type: none"> • A flare/ incinerator and secondary incineration unit (e.g. the lime kiln), or • A pre-purged alternative disposal point immediately available with interlocks permitted to allow switching without venting (bump less transfer) to a power boiler • Collection and incineration of dilute NCG (DNCG) in the recovery boiler after their addition to its secondary or tertiary combustion air³ • Methanol recovery from the foul condensate stripper off-gases • For the recovery boiler: computerised combustion control and carbon monoxide (CO) measurement • For the lime kiln: control of the excess oxygen, use of low-sulfur fuel, and control of the residual soluble sodium in the lime mud fed to the kiln • Spot monitoring program carried out by measuring odour with a mobile gas chromatograph/ mass spectrometer (GC-MS). Testing will be more frequent initially and less frequent later in the program

Table 4 AMT for the reduction of emissions to the atmosphere (continued)

Pollutant(s)	Description of AMT
Dioxins and furans	<ul style="list-style-type: none"> • Inhibiting the formation of dioxins and furans within power and recovery boilers by appropriate design to achieve the most suitable time/ temperature profile, and by appropriate operation including control of oxygen content, instituting systematic sootblowing, and the firing of fuels having minimum contamination with dioxins, furans and their precursors to minimise dioxins and furans in the flue gases⁴
Sulfur dioxide (SO₂)	<ul style="list-style-type: none"> • For the recovery boiler: firing of black liquor with high dissolved solid concentration to mitigate SO₂ formation or flue gas scrubbing, or both • For a standalone CNCG incinerator: flue gas cooling with either steam boiler or quench coolers and flue gas scrubbing • For the power boiler: use of bark, gas, low-sulfur oil, low-sulfur coal or flue gas scrubbing
Nitrogen oxides (NO_x)	<ul style="list-style-type: none"> • For the recovery boiler: control of combustion temperature profile; air distribution and excess air; and black liquor nitrogen content; and also appropriate design (low NO_x) • For the lime kiln: control of firing conditions and also appropriate design (low NO_x) • For the power boiler: control of firing conditions and also appropriate design (low NO_x)
Particulate matter (PM) or dust	<ul style="list-style-type: none"> • Cleaning of the flue gases from the recovery boiler, the power boiler (in which other biofuels or fossil fuels, or both are burned) and the lime kiln with efficient electrostatic precipitators
<p>Notes:</p> <ol style="list-style-type: none"> 1. Small amounts of elemental chlorine are produced when chlorine dioxide reacts with the pulp in ECF bleaching. 2. Sources for CNCG are the digester plant, the vacuum system of the evaporation plant and the foul condensate stripper. 3. Sources of DNCG are the fibrelines process vents, tank vents, chip bin vents and include the smelt dissolving tank (SDT) vent. The SDT vent is cooled and scrubbed before being piped to the recovery boiler. 4. This is also considered a best available technique (BAT) for the purposes of the Stockholm Convention on Persistent Organic Pollutants. 	

Emission levels to the atmosphere for BKP mills employing AMT/BPEM

Depending on the type of the specific process-integrated measures implemented, the following atmospheric process emissions associated with the use of AMT/BPEM can be generally achieved (Beca AMEC), [IPPC BREF, 2001].

It should be noted that a direct comparison of the emission limits between countries requires concentrations from combustion sources to be corrected for reference oxygen level, which differs among jurisdictions. This correction can be only approximate in Sweden and other Nordic countries where the concentrations are specified at actual oxygen content of the flue gas.

Table 5 Daily average emission levels to the atmosphere from the pulping process associated with the use of a suitable combination of AMT/BPEM

Gas	Units ^a	Recovery boiler	Lime kiln	Bleach plant scrubber	ClO ₂ plant scrubber
Inorganic chlorinated compounds	mg/NDm ³ kg/ADt	N/A	N/A	30-50 0.03-0.05	10 0.01
PM	mg/NDm ³ kg/ADt	30-50 ^b 0.2-0.45	30-50 0.03-0.05	N/A	N/A
TRS as S	mg/NDm ³ kg/ADt	15-20 0.1-0.2	20-25 0.02-0.025	N/A	N/A
SO ₂ as S	mg/NDm ³ kg/ADt	10-50 ^c 0.1-0.4	5-30 ^d 0.005-0.03	N/A	N/A
NO _x as NO ₂	mg/NDm ³ kg/ADt	80-120 0.7-1.1	100-200 ^e 0.1-0.2	N/A	N/A
Flow	m ³ /ADt	7000-9000	1000	1000	25

Notes:

- Concentrations of emissions are given with respect to a normal cubic metre of dry gas at standard conditions of 0°C and 101.325 kPa.
- For ESP only. With an SO₂ scrubber after the ESP, emissions of about 15 mg/NDm³ are achievable.
- Recovery boilers operating with high dry solid content of black liquor release very low SO₂ emissions normally below 0.1 kg S/ADt or down to 5-10 mg S/NDm³.
- Oil fired kiln without NCG incineration. Oil fired kiln with NCG incineration achieve 150-300 mg S/NDm³ or 0.15-0.3 kg S/ADt.
- Oil fired lime kiln. Gas fired kilns achieve 380-600 mg/NDm³ or 0.4-0.6 kg NO_x/ADt. Combustion of odorous gases in the lime kiln can also increase NO_x emissions. A separate furnace for TRS burning adds about 0.1-0.2 kg NO_x/ADt.
- The emission values refer to daily averages. The reference oxygen content is 5% for both recovery boilers and lime kilns.

Depending on the actual energy balance of the mill, the type of external fuels used and the fate of possible biofuels like bark and wood waste, there are additional atmospheric emissions from power boilers to consider. Emission levels associated with AMT from power boilers incinerating biofuels and different fossil fuels are given in Table 6. The total releases to the atmosphere are very site specific (e.g. type of fuel, integrated or market pulp mill, production of electricity). It should be noted that many mills use fuel mixes [IPPC BREF, 2001].

Table 6 Emission levels from power boilers associated with the use of amt for different fuels

Released substance	Unit	Coal	Heavy fuel oil	Distillate	Gas	Biofuel (e.g. bark)
Sulfur	mg S/MJ fuel input	100-200 ^a (50-100) ^b	100-200 ^a (50-100) ^b	25-50	<5	<15
NO _x	mg NO ₂ /MJ fuel input	80-110 ^c	80-110 ^c	45-60 ^b	30-60 ^b	60-100 ^c
PM	mg/NDm ³	10-30 ^d 6% O ₂	10-40 ^d 3% O ₂	10-30 3% O ₂	<5 3% O ₂	10-30 ^d 6% O ₂

Notes:

- S emissions for oil or coal fired boilers depend on the availability of low-sulfur oil and coal. Certain reduction of S could be achieved with injection of CaCO₃.
- When a scrubber is used; only applied to larger installations.
- Only combustion technology is applied.
- Achieved values when electrostatic precipitators (ESP) are used. These data appear to be based on actual performance and in some cases may be well below the regulatory requirement, for a variety of reasons:
 - The first reason for the low PM outlet concentrations is to provide a margin over regulatory limit values.
 - The second reason is that the ESP may have more than one chamber, so compliance with regulations can continue to be achieved with one chamber down and possibly with the unit only partly loaded. Such sizing criteria are common in the case of recovery boilers. Thus low reported outlet concentrations result from deliberate over-design to thwart the risk of downtime.
 - The third reason for low concentrations in the table may result from deliberate over-design of emission control equipment to allow operation at increased throughput at some later date. In the case of an ESP, all other things being equal, lower outlet concentrations are achieved by adding collection plate area. This investment and related operating cost increase exponentially as the outlet concentration is decreased. It should be recognised that the least expensive way to increase collection area is at the time of the initial design, because retrofitting collection area requires changes to ductwork and adequate space is frequently not available.

It has to be noted that power boilers within the pulp and paper industry are of a very variable size (from 40GJ/h or less to above 800GJ/h). For the smaller ones only low-sulfur fuel and combustion technologies can be employed cost effectively while for the larger ones additional control measures like scrubbers are also cost effective.

The higher emission levels in Table 6 are considered AMT for smaller installations and are achieved when only quality fuel and good combustion technologies are applied. The lower emission levels (in parenthesis) are associated with additional control measures like scrubbers and are regarded as AMT for larger installations.

In a modern non-integrated mill the heat generated from black liquor and incineration of bark exceeds the energy required for the entire production process. However, fuel oil will be needed occasionally during start-up and also, in many mills, in the lime kiln.

Selected reported emissions to the atmosphere from Swedish BKP mills which are considered to have employed AMT are presented in Appendix D of the report entitled "Reported emissions to the atmosphere from Swedish bleached kraft pulp mills in 2002".

ACCEPTED MODERN TECHNOLOGY FOR THE REDUCTION AND HANDLING OF SOLID WASTE

Table 7 includes technologies that are considered AMT for the reduction and handling of solid waste.

Table 7 AMT for the reduction and handling of solid waste

<ul style="list-style-type: none"> Minimised generation of solid waste and recovery, recycle and reuse of these materials as far as possible
<ul style="list-style-type: none"> Separate collection of waste fractions at the source and, if necessary, intermediate storage of residuals/ waste to make possible an appropriate handling of the remaining waste products
<ul style="list-style-type: none"> Incineration of all non-hazardous organic material (e.g. bark, wood waste, effluent sludge) in a power boiler, specially designed for burning of moist, low calorific value fuels (e.g. a fluidised bed boiler). Biosludge may be burned in the recovery boiler. All material to be burned after pressing to the maximum possible consistency
<ul style="list-style-type: none"> Disposal of hazardous waste should be carried out by authorised firms only
<ul style="list-style-type: none"> Material that cannot be reused, recovered or has to be handled differently should be taken to a secure landfill facility. Only inert, primarily inorganic waste should be landfilled. All material to be landfilled after pressing to the maximum possible consistency. Organic waste should not be landfilled
<ul style="list-style-type: none"> Generation of dioxins and furans can occur in the convection back passes (the cooler sections) of power and recovery boilers. Depending on concentrations, dusts from these sections should be managed in the same way as other special wastes and not spread on land
<ul style="list-style-type: none"> Efficient washing of green liquor dregs prior to disposal to landfill, to minimise leaching of caustic
<ul style="list-style-type: none"> Efficient washing of lime mud prior to reuse in the lime kiln to minimise the formation of hydrogen sulfide (H₂S) during the mud drying process
<ul style="list-style-type: none"> External utilisation of residuals/ waste as substitutes in forestry, agriculture or other industries, if possible and subject to approval under the <i>Waste Management Regulations 2000</i>

Solid waste discharges for BKP mills employing BAT

It should be noted that there is little detailed and reliable information available on achievable amounts of solid wastes. There is a lack of statistical data and various terms for different waste fractions may be used. Some countries report only those solid wastes, primarily inorganic solid wastes, which can no longer be recycled or reused and have to be disposed of at a landfill.

This implies that some of the organic wastes which have a reasonable heating value and/or which can be burned without the risk of hazardous emissions in the power boiler of a mill are already excluded from the given solid waste amounts (bark and wood waste, primary and biosludge from effluent treatment). Hence, the solid waste disposed of at a landfill comprises mainly boiler ashes, green liquor dregs, lime mud, some wood and bark waste rejects and miscellaneous cleaning and mixed household-type wastes.

Therefore, it is difficult to present achievable values on the amount of non-hazardous solid waste. Table 8 shows the levels of solid waste to landfill that may be expected in kraft pulp mills that employ BAT. It is assumed that bark and other wood residues as well as the mixed sludge from effluent treatment are utilised for energy production in the power boiler. The waste amounts are all given as oven dry solids (100% DS).

Table 8 Typical solid waste to landfill from bleached kraft market pulp mills

Type of Waste	Amount kg DS/ADt
Lime mud	9.7
Green liquor dregs	8.1
Bio- & primary sludge	8.7
Reject (wood handling)	2.1
Wood ashes	3.9
Other	10.5
TOTAL	43.0

A small amount of hazardous waste is generated in all mills. Such waste includes oil and grease residues, used hydraulic and transformer oils, waste batteries and other scrap electrical equipment, solvents, paints, biocide and chemical residues. This type of waste normally amounts to about 0.05-0.1 kg/ADt of product [IPPC BREF, 2001].

Solids waste can vary considerably over the year depending on maintenance shuts, general cleanup activities, and other mill activities.

SIGNIFICANT MILESTONES AND TRENDS IN KRAFT PULPING TECHNOLOGY

Economies of scale

In general, economies of scale can be accomplished because as production increases, the cost of producing each additional unit falls through operational efficiencies.

Kraft fibrelines are no exception to this rule and their size has shown an increasingly faster rate of increase in the past 40 years. The trend is shown in Figure 1.

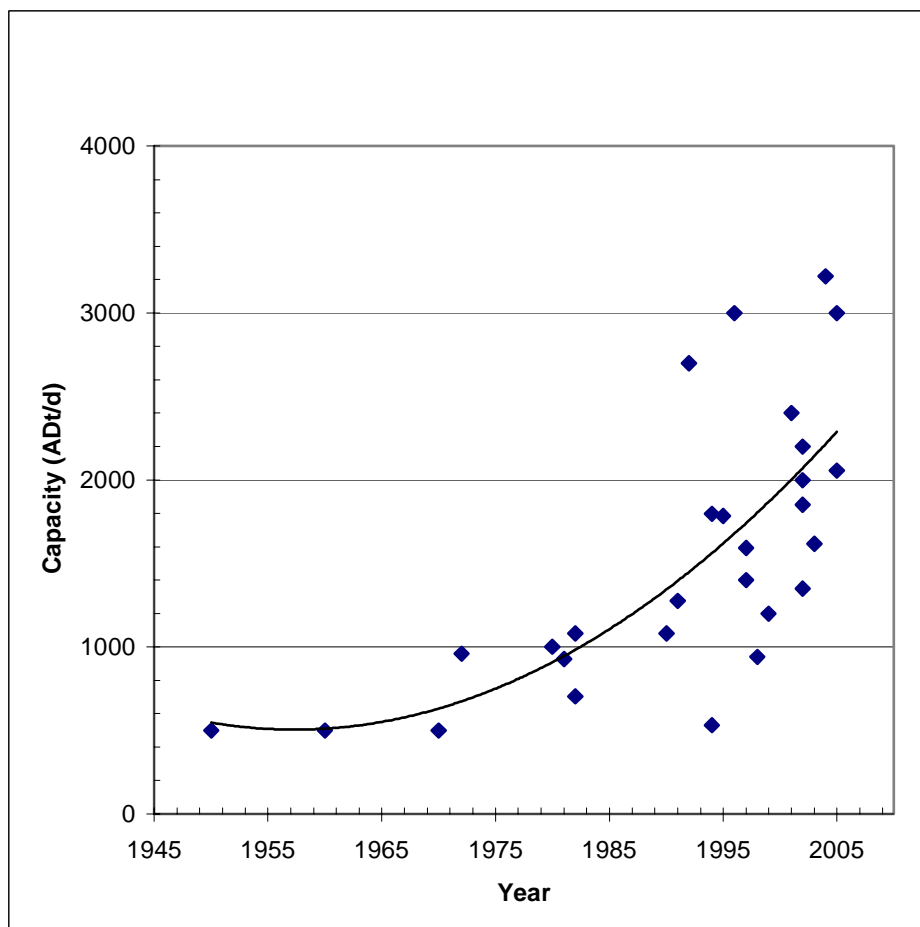


Figure 1 Chronological development of economy-of-scale size for kraft fibrelines (AMEC)

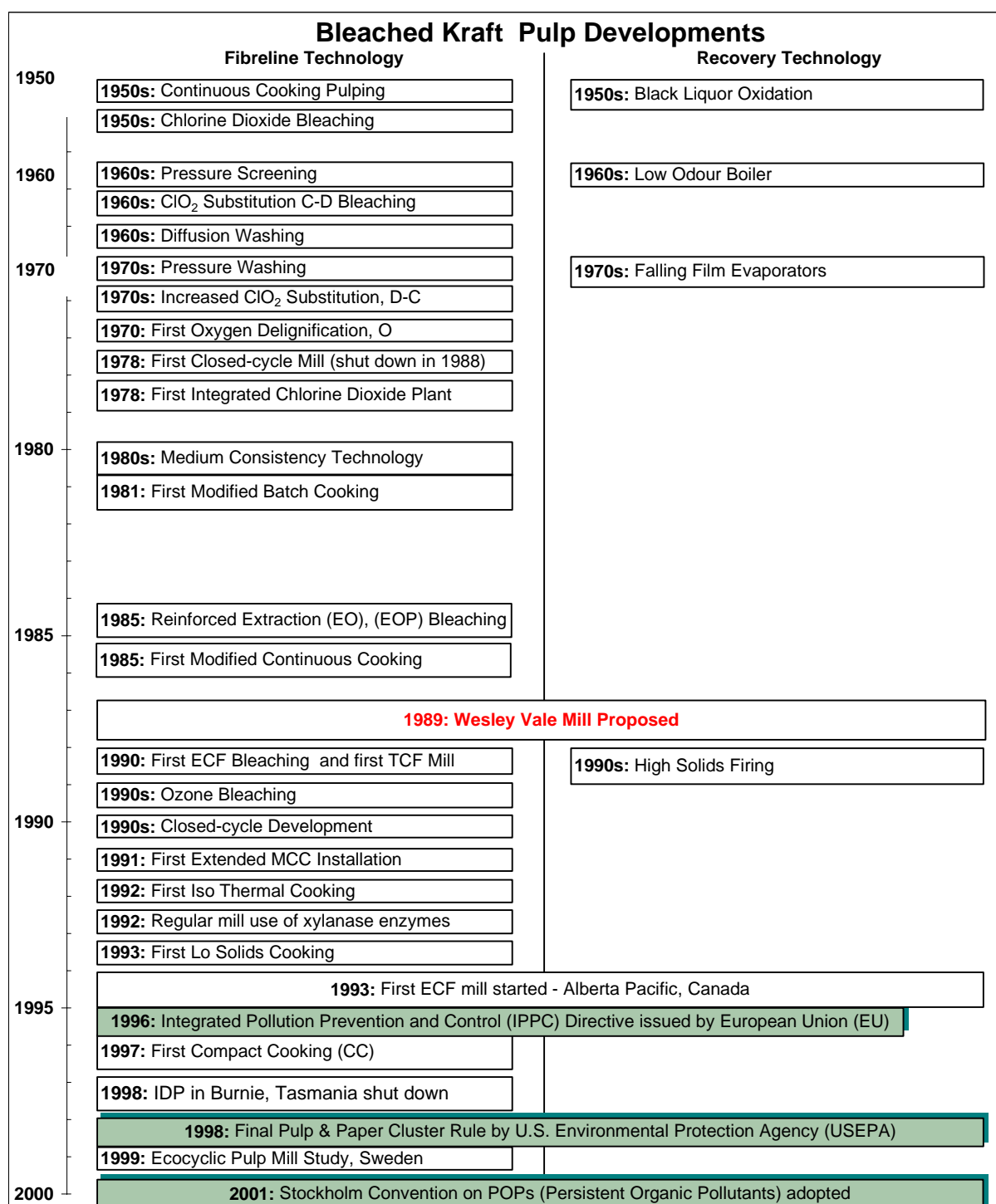
Fibrelines sizes of 2,500-3,000 ADt/d have been made possible by the development of a recovery boiler capable of burning in excess of 4,500 t/d dry solids.

Line C at the Aracruz Celulose bleached eucalypt kraft pulp mill in Barra do Riacho, Brazil, which started up in 2002, has a production capacity of up to 2,500 ADt/d. The total production capacity for the 3 lines at this site is approximately 6,300 ADt/d. This mill is depicted on the front page of this executive summary.

Significant milestones in pulping and bleaching technology

Table 9 includes some significant milestones in the development of kraft pulping and bleaching technology.

Table 9 Significant milestones in the development of kraft pulping and bleaching technology



Significant developments worth mentioning are:

- Low chlorine dioxide substitution for chlorine was practised in the 1960s in (CD) bleaching stages.
- Low-odour recovery boiler technology was available in the 1960s.
- Higher chlorine dioxide substitution for chlorine was practised in the 1970s in (DC) bleaching stages.
- Falling film evaporation technology was available the 1970s.
- The first oxygen delignification plant was started up in 1970.
- Great Lakes Paper Company in Thunder Bay, ON, Canada decided in 1978 to adopt a concept for bleached kraft mill process closure called the Rapson-Reeve Process, from the names of its developers. A major factor in taking that decision was the lack of sufficient space to install wastewater treatment facilities at the site. The mill operated in a partially closed manner for several years before the concept was abandoned in 1988 and a secondary treatment plant was installed. This pioneering effort clearly established the technical challenges that must be overcome to eliminate bleached kraft mill discharges [Stratton, 2003].
- The first modified batch cooking installation started up in 1981.
- The first modified continuous cooking installation started up in 1985.
- The first reinforced extraction bleaching stage, (EO) and (EOP), started up in 1985.
- ECF bleach plants began operating in 1990 in existing mills.
- The first mill employing TCF bleaching was Aspa Bruk in Sweden in 1990.
- High solids firing technology in the recovery boiler began being practised in the 1990s.
- The first purposely built bleached kraft pulp mill employing the ECF bleaching method and other AMT started up in 1993 at Alberta-Pacific, Boyle, AB, Canada.

These developments have had considerable impact on the reduction of emissions to the atmosphere and to the aquatic environment.

The chronology of these developments vis-à-vis the proposed pulp mill development at Wesley Vale in Tasmania in 1989 shows that the technology for minimised environmental impact from bleached kraft pulp mills had already made significant strides until then, however, ECF and TCF bleaching were, notably, not yet considered AMT.

TECHNOLOGY CHANGES THAT HAVE OCCURRED SINCE THE 1995 COMMONWEALTH GUIDELINES

The detailed discussions of AMT and emerging technologies/ future options made in Sections 2 and 3 of the report have highlighted a number of technology changes that have occurred since the publication of the 1995 Commonwealth Guidelines.

Because of the time lag that typically characterises the acceptance of any new or modified technology, most of the technology changes and developments that have occurred since 1995 are considered emerging technologies/ future options. Among these, developments in closed-cycle technologies have been particularly active.

The following sections outline technology changes and developments that have occurred since the publication of the 1995 Commonwealth Guidelines.

Technology changes in accepted modern technology

Compact cooking (CC™)

Kværner Pulping has developed a new chip feed system and a new cooking system called compact cooking. Details of the process have not been made public to maintain Kværner 's competitive position. Secrecy agreements with Kværner are required to fully understand their system. Therefore, any comments made in the report are not from full knowledge of the system details. Conversations with mill personnel have been helpful in gaining some understanding. The first installation was a retrofit at the Södra Cell Mönsterås bleached softwood/hardwood TCF market kraft pulp mill in Sweden in 1997, and the first purposely built plant was at the Stora Enso Celbi bleached eucalypt ECF market kraft pulp mill in Portugal in 1999.

At the beginning of 2004 there are 5 new and 6 rebuilt compact cooking installations worldwide.

Aerated lagoon treatment

Biological treatment in an aerated lagoon has in the past been a rather common alternative to the activated sludge process.

However, since the discharges of organic matter (measured as COD and BOD), suspended solids and nutrients are higher than those from modern activated sludge plants, this technology can no longer be regarded as AMT for a new mill.

Technology changes and developments in emerging technologies/ Future options

Hexenuronic acids

Approximately 75% of the hemicelluloses in hardwoods consists of *xylan* (4-*O*-methyl-*glucuronoarabinoxylan*). Under the kraft pulping conditions, xylan generates hexenuronic (4-*deoxy*- β -L-*threo*-4-*enopyranosyluronic*) acid groups (HexA) which form a considerable part of the residual oxidisable material after pulping (measured by the kappa number).

This had been recognised in the 1960s, e.g. [Clayton, 1962] and [Samuelson, 1967] but the full identification and verification of the occurrence of hexenuronoxylan during alkaline pulping was achieved only in the mid 1990s through nuclear magnetic resonance (NMR) spectroscopy [Buchert, 1995], [Teleman, 1996], [Dahlman, 1996].

Hardwood kraft pulps and especially eucalypt kraft pulps may contain high amounts of HexA, contrary to softwood kraft pulps.

HexA have adverse effects in bleaching. These include increased consumption of bleaching agents such as chlorine dioxide (ClO_2) and ozone (O_3) to reach target brightness, increased brightness reversion and contribution to formation and scaling of oxalates in bleaching equipment.

The HexA content in eucalypt kraft pulps can be lowered by extended cooking to a kappa number below 12 [Pedroso, 2003], but this can normally not be achieved in industrial practice. Such a low cooking kappa number in pulping of eucalypt would result in an excessive yield loss (excessive wood consumption) and low pulp bleachability.

Consequently, three other avenues have been explored for selective removal of HexA:

- Hot acid stage (A_{hot}) [Henricson, 1997], [Jiang, 2000].
- Combined hot acid and hot D stage ($(AD)_{\text{hot}}$) [Ragnar, 2002b].
- High temperature D stage also called hot D stage (designated D_{HT} or D_{hot}) [Lachenal, 2000], [Eiras, 2003], [Lindström, 2003].

A hot acid stage and a D stage at high temperature hydrolyse and remove HexA and therefore reduce the consumption of mainly chlorine dioxide (ClO_2) but also ozone (O_3), reduce the formation of AOX, decrease brightness reversion and may reduce problems with scaling of oxalate on bleaching equipment.

Despite the positive effects of A_{hot} , $(AD)_{\text{hot}}$ and D_{HT} , possible drawbacks are increased yield loss, decreased pulp viscosity/strength and refinability and increased COD content in bleach plant effluents.

The positive and negative effects of the three modes of "hot acid" or hot D stages vary considerably depending on the eucalypt species, the number of bleaching stages, the bleachability of the pulp and the conditions in pulping and bleaching.

Usually both the advantages and drawbacks are more accentuated for A_{hot} and $(AD)_{\text{hot}}$ than for D_{HT} .

There are a number of either stage in operation or coming into operation in BEKP mills. The rationale for, and effects from, the implementation of any of the stages must be evaluated from case to case.

Low-chlorine integrated chlorine dioxide plant

Small amounts of chlorinated organic compounds - such as polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF) - are formed in non-detectable or very low measurable levels in effluents from kraft pulp mills with ECF bleaching because:

- Chlorine dioxide produces small amounts of elemental chlorine when reacting with the pulp.
- Chlorine may be present in the chlorine dioxide solution, up to 0.22 kg Cl₂/kg ClO₂, depending on the generation method used.

As seen in Table 2 - AMT for the reduction of emissions to the aquatic environment, there are two AMT for the on-site generation of chlorine dioxide for ECF bleaching with low contamination of elemental chlorine:

- The methanol process (ERCO R8/ R10 and Cellchem SVP-Lite/ SVP-SCW).
- The hydrogen peroxide process (ERCO R11 and Cellchem SVP-HP).

Conventional integrated chlorine dioxide plants (IDP) - i.e. those where chlorine, electrical power and water are the only inputs to the IDP whereas sodium chlorate, acids, and reducing agents are not required as raw materials – typically generate chlorine dioxide solutions with 0.22 kg Cl₂/kg ClO₂.

The low-chlorine IDP is a recent development proposed by Chemetics, a division of Aker Kværner Canada Inc. of Vancouver, BC, Canada to address this deficiency [Ma, 2000]. Chemetics claims this type of plant generates chlorine dioxide solutions with 0.02 kg Cl₂/kg ClO₂.

Integrated chlorine dioxide plants (IDP) have higher capital cost than the non-integrated counterparts but have much lower operating costs.

Chemetics claims that the simple payback period for an IDP compared to a non-integrated alternative is 2.1 years [Ma, 2000].

While the benefits of IDP are proven, the low-chlorine capability is not and there are no installed IDP generating low-chlorine chlorine dioxide solution.

Chloride and potassium removal from the recovery cycle

The element chlorine enters a kraft mill as the chloride ion (Cl) with the wood and makeup chemicals such as sodium hydroxide (caustic). Chloride is extremely soluble in the alkaline liquors of the kraft cycle, and will accumulate there. Potassium (K) also enters with the wood. The typical Cl and K purge points in a mill include recovery boiler stack emissions, washing losses from brown stock or post-oxygen washing into the (open) bleach plant, and losses of green, white, and black liquors. Because process closure minimises such losses, Cl and K concentrations will increase unless alternative purge means are provided.

Increased concentrations of Cl and K in black liquor have a detrimental effect on recovery boiler capacity and efficiency, and can result in increased corrosion in the recovery boiler, if not controlled.

Several techniques have been developed to purge Cl and K by separating them from saltcake (Na_2SO_4) in the electrostatic precipitator (ESP) catch. Among these, the most recent are:

- Kværner has developed a leaching system in which a centrifuge is used to separate Na_2SO_4 from Cl and K and has an installation at the Aracruz, Brazil BEKP mill. There are also two Kværner systems being installed in Chile and one in China.
- The precipitator dust purification (PDP) process was jointly developed by the Pulp and Paper Research Institute of Canada (Paprican) and ProSep Technologies, Inc. of Canada. This process utilises ion exchange technology to generate a purged stream rich in NaCl and a recovered stream rich in Na_2CO_3 and Na_2SO_4 . Precipitator dust is dissolved in water and filtered prior to the ion exchange step. Water is used to regenerate the ion exchange resin. Laboratory development studies using precipitator dust from two mills showed efficiencies of more than 95% for Cl removal and of at least 85% for Na recovery. K was not significantly removed. The recovered stream would be directed to the black liquor evaporators [Jemaa, 1999].

Research programs

A number of research programs with a focus on minimum impact and sustainable, energy efficient pulp and paper manufacturing were undertaken in the 1990s, some of which continue today. Many of these are funded at national levels, and typically involve national pulp and paper research institutes. Notable programs include Sweden's ecocyclic mill research program (KAM), U.S. Department of Energy's agenda 2020, Finland's TEKES, and Progressive systems closure at Paprican.

The ecocyclic pulp mill – KAM program

The ecocyclic pulp mill or Krestsloppsanpassad massafabrik (KAM) program is an interdisciplinary research program funded by the Foundation for Strategic Environmental Research (MISTRA) and the Swedish Energy Agency (STEM). The program is also supported by the Swedish Pulp and Paper Research Foundation; Ångpanneföreningens Foundation for Research and Development; and the pulp and paper industry [KAM report A100, 2003].

The program was divided into two stages, KAM1 (1996-1999) and KAM2 (2000-2002). Its vision was a fully developed ecocyclic system for high quality paper products, with an efficient use of the potential biomass energy.

One aim of the program was the development of realistic and environmentally optimal solutions for the production of high-quality pulp and paper products which minimise the use of non-renewable resources and efficiently utilise the potential biomass energy. Another aim was the education of research scientists.

The focus was on the bleached softwood kraft pulp (BSKP) and bleached hardwood kraft pulp (BHKP) production processes.

Key issues were:

- Mineral balances.
- Minimisation of solid waste.
- Reduction of energy consumption.
- Utilisation of surplus energy.
- High degrees of system closure.
- Alternatives to the kraft process.

In each of the two stages, the base case, or starting point, for the analysis of these issues was a "reference mill", a hypothetical mill that employs the most recent and commercially available technologies (i.e. BAT), best management practices (BMP) and optimised process conditions.

These BAT, BMP and process conditions are employed on an individual basis in operating Swedish and Finnish bleached kraft pulp mills, however, they are not employed all at the same time in any single mill location². Consequently, the reference mill is a fictitious mill.

The Q(OP)(DQ)(PO) bleaching sequence was chosen for the reference mill. This sequence is powerful enough to reach high brightness targets and has a considerable flexibility in its use of hydrogen peroxide and chlorine dioxide. Similar TCF sequences with ozone or peracetic acid instead of chlorine dioxide, i.e. Q(OP)(ZQ)(PO) or Q(OP)(PaaQ)(PO), were studied. An important issue was a high degree of bleach plant closure.

The reference mill concept was similar in KAM1 and KAM2, with the exception of an increased spill recovery capability, a lower effluent load and a somewhat higher evaporation demand in KAM2.

As further improvements in the energy efficiency of the reference mill can be achieved through process integration, important focal points were changes in the secondary heat system and in the evaporation plant.

² Many of the techniques and measures included in the KAM program are considered AMT/ BPEM and are included in this executive summary and the report, however, quite a few are not included since it is believed that they cannot be considered AMT/ BPEM at present.

The KAM program compared 17 different future cases or “model mills” with a Reference Mill. The model mills built on the reference mill by including a number of emerging technologies/ future options³ having variable time frames for achieving BAT status. Consequently, it is apparent that the model mills are also fictitious mills.

The implementation of model mill technologies requires further development work. The KAM report concluded that the most important future issues may include:

- Higher pulp quality (alkaline sulfite) or good balance between pulp quality and yield (alkaline sulfite or polysulfide).
- Further decrease in the impacts on the aquatic environment (alternatives with a high degree of closure).
- Odour abatement (sulfur-free cooking).
- More efficient energy utilisation in the mill (pressurised black liquor gasification, with or without titanate auto-causticising, and increased heat integration).
- Efficient use of excess energy externally (surplus biomass energy from precipitated lignin, integration with an ethanol plant, black liquor gasification and methanol production and pressurised black liquor gasification for power generation).
- Lower generation of solid waste.

Table 10 on the following page presents the estimated time frames for the implementation of the emerging technologies/ future options studied in KAM1 and KAM2. These time frames are based on the reference mill as a starting point and the assumption that the emerging technologies/ future options have become technically effective and economically viable on an industrial scale for the production of bleached chemical pulp, i.e. BAT. The most important developments can be expected in the chemical recovery area.

³ See Section 3 - Emerging technologies/ Future options in the report for a definition of these technologies and options.

**Table 10 Time frames for the implementation of the emerging technologies/
Future options studied in KAM1 and KAM2**

	Short term 1-5 years	Medium term 5-10 years	Long term More than 10 years
Fibreline	Further development of black liquor pretreatment Polysulfide-AQ yield/strength optimisation (tear and tensile strength) Cooking chemical profiling (for optimal yield, refinability, and strength)	Chip leaching Very high closure of the water system	Alkaline sulfite cooking Simplified bleaching
Chemical and energy recovery	Condensing turbine power generation from excess energy Heat integration, primarily in black liquor evaporation Partial borate auto-causticising in regular operation	Sale of precipitated lignin Possibly black liquor gasification with power or methanol production No electrostatic precipitator ash discharge	Complete borate auto-causticising Black liquor gasification with power or methanol production Chemical recovery through gasification for alkaline sulfite cooking

Paprican

Paprican is leading the Canadian effort in system closure research. Paprican has expanded pilot plant facilities to develop system closure technologies. The recently constructed pilot plant facilities include an expanded bleaching pilot plant, a new pilot paper machine, a new mechanical pulping pilot plant, and several separation pilot units for evaluating system closure concepts.

Paprican's program in progressive system closure incorporates research, development, and mill implementation activities in the areas of water use reduction, improved prediction and design tools, dynamics and control, corrosion control, chemical separation and regeneration, removal and/or control of wood extractives, chemical additives, energy cost reduction, and management of solid and gaseous emissions [Voss, 2000], [Paleologou, 2001]. Paprican has current activities in system closure for mechanical pulp mills, chemical pulp mills, and paper machines.

Two benchmark criteria are applied to options investigated [Ramamurthy, 1998]:

- They should result in lower costs compared with current systems.
- They should help maintain or improve final product quality.

Kraft pulping process developments include improving oxygen delignification with peroxymonosulfate, use of laccase and other enzyme systems, development of efficient chelation and metal management strategies, integration of ozone stages in a low effluent fibreline, improvements in bleached pulp yield, ECF bleaching with reduced reliance on chlorine dioxide, and methods for hexenuronic acid removal.

The recently rebuilt bleaching pilot plant includes washing with filtrate recovery and can run chlorine dioxide, peroxide, ozone, and single and double oxygen bleaching stages, complete with filtrate recycle. Paprican has developed steady-state and dynamic simulation capability including pulp washer control, modelling of bleaching chemical consumptions, and dynamic modelling of bleaching upset conditions.

PROGRESS OF SOME ACCEPTED MODERN TECHNOLOGIES SINCE THE 1995 COMMONWEALTH GUIDELINES

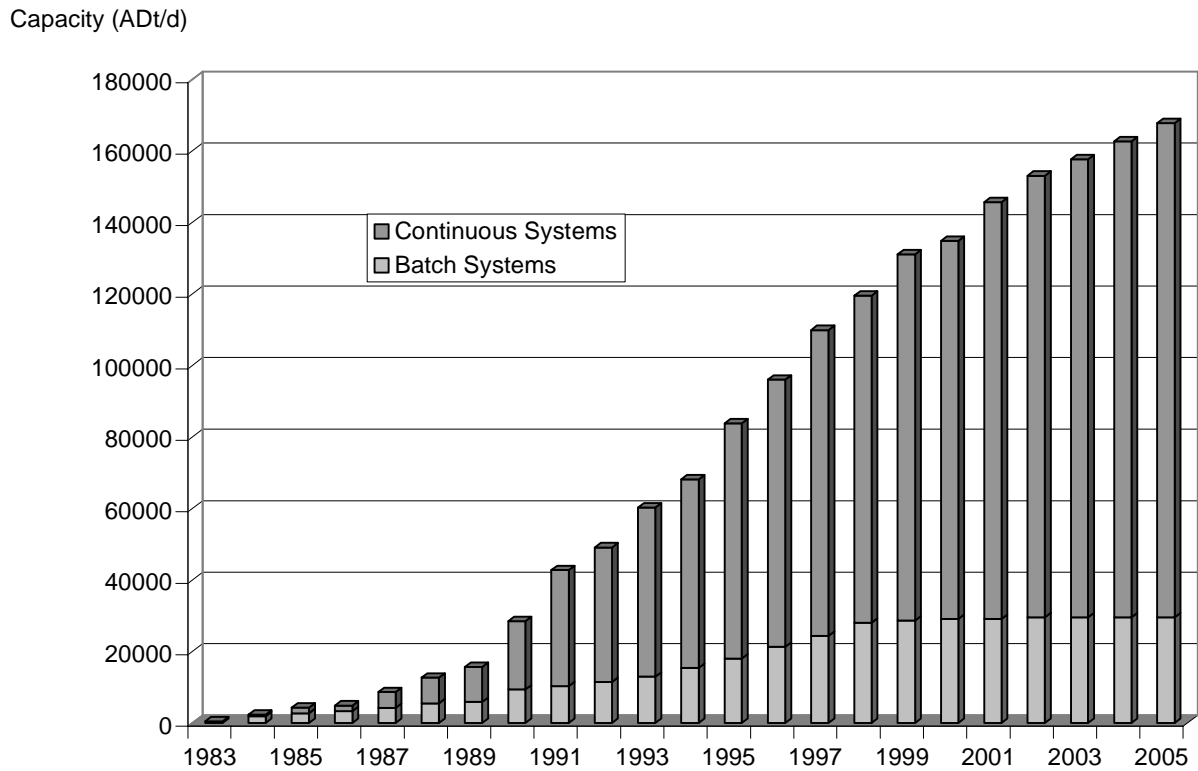
The detailed discussion of AMT made in the report has highlighted the following progress for some of the AMT that have occurred since the publication of the 1995 Commonwealth Guidelines.

Modified cooking

At the end of 1994, approximately when the Commonwealth Guidelines were issued, 59 continuous digesters were in operation, new or retrofitted, with some form of modified continuous cooking. At the beginning of 2004 there are more than 130 operating modified continuous digesters. The two main types of modified cooking systems for continuous digesters operating today are Lo Solids from Andritz and Compact Cooking from Kværner.

In total there are today 40 operating modified batch cooking systems, 14 of which have been installed since 1995, when the Commonwealth Guidelines were issued. None of these 14 installations employed new technology, although some minor process improvements have been made.

Figure 2 illustrates the acceptance of modified cooking in pulping for both batch and continuous digester systems.



Source: Beca AMEC, Vendors (February 2004)

Figure 2 World daily production capacity of pulp from modified cooking processes

Modified cooking is considered AMT in new continuous and batch digester installations. Currently there are about 131 continuous and 40 batch digester systems with modified cooking worldwide, capable of producing about 125,000 and 30,000 ADt/d of pulp. Modified cooking capacity increased more than five-fold during the 1990s, but has tapered off in recent years.

Figure 3 shows the market share of the various systems offered, based on system capacity.

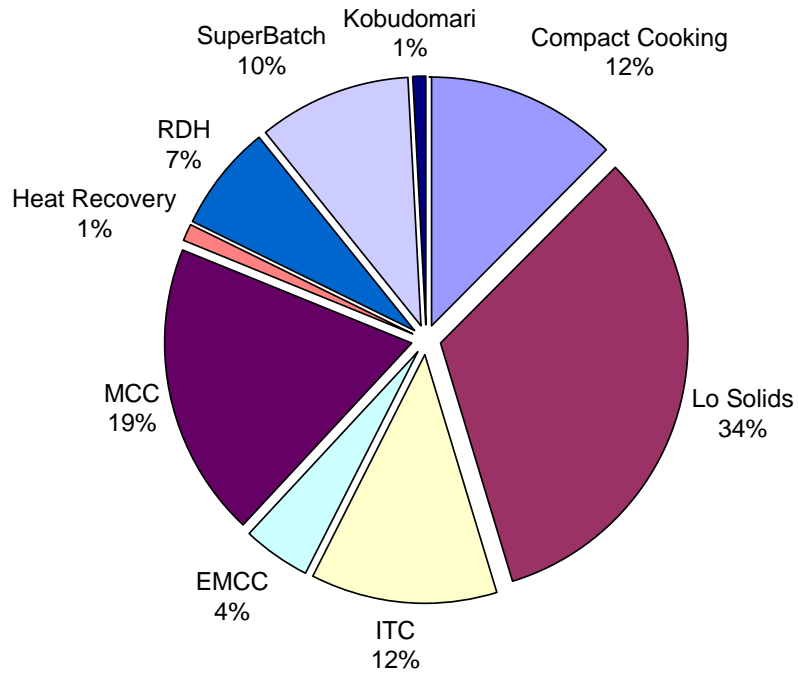


Figure 3 World market share of modified cooking processes

Oxygen delignification

Since 1995, the changes to oxygen delignification have not been major. There have been process condition changes which distinguish the systems provided by the different vendors, and pressure washers of new design which operate at medium consistency are the norm. The trend to medium consistency, two-stage installations has strengthened.

The industrial application of oxygen delignification has expanded very rapidly in recent years. In total today (2004), there are approximately 255 systems, 90% of which are processing kraft pulp. Figure 4 shows the trend.

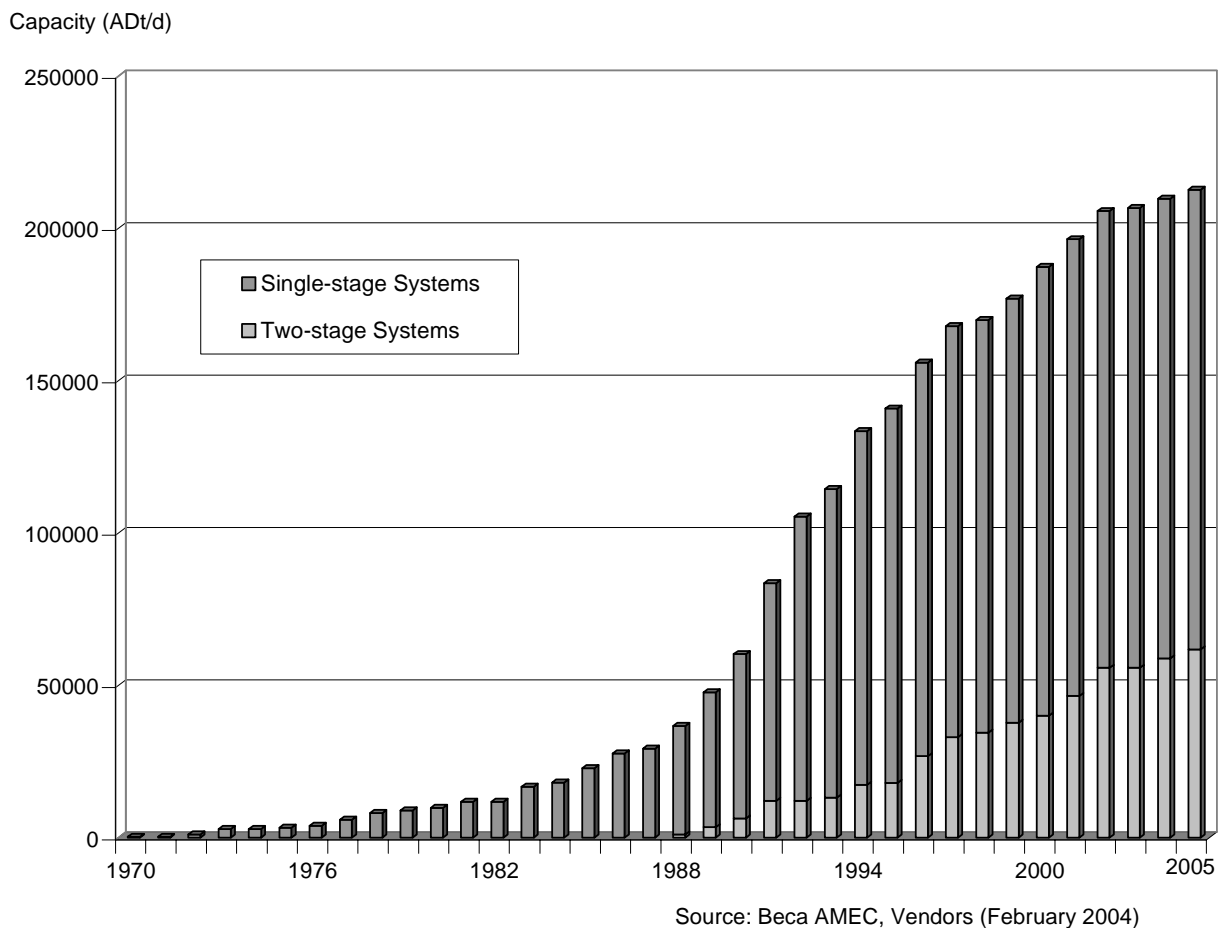


Figure 4 World daily production capacity of oxygen delignified pulp

New developments will continue to occur, which may include the use of pre-treatment, inter-stage washing, inter-stage treatments, catalysts, chelants and other enhancements, to further develop oxygen delignification performance.

In 2004, oxygen delignification is an essential part of any modern, low environmental impact fibreline. Virtually all new fibrelines incorporate oxygen delignification.

Bleaching strategies

Section 2.10 of the report outlines and compares the characteristics and features of ECF and TCF bleaching. That Section also compares ECF bleaching with the older elemental chlorine bleaching method.

A step change in the environmental impact of bleach plant effluents was made when elemental chlorine bleaching was completely eliminated and substituted by either ECF or TCF bleaching.

The progress made in ECF bleaching since 1995 includes process improvements in bleaching sequences which allow further reductions of the charge of chlorine dioxide while maintaining optical and strength properties. Examples of these process improvements include the ACF bleaching method at Aracruz Celulose Barra do Riacho, Brazil and VCF bleaching method on Line C at Votorantim Celulose e Papel Jacareí, Brazil.

ECF bleaching is today (2004) the dominant bleaching method worldwide (75% of total bleached kraft pulp production) and has been adopted in most new installations.

The market demand and production capacity for TCF pulp have remained constant in the last 5 to 10 years. At present (2004) about 5% of all bleached kraft pulp is TCF bleached and most of it is produced in Europe (mainly in the Nordic Countries with smaller amounts in Germany and Spain). Some TCF pulp is also produced in Brazil. The worldwide annual production of TCF pulp is estimated to be approximately 4 million tonnes (ÅF-Celpap).

The approximate total annual production of bleached kraft pulp in Sweden, Norway, Finland and Germany is 9.5 million tonnes of which about 2.5 million tonnes is TCF pulp, or about 25%.

A large proportion of the TCF pulp produced is sold in Germany, where the demand for paper that has been produced without the use of chlorine-containing chemicals is strong.

None of the known new or planned bleached kraft pulp mill installations is dedicated to the exclusive use of TCF bleaching technology, however, the bleach plant may, in some cases, have the built-in capability of carrying out both ECF and TCF bleaching sequences. Examples of this trend have been Aracruz Celulose Barra do Riacho, Brazil and Line B at Votorantim Celulose e Papel Jacareí, Brazil (ÅF-Celpap, Beca AMEC).

HIGHLIGHTS OF MAIN CONCLUSIONS OF ENVIRONMENTAL SIGNIFICANCE

Closed-cycle technologies

As of the beginning of 2004, there are no papergrade bleached kraft mills (using eucalypt or other raw material) that operate fully closed on a continuous basis, more specifically there are no bleach plants in papergrade bleached kraft mills that operate fully closed on a continuous basis.

The application of closed-cycle technologies to eucalypt processing was studied under the National Pulp Mills Research Program and reported in September 1994 [Galloway, 1994]. This included a review of current research work and computer based model development. Two conclusions of this study were that "implementing closed-cycle in a bleached eucalypt kraft mill would appear no less feasible for a mill using eucalypt than any other wood species" and also that as of 1994 "Closed-cycle technologies are not yet technically or commercially proven".

Today, almost 10 years later, although significant progress has been made, it appears that those conclusions are still valid.

The principal enabling elements for a closed-cycle bleached kraft pulp mill operation have been demonstrated or are in operation, for example brown stock system closure (both for continuous and upset conditions), recycle of debarking and wood preparation effluents, the recycle of bleaching effluents and foul condensate treatment. New technology has been introduced which facilitates kraft mill closure, but there are still areas where more development is needed.

Total system closure during pulp production, which theoretically makes an effluent-free pulp mill become a reality, is not yet possible because the non-process elements (NPE) which enter the process mostly with the wood, and to a lesser extent with the chemicals and the process water, accumulate in the process and must be purged out of the system.

New enabling technologies include low temperature evaporation for weak liquor, bleach plant effluent recovery, K and Cl removal and enhanced NPE removal.

These technologies have not yet been combined in a single mill. The incorporation of these emerging technologies in a single facility to achieve potential economic and environmental benefits should be carefully considered by carrying out a risk/ benefit analysis.

The approach taken by many mills is compatible with a future that may include closed-cycle operation. This includes:

- Attention to spill control and best environmental management practices.
- Water use identification and reduction.
- Reuse of water and effluent within the process (including separation and recycle of cooling waters from the process).
- Use of an ECF or TCF bleach plant.

-
- Consideration of recovery, evaporation and delignification constraints.

If a wider vision of ecological balance (which addresses yield, energy and other resource use) is sought, then higher degrees of closure may have a role to play, but approaches in which effluent discharge and treatment are retained may prove to better meet this goal.

Elemental chlorine and ECF bleaching technologies

The formation of AOX as well as of specific chlorinated organic compounds, such as polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF)⁴, in elemental chlorine bleaching is very dependent on the amount of chlorine used and, therefore, varies within wide ranges among mills still using chlorine in their bleaching sequences.

At present, AOX can typically range from about 1 to 8 kg/ADt in bleach plant effluents from mills adopting "chlorination", including old and "new" mills, with or without oxygen delignification, charging low or high amounts of chlorine and bleaching softwood or hardwood. The amount of PCDD and PCDF can also vary within a wide range because of the same contributing factors.

The United Nations Environment Programme (UNEP) has prepared a "Standardized toolkit for identification and quantification of dioxin and furan releases", which aims to assist countries in establishing release inventories [UNEP/ PCDD and PCDF, 2003]. The Toolkit includes "default" emission factors for different sources and activities, which could be used by countries with no or limited PCDD/ PCDF emission data. This Toolkit should be used in the first screening and order-of-magnitude estimates of the scale of potential PCDD/ PCDF sources and releases.

The "default" emission factor "set" by UNEP in untreated bleach plant effluent (i.e. prior to secondary treatment) for elemental chlorine bleaching of kraft pulp is 9 µg TEQ⁵/ADt bleached pulp [UNEP/ PCDD and PCDF, 2003]. This figure is somewhat conservative and is relevant for mills with relatively high charges of chlorine. If low charges of chlorine are applied, the levels of PCDD/ PCDF are much lower in the untreated bleach plant effluent, e.g. 0.02-1 µg TEQ/ADt bleached pulp [SSVL, 1991].

The "default" emission factor "set" by UNEP in untreated bleach plant effluent for ECF and TCF bleaching of kraft pulp is 0.26 µg TEQ/ADt bleached pulp [UNEP/ PCDD and PCDF, 2003].

The potential for formation of PCDD/PCDF in elemental chlorine bleaching of kraft pulp with relatively high charges of chlorine is approximately 35 times higher than that in ECF or TCF bleaching but can be of the same order of magnitude if low charges of chlorine are applied.

UNEP does not differentiate between ECF and TCF bleaching with respect to the possible formation of PCDD/ PCDF, however, PCDD and PCDF may be present in non-detectable or lower measurable levels than those indicated by the UNEP emission factor in effluents from kraft pulp mills with either ECF or TCF bleaching [SSVL, 1991], [UNEP/ PCDD and PCDF, 2003].

⁴ PCDD/ PCDF refer to all 2,3,7,8-substituted congeners of polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans.

⁵ Toxicity equivalent.

The content of AOX in bleach plant effluents from ECF bleaching is usually in the range 0.2-1.0 kg/ADt. Secondary effluent treatment can reduce the amount of AOX generated in bleaching by 40-65%.

Specific chlorinated compounds, such as PCDD and PCDF are formed in non-detectable or very low measurable levels in ECF bleaching. Thus the releases of PCDD and PCDF are non-detectable or very low with ECF bleach plant effluents [SSVL, 1991], [UNEP/PCDD & PCDF, 2003].

Chlorine dioxide primarily reacts with the pulp (lignin) through oxidation. Consequently, much less substituted chlorinated organic compounds are generated in ECF bleaching compared to bleaching with elemental chlorine.

Small amounts of chlorinated organic matter or specific compounds (such as AOX, PCDD and PCDF) are formed in ECF bleaching mainly because:

- Chlorine dioxide produces small amounts of elemental chlorine when reacting with the pulp.
- Chlorine may be present in the chlorine dioxide solution, up to 0.22 kg Cl₂/kg ClO₂, depending on the generation method used.

These small amounts of elemental chlorine, mostly in the form of hypochlorous acid (HOCl) at the prevailing bleaching conditions, are then capable of generating correspondingly small amounts of substituted chlorinated organic compounds.

Naturally occurring organochlorine levels

Several chlorophenolic isomers with biogenic origin have also been isolated. Studies in Sweden [Grimvall, 1994] have demonstrated that 2,4,6-trichlorophenol and its methylated analogue 2,4,6-trichloroanisole are ubiquitous in humus-rich waters and formed by the action of microorganisms. While chlorophenols are produced in ECF bleaching, they are usually less chlorinated than these naturally occurring compounds. Therefore, it is not surprising that organisms possess mechanisms for their effective breakdown, and some degradation products from naturally occurring chlorinated lignin are similar to those found in bleached kraft mill effluents [Dahlman, 1993].

Consequently, chlorinated compounds formed during ECF bleaching are biologically degradable in the environment. Pulp mill AOX will ultimately be mineralised through photochemical and biological processes and during mineralisation the chlorinated organic material will be released as chloride and carbon dioxide (CO₂) [Archibald, 1997].

Many studies have been carried out to assess the geographical distribution of natural surface waters and related AOX levels. In studies summarised by Tana *et al.*, levels of AOX from 1 to 80 µg/L were found in aquifers unaffected by human activities [Tana, 1996]. The sometimes very high background concentrations of AOX in water bodies are illustrated by a frequency distribution diagram based on 134 Swedish lakes that have no known point source of AOX. Concentrations of AOX ranging from 11 to 185 µg/L were found [Asplund, 1992].

The highest AOX concentrations were found in humus-rich, oligotrophic (pristine) lakes in remote areas. These concentrations were comparable to those in industrially polluted waters such as the Rhine River, where AOX concentrations ranging from 5 to 200 µg/L have been measured.

An investigation was carried out in 1991 on the concentrations of AOX in Lake Vättern, Sweden and a pristine tributary of this lake. A bleached pulp mill using conventional chlorine gas bleaching was discharging its effluent into this lake. Despite this, the mean AOX concentration in the pristine tributary was higher than that in the lake (32 µg/L in the tributary, 15 µg/L in the lake) [Grimvall, 1991].

The background concentrations of extractable organic chlorides (EOCI) in surface sediments from the Baltic Sea are reported in [SEPA, 1989]. This publication states:

“It appears to be reasonable to consider concentrations of 10-30 µg EOCl/g IG (ignition loss or organic matter) as normal background levels for surface sediment of widely different origin and composition. It is not possible to identify any geographical variation depending on where in Sweden the samples have been taken. The sediment from marine fiords has the same levels of EOCl as sediment from small and large lakes”.

Wulff *et al.* analysed EOCl levels in water along the Swedish Coast and in deep Baltic Sea waters. From a correlation between EOCl and AOX in water presented in their publication, the calculated concentrations of AOX varied from 4 to 31 µg/L [Wulff, 1993].

These background concentrations are of the same order of magnitude of those measurable at the edge of the mixing zone for BEKP using ECF bleaching and employing AMT/ BPEM.

TCF bleaching technology

In TCF bleaching the formation of AOX is usually non-detectable.

Specific chlorinated compounds, such as PCDD and PCDF may be present in non-detectable or at very low measurable levels in effluents from kraft pulp mills with TCF bleaching [UNEP/ PCDD & PCDF, 2003].

The United Nations Environment Programme (UNEP) considers the ECF and TCF bleaching methods to be equivalent with respect to their potential formation of PCDD and PCDF [UNEP/ PCDD & PCDF, 2003].

PCDD and PCDF may be detected in effluents from kraft pulp mills with TCF bleaching at the same levels as in effluents from kraft pulp mills with ECF bleaching because additives, such as defoamers and surfactants, contaminated with dibenzo-p-dioxins and dibenzofurans may be used.

TCF bleaching can be regarded as an established technology and as AMT. However, TCF pulp production usually results in higher production costs and the same or inferior pulp quality compared to ECF pulp production.

Bleach plant effluent recycle to chemical recovery

Currently, ECF effluents cannot be easily recycled to chemical recovery due to the build-up of chloride ions (Cl^-) and in some cases potassium (K), and scaling/deposition of organic and inorganic compounds.

Since TCF bleach effluents contain virtually no chloride, the problems associated with chloride in TCF bleaching are less than those in ECF bleaching when bleach plant effluent is recycled. However, the difficulty in managing the problems with NPE (need for their control and removal) and with increased concentrations of organic and inorganic compounds is the same or greater in TCF bleaching when compared with ECF bleaching since NPE have a greater impact on pulp quality and brightness in TCF bleaching. ECF and TCF bleaching are, to a great extent, alike from this point of view.

Odorous non condensable gases

Emissions to the atmosphere from kraft mills smell because odorous gases containing reduced sulfur compounds (TRS) such as hydrogen sulfide (H_2S), methyl mercaptan (CH_3SH), dimethylsulfide (CH_3SCH_3) and dimethyldisulfide (CH_3SSCH_3) are produced at various points in the kraft pulping process. The sulfur originates mainly from the sodium sulfide (Na_2S), which is one of the active cooking chemicals.

Modern kraft mills mitigate odorous emissions by employing AMT such as:

- Collection and incineration of concentrated non condensable gases (CNCG) in either the recovery boiler or a standalone low- NO_x incinerator.
- Backup system for the CNCG - which is activated during upsets, maintenance or other downtimes of the main system - consisting of:
 - A flare/ incinerator and secondary incineration unit (e.g. the lime kiln), or
 - A pre-purged alternative disposal point immediately available with interlocks permitted to allow switching without venting (bump less transfer) to a power boiler.
- Collection and incineration of dilute NCG (DNCG) in the recovery boiler after their addition to its secondary or tertiary combustion air.
- Methanol recovery from the foul condensate stripper off-gases.
- For the recovery boiler: computerised combustion control and carbon monoxide (CO) measurement.
- For the lime kiln: control of the excess oxygen, use of low-sulfur fuel, and control of the residual soluble sodium in the lime mud fed to the kiln.
- Spot monitoring program carried out by measuring odour with a mobile gas chromatograph - mass spectrometer (GC-MS). Testing will be more frequent initially and less frequent later in the program.

EXISTING SUPRA-NATIONAL, NATIONAL AND SUB-NATIONAL GUIDANCE

Section 4 of the report presents a summary of current guidelines and standards applied to new bleached kraft pulp mills in Europe and North America.

Current guidelines and standards for emissions to the atmosphere and the aquatic environment are reviewed for:

- The European Union.
- The United Nations Environment Programme.
- European countries (Austria, Finland, France, Germany and Sweden).
- United States of America.
- Canada.
- World Bank Group.

Section 4 also presents effluent variability factors and monitoring frequencies used in several jurisdictions, as well as a brief discussion on greenhouse gases.

Except for Portugal and Spain, pulp mills in Europe and North America do not generally utilise eucalypt as a source of fibre. However, guidelines and standards applied to new bleached kraft pulp mills using hardwood as a fibre source should provide a suitable benchmark for similar mills using eucalypt as a fibre source.

The Alberta-Pacific bleached aspen and pine kraft pulp mill in Boyle, AB, Canada is considered a suitable benchmark because 85% of its production is from hardwood and it has employed BPEM and AMT for the reduction of emissions to the aquatic environment. Al-Pac was the first purposely built ECF mill in the world.

A comparative table of some of the national and sub-national emission limits is presented in Appendix F of the report entitled "Emission Limit Comparison for Selected Jurisdictions".

RECOMMENDED ENVIRONMENTAL GUIDELINES FOR ANY NEW BLEACHED EUCALYPT KRAFT PULP MILL IN TASMANIA

Section 5 of the report presents recommended guidelines for emissions to the atmosphere and the aquatic environment for any new bleached eucalypt kraft pulp mill proposed to be built in Tasmania (Tasmanian Guidelines).

The recommended Tasmanian Guidelines are technology-based guidelines and minimum standards that any new BEKP mill employing ATM/ BPEM should meet, however, they do not take into account the environmental or social conditions at the site or sites proposed for the pulp mill development. The socio-environmental impact of the proposed mill will need to be assessed to determine whether these guidelines are sufficient to protect the environment or more stringent discharge limits are necessary.

Approval for construction will depend on the successful completion of an environmental impact statement (EIS) which examines a wider range of impacts than those included in these guidelines.

The emission guidelines defined below are based on the use of AMT and BPEM for the production of market grade bleached eucalypt kraft pulp that have been demonstrated to be technically effective and economically viable on an industrial scale for minimising the discharge of pollutants from the pulp mill to the environment. The treated liquid effluent from such a mill is intended to have a marine (ocean) discharge.

The combination of these technologies and practices (also called "techniques" or "measures"), or subsequently developed alternate techniques which produce similar or superior results, should be included in any new bleached eucalypt kraft pulp mill proposed to be built in Tasmania.

Once a mill is built, the only justification for requiring modifications for environmental reasons to the limits included in the mill Permit, should be that a significant impact has been identified.

Emissions to the aquatic environment

Table 11 lists the recommended monthly average and daily limits for biologically treated effluent at the point of discharge.

Table 11 Monthly average and daily discharge limits

Parameter	Units	Monthly average maximum	Daily maximum
TSS	kg/ADt	2.6	4.5
BOD ₅	kg/ADt	2.1	3.6
COD	kg/ADt	20	34
AOX ^a	kg/ADt	0.2	0.4
Colour	kg/ADt	42	72
Notes: a. These limits are not applicable to BEKP mills employing a TCF bleaching sequence.			

Notwithstanding the recommended colour limits, any proponent of a BEKP mill to be built in Tasmania should ensure that the colour emissions will not affect the visual amenity of the local beaches and environs.

Table 12 on the following page lists additional parameters, and their discharge limits, which should be included in the effluent Permit. These discharge limits apply to each individual effluent sample analysed and are not averaged. The effluent sample should be taken at the point of discharge and should exclude any uncontaminated water (such as indirect cooling water).

Table 12 Discharge limits for each effluent sample analysed

Parameter	Units	Value
Acute toxicity (LC ₅₀ /EC ₅₀) ^a	%	100
Chronic toxicity (EC ₅₀) ^b	%	Range of dilutions
2,3,7,8-TCDD	pg/L	10
2,3,7,8-TCDF	pg/L	30
Chlorate ^c	mg/L	10
Oil and grease	-	No visible contamination

Notes:

a) Acute toxicity should be measured in 100% effluent. The effect from the effluent should be less than 50%.

b) Chronic toxicity should be measured in effluent at various dilutions above and below the dilution expected at the edge of the mixing zone. The concentration at which a 50% effect is obtained should be determined. The lowest observed effect concentration (LOEC) and the no observed effect concentration (NOEC) should also be determined.

c) This limit is not applicable to BEKP mills employing a TCF bleaching sequence.

The table entitled "Recommended limits for the Tasmanian Guidelines" included in Appendix A of this executive summary is a synoptic table of the recommended discharge limits for pollutants emitted to the aquatic environment and atmosphere from BEKP mills. This table also includes the rationale for the limits, the rationale for the testing frequencies and the recommended test methods for the pollutants.

Emissions to the atmosphere

Concentration limits for specified emission points are only given for:

- Particulate matter (PM) for recovery boiler, lime kiln and power boiler.
- Total reduced sulfur (TRS) expressed as hydrogen sulfide (H₂S) for recovery boiler, lime kiln and CNCG incinerator that must not be exceeded for a given percentage of the operating time.
- Nitrogen oxides (NO_x) expressed as nitrogen dioxide (NO₂) for the power boiler.
- Polychlorinated dibenzo-*p*-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF) for recovery boiler, lime kiln and power boiler.
- Inorganic chlorinated compounds expressed as chlorine (Cl₂) for all sources.

The oxygen reference levels⁶ for combustion sources differ from those included in the 1995 Commonwealth Guidelines. According to Swedish practice, it is recommended that these reference levels be as close as possible to the actual operating conditions.

⁶ The concentration of contaminants in a gaseous stream is generally referenced to a particular oxygen content of the stream in order to fix the amount of air that might be added to the emission as a diluent.

Oxygen reference levels of 3% O₂ for all sources except the power boiler and 8% O₂ for the power boiler are recommended.

Millwide limits for sulfur and NO_x emissions from all sources excluding power boiler are given in kilograms per air dry metric tonne (kg/ADt). As presented in Section 4.3.1 – Swedish air emission limits for kraft pulp mills and Section 4.3.2 – Finnish air emission limits for kraft pulp mills in the report, the advantage of this approach for the Regulator is that all emission points in a mill are covered, including lower-strength point sources. There are advantages also for the mill, as there is room for optimisation of the techniques aimed at reducing the emissions, i.e. the mill can concentrate its efforts where they give the best results.

Total reduced sulfur, sulfur dioxide (SO₂), sulfur trioxide (SO₃), sulfuric acid mist and odour are included in millwide sulfur from all sources excluding power boiler. Nitrogen oxides are included in millwide NO_x from all sources excluding power boiler. Hydrogen chloride (HCl) from all sources is included in inorganic chlorinated compounds expressed as chlorine (Cl₂) for all sources.

The emission of SO₂ from the power boiler depends on fuel sulfur content and is not included in millwide sulfur from all sources. The emission of NO_x from the power boiler is not included in millwide NO_x from all sources.

In-plant air emission levels should also meet relevant Occupational Health and Safety criteria.

The recommended emission limits to the atmosphere are presented in Table 13 on the following pages.

Table 13 Emission limits to the atmosphere

Emission point	Pollutant	Units ^a	Annual average	Monthly average	Testing frequency
Recovery boiler	PM ^b	mg/NDm ³		50 @ 3% O ₂	See note s)
	TRS	mg H ₂ S/NDm ³		7 @ 3% O ₂ for >99% of the time See notes c) and d)	Continuous
	NO _x	mg NO ₂ /NDm ³		See note e)	Continuous
	SO ₂	mg S/NDm ³		See note d)	Continuous
	PCDD/PCDF	pg I-TEQ/NDm ³		100 @ 3% O ₂	See note p)
Lime kiln	PM	mg/NDm ³		40 @ 3% O ₂	See note s)
	TRS	mg H ₂ S/NDm ³		16 @ 3% O ₂ for >95% of the time See notes c) and d)	Continuous
	NO _x	mg NO ₂ /NDm ³		See note e)	Continuous
	SO ₂	mg S/NDm ³		See note d)	Continuous
	PCDD/PCDF	pg I-TEQ/NDm ³		100 @ 3% O ₂	See note p)

Table 13 Emission limits to the atmosphere (continued)

Emission point	Pollutant	Units	Annual average	Monthly average	Testing frequency
CNCG incinerator ^{f)}	TRS	mg H ₂ S/NDm ³		7 @ 3% O ₂ for >99% of the time See notes c), d) and r)	Continuous
	NO _x	mg NO ₂ /NDm ³		See note e)	Continuous
	SO ₂	mg S/NDm ³		See note d)	Continuous
	SO ₂ +SO ₃	mg S/NDm ³		See note d)	Twice yearly
	H ₂ SO ₄ mist	mg SO ₃ /NDm ³		See note d)	Twice yearly
CNCG emergency incinerator ^{g)}	TRS	mg H ₂ S/NDm ³		See note d) and r)	To be calculated ^{o)}
	NO _x	mg NO ₂ /NDm ³		See note e)	To be calculated ^{o)}
	SO ₂	mg S/NDm ³		See note d)	To be calculated ^{o)}
	SO ₂ +SO ₃	mg S/NDm ³		See note d)	To be calculated ^{o)}
Power boiler	PM	mg/NDm ³		30 @ 8% O ₂	See note s)
	NO _x	mg NO ₂ /MJ fuel input		80 See note h)	Continuous
		mg NO ₂ /NDm ³		~200 @ 8% O ₂ ⁱ⁾	
	SO ₂	mg S/NDm ³		See note j)	Continuous
	PCDD/PCDF	pg I-TEQ/NDm ³		100 @ 8% O ₂	See note p)

Table 13 Emission limits to the atmosphere (continued)

Emission point	Pollutant	Units	Annual average	Monthly average	Testing frequency
All sources	Sulfur	kg S/ADt	0.4	See note k)	Continuous & manual
All sources	NO _x	kg NO ₂ /ADt	1.3	See note l)	Continuous & manual
All sources	H ₂ SO ₄ mist	mg SO ₃ /NDm ³		See note d)	Twice yearly
All sources	Hydrogen chloride (HCl)	mg HCl/NDm ³		See note m)	Continuous
All sources	Odour	mg H ₂ S/NDm ³		See note d)	See note n)
All sources	Inorganic chlorinated compounds	mg Cl ₂ /NDm ³		50	Continuous

Notes:

- a. NDm³ = Normal cubic metre of dry gas, measured at atmospheric pressure (101.325 kPa) and 273.15 K (0°C).
- b. PM = Total particulate matter.
- c. For >95% (99%) of the time = the limit can be exceeded for a total of ~36 (7) hours in a month.
- d. Included in millwide sulfur from all sources excluding power boiler.
- e. Included in millwide NO_x from all sources excluding power boiler.
- f. The CNCG incinerator does not emit significant amounts of PM.
- g. ÅF-Celpap believes the CNCG emergency incinerator need not be regulated.
- h. Not included in millwide NO_x from all sources.
- i. Recalculated for a 8% O₂ reference level.
- j. Dependent on fuel sulfur content. Not included in millwide sulfur from all sources.
- k. Includes lower-strength sulfur point sources.
- l. Includes lower-strength NO_x point sources.

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- m. Included in inorganic chlorinated compounds from all sources.
 - n. Depending on results of spot monitoring program carried out by measuring odour with a mobile gas chromatograph/ mass spectrometer (GC-MS) or instrumentation of equivalent sensitivity. Results to be added to the results from continuous emission monitoring (CEM). The proponent will be required to conduct an odour monitoring program 12 months into full operation of the mill. The frequency of this testing will depend on the number of reported odour events. Testing will be more frequent initially and less frequent later in the program.
 - o. From the CNCG emergency incinerator sulfur and nitrogen loads and the operating time.
 - p. Quarterly in the first year of operation, twice yearly thereafter. Average value over sampling period of 4-8 hours.
 - q. With the exception of odour and PCDD/PCDF, test methods for all emissions to the atmosphere will be in accordance with USA Code of Federal Regulations: Title 40 part 60, Appendix A or equivalent.

The test method for odour will rely on the establishment of a panel of at least 10 local residents, to be agreed by the Tasmanian regulatory authority, and supported by the spot monitoring program carried out by measuring odour with a GC-MS or instrumentation of equivalent sensitivity.

The test method for PCDD/PCDF will be European Standard (CEN or Comité Européen de Normalisation) method EN 1948:1997 with sampling period of 4 hours minimum and 8 hours maximum.

- r. As the CNCG incinerator and CNCG emergency incinerator can be sources of odour at times of process instability, it is strongly recommended that the stacks for these incinerators be taken to the same height as the recovery boiler stack to facilitate optimum dispersion of any adventitious TRS release. Furthermore, it is good practice for the lime kiln and the power boiler stacks to be taken to the same height as the recovery boiler stack. If practical, these stacks should be supported by a common structure.
- s. Manual testing carried out initially once a month and less frequently later depending on results.

The table entitled “Recommended limits for the Tasmanian Guidelines” included in Appendix A of this executive summary is a synoptic table of the recommended discharge limits for pollutants emitted to the aquatic environment and atmosphere from BEKP mills. This table also includes the rationale for the limits, the rationale for the testing frequencies and the recommended test methods for the pollutants.

Emission limit comparison

The table entitled “Emission limit comparison between recommended Tasmanian Guidelines and 1995 Commonwealth Guidelines” included in Appendix B of this executive summary is a synoptic table that allows a direct comparison between the emission limits of the recommended Tasmanian Guidelines and those of the 1995 Commonwealth Guidelines.