

report

# Air Permit Technical Review on the Carter Holt Harvey Tasman Kraft Pulp Mill

prepared for  
Environment Bay of Plenty



June 2006

▪ Report

# **Air Permit Technical Review on the Carter Holt Harvey Tasman Kraft Pulp Mill**

Prepared for  
Environment Bay of Plenty  
for  
Carter Holt Harvey Tasman Limited

By  
Beca AMEC Limited

June 2006

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# 1 Summary

This document describes the current air emissions controls at the Kawerau kraft pulp mill of Carter Holt Harvey Tasman (CHH Tasman), and compares it with mills of a similar age and configuration as well as state-of-the-art mills, both in terms of technology used and emission performance itself. The emissions considered are particulate matter (PM), total reduced sulphur (TRS), chlorine and chlorine dioxide ( $\text{Cl}_2$  /  $\text{ClO}_2$ ), and polychlorinated dibenzo-p-dioxins and polychlorinated dibenzo-furans (PCDD/F). The PCDD/F are primarily emitted from the main combustion sources.

In general, CHH Tasman emission performance is consistent with mills of a similar age and the compliance with the permits is generally very good. In keeping with most mills of comparable age, CHH Tasman mill has over the years made numerous equipment upgrades and improvements to all the important areas of the mill and the generally good air emission control performance bears this out.

Technology and emission performance gaps with mills of comparable age and technology as well as state-of-the-art more recent mills today are summarized as follows:

**Woodyard, Chips and Woodwaste** In its use of belt conveyors in the kraft mill, CHH Tasman is more advanced than mills of a comparable age and is essentially comparable to state-of-the-art technology. CHH Tasman's belt conveyors have a skirt extending below the conveyor rollers to reduce the effect of cross winds that can blow fine material off the belt and create a source of PM emissions.

**Digester, Brownstock and Oxygen Delignification** CHH Tasman has a concentrated non-condensable gas (NCG) system and is more advanced than mills of a comparable age in that the No.2 continuous digester (CD2) chip bin Total Reduced Sulphur (TRS) gases are also treated in a scrubber before discharge to atmosphere. To provide state-of-the-art TRS control, a new dilute NCG system would have to be installed with two separate incineration destinations.

**No 2 Bleach Plant, Bleach Chemical Preparation and PulpMachines** All these areas have no significant gaps with mills of a comparable age in terms of  $\text{Cl}_2$  and  $\text{ClO}_2$  air emissions.

**Recovery Boiler** The No. 2 Recovery Boiler PM and average TRS levels at CHH Tasman are generally in line with comparable mills. The SBLOX plant emission control system with scrubbing and the tertiary air system of the No. 2 Recovery Boiler brings the CHH Tasman mill to a higher technical level in terms of TRS control than many mills of comparable age. PCDD/F emissions are consistent with those from recovery boilers of comparable age.

**Smelt Dissolver Vents.** There does not appear to be any significant gap with comparable or state-of-the-art mills based on average PM and TRS emission performance. Relative to other sources, PCDD/F emissions are usually small and these two sources have not been sampled.

**Evaporators and Stripper** NCGs from the Crude Tall Oil plant are now collected and piped to the inlet pipe to the SBLOX scrubbers for treatment which is not normally included in mills of comparable age. The addition in 1995 of the foul condensate stripper and incineration of the stripper off-gases in the lime kilns is consistent with mills of comparable age in the US where treatment is now mandated and preferred to treatment of foul condensates in the effluent treatment system. To be comparable with state-of-the-art mills, a secondary disposal device would be required. State-of-the-art mills often include a third disposal point.

**Kilns and Causticising** CHH Tasman's lime kiln PM and TRS emissions compare favourably with similar kilns, and the average values are in line with those of typical state-of-the-art mills. PCDD/F emissions are several times higher than the few measurements made at comparable kilns, but are several-fold less than the 2004 Tasmanian Guidelines - New Bleached Eucalypt Kraft Pulp Mill In Tasmania.

**Power Boilers** CHH Tasman's power boilers fire wood waste from wood yard and sawmill processes as well as some reclaimed waste consisting of wood billets, pallets, and the like from a dump on the mill site. The emissions of PM compare favourably with that of similar mills. However, PCDD/F emissions are up to 6-fold higher than the maximum level of testing done for comparable power boilers, and exceed the Tasmanian Guidelines as well by a wide margin. Possible explanations for these high emissions are less than ideal boiler operating conditions such as low combustion temperature combined with wood waste that contains chlorides, chlorinated organics or other dioxin and furan precursors.

**Site-wide air emissions comparison** Site-wide air emissions for total PM, TRS and ClO<sub>2</sub> per Air Dried tonne kraft production (kg/ADt) for CHH Tasman are shown to compare favourably with data from selected Canadian market kraft pulp mills of similar age.

## 2 Introduction

Environment Bay of Plenty (EBOP) has requested a document describing current best practice in air emissions controls and performance in mills of a similar age and configuration to the Kawerau operations of CHH Tasman. As well, emissions controls and performance with state-of-the-art mills are described. With these two categories of mills used as benchmarks, the gaps with CHH Tasman are identified.

This document is an update of the July 2000 report covering emissions of particulate matter (PM), total reduced sulphur (TRS), chlorine and chlorine dioxide (Cl<sub>2</sub> / ClO<sub>2</sub>), but considers the kraft pulp mill only. The scope has been extended to include emissions of polychlorinated dibenzo-p-dioxins and polychlorinated dibenzo-furans (PCDD/F), commonly called dioxins and furans, which are classified as hazardous air contaminants in the major pulp and paper exporting countries.

A glossary of abbreviations, terms and units can be found in Appendix A.

A layout drawing showing CHH Tasman's emission point sources can be found in Appendix B.

### **The Approach**

The approach adopted to approximate "best current practice of mills of a similar age and configuration" to CHH Tasman is to tabulate the applicable regulations that applied to mills constructed or modernised in the 1970s/early 1980s in major jurisdictions such as the US, Canada and Europe. The source for these regulations is a survey of air emission control practices conducted by AMEC in 1994 [AGRA Simons, 1994]. This information has been updated with the US Cluster Rule regulations that apply to existing mills which have come into force since the previous version of this report in 2000.

To provide further comparison of the CHH Tasman mill with other mills, site-wide air emission data has been studied. These are compared with the Canadian National Pollution Reduction Inventory data for kraft pulp mills which give average annual site-wide PM, TRS, and PCDD/F emissions in kg / ADt for the 45 or so kraft mills in Canada, of which 26 are of a comparable age and technology to CHH Tasman. This information shows CHH Tasman emissions in relation to these Canadian mills in chart form.

For state-of-the-art mills, the primary source is the new recommended environmental emission limit guidelines issued in August 2004 by the Tasmanian Government that would apply to any eucalypt kraft pulp mill built in Tasmania [RPDC, 2004]. These emission limits would differ little for kraft pulp mills using other species of wood and accordingly are considered indicative of new state-of-the-art mills. Beca AMEC with its parent company AMEC of Vancouver and with ÄF-Celpap of Stockholm were retained to provide independent advice and prepare a study report to review:

- o state-of-the-art technologies and management practices aimed at minimising the environmental impact of emissions,

- current guidelines and standards in Europe and North America, and
- emission limits currently achievable by bleached kraft pulp mills employing accepted modern technology and operated in accordance with best management practices.

The Beca AMEC report considered the US Cluster Rule regulations to control hazardous air pollutants that apply to existing and new mills, including Maximum Achievable Control Technology (MACT) for kraft pulp mill sources including fibreline and combustion sources. The Rule applicable to power boilers was issued on 12 Sept 2004. The limits are included in this report as an indicator of state-of-the-art power boiler performance.

As a secondary basis for benchmarking performance for state-of-the-art mills, the AGRA Simons (now AMEC) 1994 survey of regulations is used. Besides regulations, the report included a review of air emission permits from a significant proportion of the new and modernised pulp mills worldwide which started up in the 1990 - 1995 time period (AGRA Simons, 1994). Though now somewhat dated, these limits show the range values that were adopted by regulatory authorities at that time. Permits of 22 new and extensively modernised mills in the US, Sweden, Finland, France, and Germany, were analyzed in these stringent regulatory jurisdictions.

Gaps are established by comparing the Kawerau kraft pulp mill source emission performance with these two categories of mills used as benchmarks, namely mills of comparable age and technology and state-of-the-art mills. Air emission data averaged over 5-years (2000-2005) is used as a measure of the Kawerau kraft pulp mill emission performance.

### **Dioxins and furans**

Polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF) are environmental contaminants detectable in trace amounts in the global ecosystem which have caused major environmental concern. In contrast to other chemicals of environmental concern such as polychlorinated biphenyls (PCB), and polychlorinated pesticides like DDT, pentachlorophenol (PCP) or others, PCDD/F were never produced intentionally. They are formed as by-products of several industrial activities and all combustion processes.

The terms "dioxins" or "dioxins and furans" refer to the 75 congeners of polychlorinated dibenzo-p-dioxin (PCDD) and 135 congeners of polychlorinated dibenzofuran (PCDF). Among these 210 compounds, there are 7 PCDD and 10 PCDF congeners that have a chlorine atom in each of the four lateral positions of the aromatic ring of the parent molecule (i.e. the 2, 3, 7 and 8 positions). These 17 compounds are persistent and the most toxic of the 210 congeners. The remaining 193 congeners are relatively harmless. The most toxic congener is 2,3,7,8-TCDD. The group of 2,3,7,8-chlorine substituted congeners are toxic to in varying degrees in laboratory animals, resistant to chemical, biological, and physical breakdown, and thus accumulate in the environment and in organisms. In this report, the term PCDD/F is used to mean dioxins and furans and all their congeners with toxic effect and is expressed in toxic equivalents using accepted Toxicity Equivalency Factors abbreviated in this report as TEQ.

Trace amounts of metals and organic compounds including dioxins are emitted from recovery boilers, smelt dissolving tank vents, power boilers and lime kilns. Dioxins in boilers are formed in the thermal processes in which fuels containing even small amounts of chloride are fired. Fuels containing chloride in small amounts include black liquor and hog fuel from naturally occurring chloride in wood and bark. Pulp and paper mill lime kiln flue gases have been found to contain dioxin in comparatively small quantities which is consistent with the lime mud being substantially free of organics.

The control of dioxins and furans has received attention in the permitting of new mills following the release in the US of the EPA National Dioxin Study Tier 4 - Combustion Sources report in 1987. The report identified pulp mill combustion sources as significant but not major sources of these species when compared with other sources (USEPA-450, 1987), such as municipal waste incineration, and some other industrial processes.

## 3 Description and Benchmarking

### 3.1 Woodyard, Chips and Woodwaste

The air emissions from this area, which include the woodyard, chip preparation, storage and handling as well as wood waste storage, preparation and handling, are particulate matter and Volatile Organic Compounds (VOCs). The VOC emissions result from the evaporation of volatile compounds in the wood, mainly terpenes. Compared with other areas of the mill, little information is available on the significance of this VOC emission source and it is not controlled or regulated. VOC originating from the wood chips mainly evolves later in the process where it is controlled.

#### Particulate Matter

##### *Kawerau Mill*

The wood processing facility at Kawerau supplies the kraft lines of CHH Tasman. The kraft line has 2 loading decks and one debarking drum followed by a horizontal feed Rauma Repola chipper. This is followed by a first in, first out chip storage and distribution system with 3 chip piles. There is a chip truck unloading facility as well. After the chip reclaimers there are two Retec chip thickness screen lines before the chips are conveyed to the two continuous digesters. Belt conveyors rather than pneumatic conveyors are used throughout to minimise chip damage and prevent fines generation. The conveyors are equipped with a skirt extending below the conveyor rollers to reduce the effect of cross winds that can blow fine material off the belt.

**Comparable Mill** The most important point sources of PM emission are the discharge points from the systems at chip piles and chip bins where chips and wood waste fall freely. The emissions are much more significant if the conveying is pneumatic rather than using belt conveyors and both types of conveyors are found in mills of comparable age. Belt conveyors need not be enclosed to reduce fugitive emissions (dusting), and even older designs can be seen to have only a partial cover (hood) over the belt extending just below the return belt on one side. This has generally been found to be sufficient to prevent cross-winds carrying off material being transported. Only severe weather conditions may require the conveyor galleries to be totally enclosed.

In general though, these dispersed PM sources are primarily of local concern since almost all the particulate material would fall within mill property, except in those cases where they are located nearby public roads or residences.

Other PM point sources are the chip screening plant discharge points such as found at pin chip and overs bunkers, where material falls freely. Air density separators create PM emissions as they are short pneumatic conveying systems for classifying chips by size and directing oversize chips to chip slicers.

Fugitive PM emissions also result from the pick up by winds of material such as chips and chip fragments as they drop onto chip storage piles and during load out, from mobile equipment and from unenclosed belt conveyors.

**State-of-the-art Mill** Belt conveyors rather than pneumatic conveyors are used exclusively to minimise chip damage and generation of fines. The belt conveyors would be enclosed top and sides to minimise fugitive particulate emissions by winds. Discharge points may have telescoping downspouts to limit air transport of chip fines. In some cases, wind screens and enclosures have been used in a number of operations especially around truck and rail car dump areas.

Some installations handling very dry material use dust extraction fans with dust collectors such as in chip screen buildings or at transfer points of conveyors from the chip storage.

Good housekeeping practices are adopted to minimise emission generation by using appropriately shaped chip piles and eliminating unnecessary chip handling with mobile equipment.

**Gap with Other Mills** In its use of belt conveyors in the kraft mill, and the use of belt conveyor skirts extending below the conveyor rollers, CHH Tasman is more advanced than some mills of a comparable age and in these respects more typical of state-of-the-art mills.

### 3.2 Digesters, Brownstock and Oxygen Delignification

The air emissions from this area are TRS and VOCs.

#### Total Reduced Sulphur

##### *Kawerau Mill*

Digesters - CHH Tasman operates 2 single vessel continuous digesters. Both operate at 400-550 Air Dried tonnes per day (ADt/d). The older digester, No.2 Continuous Digester (CD2), was constructed in 1974 and the fibre line produces predominantly unbleached kraft pulp. The chip bin is an atmospheric bin. In 1999 a single vessel scrubber was installed to collect the chip bin gases, scrub them with sodium hypochlorite solution and discharge them above roof level at 38.7m mill elevation<sup>1</sup>.

The newer digester, CD3, was built in 1989 and rebuilt in 1995 for IsoThermal Cooking. This digester and its associated fibreline produces bleached market kraft pulp. This digester has an enclosed chip bin that is fed by a screw conveyor to minimise TRS gas leakage from the steaming vessel/low pressure feeder back feeding into the chip bin. The vent from this chip bin is combined with the No. 3 Fibreline Vent and discharged above roof level at 32m elevation.

No. 2 Fibreline - The No. 2 Fibreline follows CD2, and was installed in 1974. The digester blows pulp to an atmospheric diffuser washer, which is on top of the discharge tank. This storage tank is followed by an enclosed pressure knotter, screen room including a new closed primary pressure screen (March 2006) and brown stock decker. The pulp is well washed in the atmospheric diffuser so vent gases are relatively uncontaminated. The fibreline chests are enclosed. The knots are sent to a new enclosed secondary vibratory knotter installed in March 2006. The secondary vibratory knotter is enclosed. The safety

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<sup>1</sup> Elevations given are from mill datum. For these and other discharge point elevations, refer to Appendix B - Stack Drawing.

relief valves are piped to a large central standpipe to ensure safe release to the atmosphere in the event of an upset condition.

No. 3 Fibreline – The No. 3 Fibreline follows CD3. It was constructed at the same time as CD3 in 1989. The digester discharges into a discharge tank, which provides buffer storage capacity. This is followed by a closed system of pressure knotted, pressure screens, and enclosed pressure filter for washing prior to the oxygen delignification stage. After the oxygen reactor the pulp goes to the small blow tank and then two washing stages – a pressure diffuser and a wash press. The primary pressure screens cascade the rejected pulp via two further stages. Vents from equipment and tanks that contain pulp and liquor are ducted to a collection system, which is vented above roof level at 32m elevation. There are seven tanks as well as the white liquor oxidation reactor that are vented. Each collection point has a manual valve to ensure the system is balanced and gases do not enter the work area.

**Comparable Mill** Atmospheric or open chip bins used on continuous digesters have emission discharges that result from the re-use of steam from the chip steaming vessel and chip feeder. These sources are not typically collected, despite being relatively strong in terms of TRS emission rate.

The problem with collection is that the source contains a variable and generally significant amount of air, which precludes their safe introduction into a concentrated NCG system. Admixture of this air-containing stream to the concentrated NCG stream risks creating a mixture that contains enough oxygen to be in the explosive range.

Continuous digester systems condense flash steam from relief condensers and other strong sources prior to leaving the department. The uncondensed gases are then collected in the concentrated NCG system for disposal by incineration. An advantage of continuous digesters is that they generate NCG volumes at a relatively uniform rate as compared with batch digesters, making them simpler and less expensive to capture. Batch digester systems require direct or indirect blow gas coolers on accumulator discharges to manage the large volumes of gases, which are released during the blow.

Vacuum-type drum washers used in brownstock result in NCG emissions from the liquor-pulp mixture on the drum. The drums have hoods over the vats to collect then direct the vapours out of doors. Such older systems would not have a dilute NCG system for the collection and disposal of the washer vents, the chip bin vents and other lesser odour sources with large volumetric flow rates.

**State-of-the-art Mill** For continuous digesters, the chip bin sources are collected in the dilute NCG system after cooling for removal of turpentine, methanol and other condensable organics. This vapour flow can be minimised by the adoption of tall chip bins, which also result in more pre-heating of the chips and condensation of volatile vapours. All other continuous sources of gases and vapours containing TRS in the digester system are collected in the concentrated NCG system. Process upsets can cause over pressure situations, which create safety relief discharges. These flows are piped to a central standpipe for reasons of personnel safety. The safety relief discharges are released to atmosphere untreated.

Brown stock washing is carried out with presses, diffusion washers or pressurised drum washers. Such modern equipment is essentially enclosed which limits entrainment of air, reducing the volume of off-gases thereby making it less costly to collect and treat. All significant sources from the washers, filtrate tanks, knotters, fibre filter, blow tubes and chests are directed to the dilute NCG system for disposal.

Rotary drum-type brown stock washing systems, if used in state-of-the-art fibre lines, are hooded and sealed to capture all significant sources of TRS. Post-Oxygen delignification washing systems not based on presses would not normally be collected because of the very dilute concentration of TRS and organics that occur from the well-washed pulp at that point in the fibre line.

The US EPA Maximum Achievable Control Technology (MACT) limits promulgated in April 1998 to substantially reduce hazardous air pollutants, impose control technology and uncontrolled venting time limits. All significant TRS sources are collected in either a concentrated NCG (cNCG) system, or dilute NCG (dNCG) system depending on the source. The regulations required compliance by April 2001 for cNCG and by April 2006 for dNCG systems, which must meet the performance summarized in Table 1.

**Table 1: MACT Requirements**

|                                       | cNCG systems                | dNCG systems       |
|---------------------------------------|-----------------------------|--------------------|
| Destruction efficiency, %, conditions | >98.0<br>1600°F, 0.75s      | -<br>1600°F, 0.75s |
| Destruction destinations              | Primary and backup required | Primary only       |
| Minimum availability, %               | >99.0                       | >96.0              |

**Gap with Other Mills** CHH Tasman has a cNCG system and is more advanced than many mills of a comparable age in that the CD2 chip bin TRS gases are also treated in a scrubber before discharge to atmosphere. To provide state-of-the-art TRS controls, an expanded dNCG system collecting from other weaker sources and vents would have to be added with disposal at two devices, such as in the recovery boiler, an incinerator or the power boiler. The system should operate with high availability.

### 3.3 Bleach Plant and Bleach Chemical Preparation

The air emissions from this area are chlorine (Cl<sub>2</sub>), chlorine dioxide (ClO<sub>2</sub>), TRS and VOCs.

#### Cl<sub>2</sub> and ClO<sub>2</sub>

##### *Kawerau Mill*

CHH Tasman has 2 bleach plants, one operating and one shut down. No. 1 Bleach Plant has used 2 stages of sodium hypochlorite in the sequence HH. The bleach plant was shut down on 30 April 2006.

No. 2 Bleach Plant uses a 5-stage sequence of D(EOP)PD where there are single first and last chlorine dioxide stages and two parallel (EOP)(P) stages. This means there are 6 washers, 6 seal tanks and 6 towers with smaller tubes for the short E2 stages when the alternative sequence D(EOP)(D/E)D is used. All seal tanks, the acid stage upflow towers, the transfer tank, the acid sewer vent and the scrubbing solution tank are ducted to the 1<sup>st</sup> scrubber. This scrubber uses a scrubbing solution of sodium hydrosulphide and caustic. The exhaust from the 1<sup>st</sup> scrubber goes to the 2<sup>nd</sup> scrubber. Each washer hood is collected and has a damper in the ducting to allow balancing of the scrubber system. The washer hood gases go directly to the 2<sup>nd</sup> scrubber. This scrubber also uses a scrubbing hydrosulphide solution of sodium hydrosulphide and caustic. The 2<sup>nd</sup> scrubber is located on the roof and discharges via a high stack at the top of the CD2 stair tower at 75.52m elevation.

The Chemical Preparation Area consists of 3 plants with their ancillary operations; namely a chloralkali plant, sodium chlorate plant and a Single Vessel Process (SVP) chlorine dioxide plant.

The chloralkali plant is a membrane type plant for generation of chlorine, hydrogen and caustic, and in turn some sodium hypochlorite and hydrochloric acid are generated. Associated with this is a hydrochloric acid burner, which burns the hydrogen and chlorine from the cells to generate hydrochloric acid. The vent from the plant has an environmental scrubber called a tail gas scrubber. This operates with sodium hypochlorite scrubbing medium and this is in turn returned to the hypo blow down tanks. The plant is controlled from a Distributed Control System (DCS).

The sodium chlorate plant releases a small stream of chlorine and hydrogen which is absorbed in a hypochlorite scrubber and is returned to the hypo blow down storage tanks.

The SVP chlorine dioxide plant has a vent gas scrubber, which uses 1% sodium hydrosulphide solution supplied from the No. 2 Bleach Plant. This scrubs the tail gases from the chlorine dioxide process downstream of the chilled water absorber/scrubber. This is a recirculating scrubber where spent scrubbing solution is bled to the acid sewer. There is a chlorine dioxide monitor in the scrubber stack which discharges at 26.06m elevation. A 2005 project converted the 2<sup>nd</sup> absorber to a chlorine dioxide absorber and any chlorine present was absorbed in caustic to generate sodium hypochlorite. Additionally, the complete sodium chlorate plant and chlorine dioxide plant were converted from pneumatic to DCS control.

The acid sewer collects the sewers from No. 2 bleach plant and the SVP. The sewer has a vent tank equipped with spray showers, which use an 8% caustic solution to knock down foam and neutralise gases before venting. Scrubbing solution from No. 2 Bleach Plant can also be used in this vent tank shower system. The sewer vents at the same height as the SVP scrubber vent.

**Comparable Mill** At the time of start-up, these mills would have used elemental chlorine in the bleach plant. Mills in most major pulp manufacturing and exporting countries today have replaced elemental chlorine in the bleaching sequence with chlorine dioxide (ClO<sub>2</sub>) in order to eliminate PCDD/F generation and to minimize Absorbable Organic Halides (AOX) discharges in their effluent. The acid stage using ClO<sub>2</sub> as bleaching chemical has

emissions originating from the tower vents, the washer hood and seal tank vent and other more minor sources. These would typically be scrubbed, either in several scrubbers or more typically, ducted together and treated in a single scrubber. The scrubbing medium can be sodium hydroxide, extraction stage filtrate, chilled water, sulphur dioxide (SO<sub>2</sub>) water, weak wash, sodium hydrosulphide and white liquor.

Sources originating in the caustic stages would be vented to atmosphere.

The ClO<sub>2</sub> generator would have a tail gas scrubber using chilled water, and, depending on the type of process, an alkaline after-scrubber. For instance, an R3 process which has a relatively high concentration of chlorine co-product would have a caustic scrubber to make hypo which would be returned to the bleach plant, as much an economy measure as an emission control measure.

Under the US EPA Maximum Achievable Control Technology (MACT) limits promulgated in April 1998 aimed at reducing hazardous air pollutants (HAPs), a ClO<sub>2</sub> generator would have an after-scrubber using white liquor as scrubbing medium on the outlet from the chilled water tail gas scrubber in order to meet the limit of 10ppm<sub>DV</sub> of chlorinated HAPs as Cl<sub>2</sub>. MACT limits also require that all vents from processes where chlorinated bleaching agents are used be collected and treated to one of these conditions:

- 99% removal efficiency
- 10 ppm<sub>DV</sub> as chlorine
- 1g/BDt pulp

**State-of-the-art Mill** Elemental chlorine is not used to minimise AOX formation and hypo is not used to minimise chloroform generation. For the acid stages of Elemental Chlorine Free (ECF) bleaching processes, the collection and treatment would be as already described and would probably use a single scrubber. The alkaline stage vents would be collected and passed through water sprays and a mist eliminator before joining the scrubber discharge for release from a common short stack.

In a Totally Chlorine Free (TCF) bleaching process neither chlorine nor chlorine dioxide are used, therefore the emissions from TCF bleaching would not be treated beyond droplet removal with a mist eliminator.

**Gap with Other Mills** CHH Tasman's 2-stage system for No. 2 Bleach Plant compares well with mills of comparable age.

## VOC

**Kawerau Mill** No treatment.

**Comparable Mill** No treatment.

**State-of-the-art Mill** For the acid stages of an ECF bleach plant, the gasses would be collected and treated in a two stage scrubber, the first using white liquor or weak wash as scrubbing medium for the removal of chlorine dioxide and trace chlorine and a second section using water for the removal of methanol and other organics. The alkaline stage vents would be collected and passed through a wet scrubber for the removal of methanol and other organics before joining the scrubber discharge and release from a short stack.

For TCF bleaching, emissions are collected and scrubbed with water for removal of methanol and other organics.

**Gap with Other Mills** CHH Tasman has no significant gap with these emissions with mills of a comparable age.

### 3.4 Pulp Machines

#### Particulate Matter

**Kawerau Mill.** CHH Tasman has 2 pulp machines with Flakt air dryers. After the air-to-air heat exchangers the exhausts are discharged to atmosphere without any environmental controls.

**Comparable Mill** There are minor amounts of fibre discharged at very low concentrations in the moist air from the pulp machine miscellaneous exhausts and dryer exhausts. In the US, this source falls under MACT III of the HAP regulations, covering paper machines, mechanical pulping and secondary fibre that was proposed in March 1996 and required compliance by 16 April 2001. Treatment of air emissions is called for if chlorine or chlorine dioxide or certain solvents are used in the process of this group of operations, but otherwise no controls are required. This recognises the fact that the fibre is essentially clean and volatile emissions can only come from coatings or additives. Fine particulate emissions are in the longer term potentially under scrutiny as ambient air quality standards are being tightened with the focus on material below 2.5 microns diameter.

These exhausts discharge directly to atmosphere without emission controls.

**State-of-the-art Mill** These exhausts discharge directly to atmosphere without emission controls.

**Gap with Other Mills** CHH Tasman has no significant gap with these emissions from mills of a comparable age or state-of-the-art mills.

### 3.5 Recovery Boiler

CHH Tasman has one recovery boiler – No. 2 Recovery Boiler. The original No. 1 Recovery Boiler was shut down permanently on 31<sup>st</sup> March 2000. No. 2 Recovery Boiler has a twin unit direct contact cascade evaporator and fires black liquor at approximately 68% solids content. The CE boiler was built in 1968 and was rated for 47.2 t BLS/hour with fuel calorific value of 15,200kJ/kg. It has had several significant upgrades over the years including replacement of the cascade wheels in 1982, the addition of the 3<sup>rd</sup> precipitator chamber in 1991, addition of a tertiary air system in 1998 and a roof tube replacement in 2006.

In April 2006, it is now handling around 66 t BLS/hour with a maximum rate close to 70 t BLS/hour. The fuel calorific value is, however, lower at approximately 14,400 kJ/kg. At these firing rates and heat values, the boiler is relatively heavily loaded on the assumption that it was originally designed for 850 000Btu/ft<sup>2</sup>/h, and the liquor heating values and flows are consistent in terms of where the samples were taken.

All the emission data for the recovery boiler is presented together in Table 2, which follows at the end of this subsection.

#### **Particulate Matter**

**Kawerau Mill** The emission control devices are the 3 dry bottom electrostatic precipitator chambers 2A, 2B and 2C, which discharge into a single stack discharging at elevation 57.912m elevation. All precipitator chambers are dry bottom type, which prevent black liquor vapour being entrained by the flue gas and discharged to atmosphere.

Sampling data over the last 5 years has been averaged and is presented in the table which follows at the end of this subsection.

**Comparable Mill** Boilers would either be of the direct contact type or the low odour type. Firing solids would be 63 – 70% solids concentration. Two level air systems would be used on all except B&W supplied boilers, which always have had three levels of air.

Control would be with two chamber wet bottom electrostatic precipitators following the cyclone or cascade-type direct contact evaporator boilers, and dry bottom-type for the low odour boilers. In some cases, these precipitators have been supplemented with low-pressure drop secondary wet scrubbers (e.g., Flakt Modo type) to further reduce particulate emissions, and as a source of hot water.

One of the sources of PM emission data from a typical “Comparable Mill” are the regulatory limits for air emissions that applied to mills constructed in the 1970s/early 1980s in major jurisdictions such as the US and Europe. These are found in the AGRA Simons (now AMEC) 1994 survey of regulations (AGRA Simons, 1994).

The second source for PM emission data from a typical “Comparable Mill” are the MACT II limits promulgated the 12 January 2001 which apply to existing and new chemical recovery boiler sources which imposed PM emission limits. Existing sources had 3 years to be in compliance with the limit of  $100\text{mg}/\text{S}_{20}\text{Dm}^3$  at 8% reference oxygen, that is, by January 2004. The US EPA uses  $20^\circ\text{C}$  as Standard temperature for this industry, written  $\text{S}_{20}$ . Converted to the Kawerau reference conditions of 5% oxygen, this limit is  $133\text{mg}/\text{NDm}^3$ .

**State-of-the-art Mill** Low odour boilers fire 72 – 85% dry solids concentration for maximum thermal efficiency, generating more steam per tonne of black liquor dry solids than boilers of the 1970s and 1980s. Control would be with dry-type precipitators with two or three chambers in parallel, each with three or more fields in the direction of gas flow.

One of the sources of information on state-of-the-art mill PM emissions are the MACT II limits applicable to new recovery boilers in the US of  $34\text{mg}/\text{S}_{20}\text{Dm}^3$  at 8% reference oxygen that must comply by January 2004. Converted to the Kawerau reference conditions of 5% oxygen, this limit is  $45\text{mg}/\text{NDm}^3$ .

A second source for state-of-the-art PM emission data are the guidelines issued in August 2004 by the Tasmanian Government that would apply to any eucalypt kraft pulp mill built in Tasmania (RPDC, 2004). The limit for recovery boilers is  $30\text{mg}/\text{NDm}^3$  at 8% reference oxygen.

A third source for PM emissions from fairly recent mills are the emission limits found in the AGRA Simons (now AMEC) 1994 report which included a review of air emission permits from a significant proportion of the new and modernised pulp mills worldwide which started up in the 1990 – 1995 time period (AGRA Simons, 1994). Though now somewhat dated, this information is included for reference to show the range of limit values that were adopted by regulatory authorities at that time.

#### PCDD/F

**Kawerau Mill** No 2 Recovery Boiler was sampled once on 27 June 2000 for PCDD/F and reported in September 2000.

**Comparable Mill** Since the late 1990s, Canada, the US and other countries have been compiling national inventories of dioxins and other hazardous discharges in preparation for hazardous material reduction plans. Determining PCDD/F concentrations is expensive and this has created the need for the development of scientifically-defensible emission factors. Accordingly, Environment Canada commissioned an extensive review of existing scientific literature on dioxin formation in and emissions from various pulp and paper combustion processes and of all valid available dioxin stack testing results performed on pulp and paper sources in Canada and other countries. This work was undertaken by the Pulp and Paper Research Institute of Canada and published in 2002. The results of 45 stack tests in the US and Canada are presented and show the wide range of the results. A significant conclusion quoted from a study for the US EPA was that there was no evidence of systematic difference in results between direct contact evaporator boilers and the newer low odour type boilers without direct contact evaporators.

**State-of-the-art mill** Information on state-of-the-art mill PCDD/F emissions are the guidelines issued in August 2004 by the Tasmanian Government that would apply to any eucalypt kraft pulp mill built in Tasmania (RPDC, 2004). The limit for recovery boilers is 100pg TEQ/NDm<sup>3</sup> at 3% reference oxygen. This results in an emission limit of 89 pg TEQ /NDm<sup>3</sup> at the 5% reference oxygen conditions used at CHH-Tasman.

#### Total Reduced Sulphur

**Kawerau Mill** CHH Tasman uses a Strong Black Liquor Oxidation (SBLOX) system to reduce TRS emissions. The original weak BLOX system was replaced by a SBLOX system in 1988. The SBLOX plant consists of primary and secondary oxidation tanks followed by a foam tank. The gases from the foam breakers on each vessel are treated in a 3-stage scrubber to control TRS emissions. The scrubber discharges at elevation 52.544m. The main components of TRS are hydrogen sulphide and methyl mercaptan. Dimethyl sulphide (DMS) and dimethyl disulphide (DMDS) are also present. These TRS compounds are stripped from the black liquor by air used in the SBLOX plant. About 2 or 3 years ago, the mill piped the emissions from their Crude Tall Oil plant to the feed line to the SBLOX scrubbers.

1st stage SBLOX scrubber - scrubbing medium is sodium hypochlorite (HOCl) and water and operates at alkaline pH. It removes hydrogen sulphide with the caustic. Some of the methyl mercaptan forms dimethyl sulphide (DMS) and dimethyl disulphide (DMDS) by

recirculation and air oxidation. Higher pH means more HOCl is available, so more oxidising occurs.

2nd stage - scrubbing medium in the 2<sup>nd</sup> stage SBLOX scrubber is hypo and hydrochloric acid (HCl) with acid conditions of pH 2-4. Both chemicals are made on site. DMS and DMDS react and are absorbed in the acid conditions.

3rd stage - scrubbing medium in the 3<sup>rd</sup> stage SBLOX scrubber is water, which is to wash out any hypo and liquid carryover. Since 22 October 2005, weak wash has been added to the 3<sup>rd</sup> stage scrubber.

The scrubber is quite unique because most SBLOX plants do not capture and treat their TRS discharges. The scrubber is very effective.

**Comparable Mill** For direct contact boilers, TRS emission control is by thorough oxidation of the black liquor to 0.1g/L Na<sub>2</sub>S content prior to final evaporation in the cascade or cyclone. For both direct contact and low odour type boilers, TRS generation in the furnace is controlled by limiting the degree of boiler overload in terms of solids and heat input, and ensuring an adequate amount of combustion air combined with the best degree of furnace gas mixing possible, often difficult to achieve with the old style combustion air system configurations. Mills of a comparable age elsewhere would not normally be required to treat their weak or strong BLOX vents.

The source for TRS emission data from a typical "Comparable Mill" are the limits for air emissions in the regulations that applied to mills constructed or modernized in the 1970s/early 1980s. For instance, the US regulation selected is the New Source Performance Standards (NSPS) enacted in 1978, which applies to new mills built after 24 September 1976. We believe that this, together with European regulations of the same period, is a reasonable guide for what the best mills at that time were able to achieve. These were reviewed in the AGRA Simons (now AMEC) 1994 survey of regulations (AGRA Simons, 1994).

In 1998, the US EPA MACT II limits were introduced to control of hazardous air pollutants (HAPs) such as metals and certain organics, but the components of TRS are not considered HAPs. There are no gaseous organic HAP standards applicable to existing recovery boilers.

**State-of-the-art Mill** Emission control in the low odour furnace is by concentrating the heat release in the lower furnace, having well defined zones for drying and pyrolysis, reduction, oxidation in the furnace, and providing good mixing within each zone so that completion of reactions to the practical amount is attained.

One of the sources of information on state-of-the-art mill TRS emissions are the guidelines issued in August 2004 by the Tasmanian Government that would apply to any eucalypt kraft pulp mill built in Tasmania (RPDC, 2004).

A second source for TRS emissions from mills started up in the 1990-1995 time frame are the emission limits found in AGRA Simons (1994), which provide the range of limit values that were adopted by regulatory authorities at that time.

The MACT limits of 1998 applicable to new recovery boilers limit gaseous organic (TGO) emission 0.012 kg methanol/t black liquor solids. This may pose a problem for overloaded recovery boilers. There are no TRS limits.

**Gap with Other Mills** CHH Tasman's recovery boiler emission performance comparison is presented in Table 2. The table compares CHH Tasman recovery performance with two other groups of boilers. The first group are comparable recovery boilers using technology of the 1970s/1980s similar to the technology used at the CHH Tasman mill. The second group are state-of-the-art recovery boilers that have undergone major modernisations in the last decade or so.

**Table 2 - Comparison of No. 2 Recovery Boiler Air Emission Performance**

| Parameter | Units<br>(a)  | Kawerau                                 | Comparable Mills<br>of Similar Age | Recent mills /<br>State-of-the-art mills           |
|-----------|---|---|------------------------------------|--|
| PM        | mg/NDm <sup>3</sup>   | 91                                      | 130-400 (b)<br>133 MACT (c)        | 149-median (b)<br>61-minimum (b)<br>/ 45(e), 44(g) |
|           | Averaging<br>time   | 5 year average of<br>monthly tests, (d) | (d)                                | (d)  |
| PCDD/F    | pg TEQ/NDm <sup>3</sup>   | 10                                      | 0.016 - 10 (f)                     | 89 (g) / -   |
|           | Averaging<br>time   | (d)                                     | (d)                                | (d)  |
| TRS       | mg/NDm <sup>3</sup>   | 7.3                                     | 9.3-37 (b)                         | 10.1-median (b)<br>5.6-minimum (b)                 |
|           | Averaging<br>time   | 5 year average of<br>24h tests          | 12h, 24h                           | 0.5, 1, 4, 12, 24h<br>(30d Norscan)                |
| Notes:    | a - Concentrations at Normal (N) Conditions of 0°C, 101.325 kPa, dry (D), and 8% reference oxygen<br>b - From AMEC, reference 1.<br>c - MACT: Boilers existing before 12 Sept 2004, to be in compliance by Sept 2007.<br>d - Averaging time is the duration of the sampling time, typically 1h per PM sampling run, 4h per PCDD/F run<br>e - MACT: New boilers started up after 12 Sept 2004, to be in compliance by Sept 2007.<br>f - From Uloth, reference 3.<br>g - Tasmanian Guidelines |   |                                    |  |

The No. 2 Recovery Boiler average TRS levels at CHH Tasman are generally in line with any of today's mills. CHH Tasman's SBLOX emission control system with scrubbing and the tertiary air system in the No. 2 Recovery Boiler means that they are better positioned with respect to TRS control than comparable mills.

### 3.6 Smelt Dissolver Vents

#### Particulate Matter and TRS

**Kawerau Mill** No. 2 Recovery Boiler has two smelt dissolving tanks and each has a scrubber. Each scrubber is a dynamic-type wet scrubber with a fan and hot water as the scrubbing medium. The two separate stacks discharge at elevation 56.083m.

**Comparable Mill** Emission control is either water spray, or water spray with mesh pad demister or packed tower, using evaporator stripped process condensates, weak wash or warm water. PM and TRS emissions in the US are limited by the New Source Performance Standards (NSPS) enacted in 1978, which applies to new mills built after 24 September

1976. We believe that this, together with European regulations of the same period, is a reasonable guide for what the best mills at that time were able to achieve. These limits are from AGRA Simons (1994). For this source, no continuous TRS emission monitoring is normally done, as compliance is determined on the basis of periodic tests. In many jurisdictions, compliance is determined by the surrogate of continuously recording the scrubber pressure drop and scrubbing medium flow rate.

**State-of-the-art Mill** Control is by a dynamic, ie, fan-driven, wet scrubber using fresh water or weak wash as scrubbing medium which may be followed by a packed column for higher removal efficiency of particulate, TRS and SO<sub>2</sub>. In some of the most recent mills, the smelt dissolver scrubber exhaust is cooled to remove a large proportion of the moisture and introduced into the recovery boiler furnace along with the combustion air. In some other mills, a wet condenser is used on the exhaust to recover heat, greatly diminishing the flow.

The US EPA has also MACT II limits for PM<sub>10</sub> from dissolving tanks which is the same as the NSPS limit but is expressed in terms of PM<sub>10</sub> rather than total PM. A control technology remains the wet dynamic scrubber.

#### **PCDD/F**

**Kawerau Mill** No dioxin or furan measurements have been made of this source.

**Comparable Mill** According to Uloth (2002), there is no data in the open literature on PCDD/F emissions from this source. The rapid quenching of the gas stream eliminates the possibility of de novo synthesis of these compounds. The reference develops estimates from PCDD/F in green liquor and green liquor dregs. The result is a PCDD/F emission factor for the dissolver vent that means the source is a small fraction of the corresponding recovery flue gas emission.

**State-of-the-art mill** There is no limit specified in the Tasmanian guidelines (RPDC, 2004), as disposal of the dissolver vent gases in the recovery boiler after cooling and moisture removal is implied. Such disposal has been undertaken in a number of recent kraft recovery boiler installations.

#### **Gap with Other Mills**

CHH Tasman's emission performance for the No. 2 Recovery Boiler North and South smelt dissolver scrubbers is presented in Table 3 and 4. It is compared with two other groups of dissolver scrubbers, those using technology of the 1970s/1980s comparable to CHH Tasman and the other, for newer state-of-the-art dissolver scrubbers, which attain lower emissions for PM. For TRS, CHH Tasman has excellent performance.

**Table 3 - Comparison of No. 2 RB North Smelt Dissolver Air Emission Performance**

| Parameter | Units<br>(a)      | Kawerau                                 | Comparable Mills<br>of Similar Age | Recent mills /<br>State-of-the-art mills   |
|-----------|-------------------|---|------------------------------------|--|
| PM        | g/tBLS            | 146-ave                                 | 100-167 (b)<br>100 (c)             | 84-median (b)<br>44-minimum (b)<br>/ 60(e) |
|           | Averaging<br>time | 5 year average of<br>monthly tests, (d) | (d)                                | (d)  |
| PCDD/F    | pg TEQ/tBLS       | Not measured                            | 550 (f)                            | (g)  |
|           | Averaging<br>time | (d)                                     | (d)                                |  |
| TRS       | g/tBLS            | 2.2                                     | 9.3-37                             | 13-median<br>7-minimum                     |
|           | Averaging<br>time | 5 year average of<br>24h tests          | (d)                                | (d)  |

Notes:

- a - Concentrations in grams per tonne of black liquor solids fired in the recovery boiler
- b - From AMEC, reference 1.
- c - MACT: Boilers existing before 12 Sept 2004, to be in compliance by Sept 2007.
- d - Averaging time is the duration of the sampling time, typically 1h per PM sampling run, 4h per PCDD/F run
- e - MACT: New boilers started up after 12 Sept 2004, to be in compliance by Sept 2007.
- f - From Uloth, reference 3.
- g - Tasmanian Guidelines do not specify a limit

**Table 4 - Comparison of No. 2 RB South Smelt Dissolver Air Emission Performance**

| Parameter | Units<br>(a)      | Kawerau                                 | Comparable Mills<br>of Similar Age | Recent mills /<br>State-of-the-art mills   |
|-----------|-------------------|---|------------------------------------|--|
| PM        | g/tBLS            | 106                                     | 100-167 (b)<br>100 (c)             | 84-median (b)<br>44-minimum (b)<br>/ 60(e) |
|           | Averaging<br>time | 5 year average of<br>monthly tests, (d) | (d)                                | (d)  |
| PCDD/F    | pg TEQ/tBLS       | Not measured                            | 550 (f)                            | (g)  |
|           | Averaging<br>time | (d)                                     | (d)                                |  |
| TRS       | g/tBLS            | 1.7                                     | 9.3-37                             | 13-median<br>7-minimum                     |
|           | Averaging<br>time | 5 year average of<br>24h tests          | (d)                                | (d)  |

Notes:

- a - Concentrations in grams per tonne of black liquor solids fired in the recovery boiler
- b - From AMEC, reference 1.
- c - MACT: Boilers existing before 12 Sept 2004, to be in compliance by Sept 2007.
- d - Averaging time is the duration of the sampling time, typically 1h per PM sampling run, 4h per PCDD/F run
- e - MACT: New boilers started up after 12 Sept 2004, to be in compliance by Sept 2007.
- f - From Uloth, reference 3.
- g - Tasmanian Guidelines do not specify a limit

There is no significant gap with comparable dissolver vent PM emission performance. TRS emission control exceeds state-of-the-art performance.

### 3.7 Evaporators and Stripper

#### TRS and VOC

##### *Kawerau Mill.*

CHH Tasman has three sets of evaporators. One operates off geothermal steam and is a single body pre-evaporator and there are two sets of multiple effect LTV-type black liquor evaporators. Concentrated non-condensable gasses (cNCGs) are collected from the evaporator sets (seal tanks, hot wells and vacuum system) and ducted via steam ejectors to a lime kiln for incineration. The NCGs are collected and scrubbed in a white liquor scrubbing system for TRS removal prior to incineration in one of the lime kiln with the other kiln held as the stand-by incineration device. This cNCG system also collects gasses from CD2 and CD 3 turpentine condensers, the turpentine recovery system and the stripper feed tank.

CHH Tasman installed a foul condensate stripper in 1996. This treats the most foul evaporator condensates from the 6<sup>th</sup> effect of No. 1 Evaporators and a fraction from the 6<sup>th</sup> effect of No. 2 Evaporators, thereby capturing a significant portion of the odour and HAP compounds in the evaporator process condensates. Additionally turpentine decanter underflow and displaced padding water from the turpentine system is collected in the pulp mill and stripped. There are also a few minor sources from drains that are stripped. The steam stripper is a closed system with no venting to atmosphere under normal operation. During upset conditions, potentially large releases can occur directly to atmosphere from relief valves and rupture discs. Stripper off-gases (SOG) are normally burnt in the No.1 lime kiln, with No.2 lime kiln as the standby incineration device. The SOG and cNCGs are handled in separate lines. There is no official site policy for which kiln burns NCG and SOG. Operators shift the gases according to site conditions and TRS emission levels.

CHH Tasman operates a tall oil plant where soap is processed to make crude tall oil. The soap and black liquor tanks are open to the atmosphere. The separation tank (cook tank) where TRS compounds are generated is now piped to the SBLOX scrubber as of about 2003.

***Comparable Mill.*** All strong odour sources from this area such as the condenser hot well and ejector condenser vents are collected in the cNCG system for incineration in lime kilns or power boilers. Until recently, incineration in the recovery boiler was considered an unsafe practice by the Black Liquor Recovery Boiler Advisory Committee and most of the industry.

Generally no steam stripper would be operated or, if it was, it would be a steam stripper of low efficiency that removed about 80 - 95% of the TRS, but little of the methanol.

Under the MACT I Rule, existing mills have to meet a criteria that, depending on the approach adopted, can include collecting a minimum of 65% of the total methanol from the evaporator and digester areas, turpentine and NCG handling system, or a minimum of 3.6kh Methanol/BDt of pulp. Treatment criteria include 92% reduction by weight through steam stripping or biological treatment system, or otherwise reduce HAP to 210 ppm in the liquid stream. Compliance was required by 15 April 2001. In many US mills the alternative to a stripper has been to separately pipe the foul condensates ("hard piping") to the head of the secondary effluent treatment system.

**State-of-the-art mill.** In addition to the preceding paragraph, a high efficiency stripper for methanol removal would have off gases directed to the concentrated NCG collection system for delivery to the primary and secondary disposal points, such as the lime kiln, power boiler and stand-alone incinerator, the latter equipped with an SO<sub>2</sub> scrubber. In some recent cases, the cNCG is incinerated in the recovery boiler. This disposal option has a unique advantage over others of recycling the sulphur directly back into the chemical process.

A review of permit summaries for Tall Oil Plant permits in Norscan countries shows that no controls are required, though the regulatory authorities inspect facilities up to three times a year.

**Gap with Other Mills** With the steam stripper, CHH Tasman has comparable technology for foul condensate control to most mills of similar age. To be comparable with state-of-the-art mills, a secondary and tertiary disposal device would be required for the stripper off gases. In many cases, "bumpless" transfer is arranged with the backup line purged and appropriate control logic in place for a permitted case.

### 3.8 Kilns and Causticising

#### Particulate Matter

**Kawerau Mill** CHH Tasman has two lime kilns. Each is fitted with a venturi-type scrubber that uses hot water as the scrubbing medium. In 1998 the larger No. 2 Lime Kiln was fitted with a cyclone to capture dust and return it to the lime kiln.

**Comparable Mill** The only significant source of PM emission in this area is the lime kiln. Control is with a wet scrubber of the impingement type (Peabody) or less frequently, the venture-type, using a scrubbing medium of fresh or combined condensates water. Scrubbing devices are very occasionally preceded by a mechanical cyclone collector.

The US EPA has also proposed MACT II limits for PM from lime kilns. The preferred control technology remains the electrostatic precipitator. For an existing mill, a very efficient wet dynamic scrubber, such as a high pressure drop venturi, might be found to be cost effective.

**State-of-the-art mill** Control of the lime kiln emissions is with a four field single chamber electrostatic precipitator, almost always preceded by a mechanical cyclone collector.

#### PCDD/F

**Kawerau Mill** No 1 and 2 Lime Kilns were sampled once on 28 June 2000 for PCDD/F and reported in September 2000 (Norske Skog Tasman, 2000).

**Comparable Mill** Pulp and paper mill lime kiln flue gases have been found to contain dioxin in comparatively small quantities which is consistent with the lime mud being substantially free of organics. According to Uloth (2002), there is no data in the available technical literature on PCDD/F emissions from this source. This contrasts with lime and cement kilns in industry in general that are often co-fired with waste products that may

contain PCDD/F precursors and chloride, as emission testing has shown significant emissions in some cases.

***State-of-the-art mill*** Information on state-of-the-art mill PCDD/F emissions are the Tasmanian guidelines (RPDC, 2004). The limit for lime kilns is 100pg/NDm<sup>3</sup> at 3% reference oxygen. This results in an emission limit of 89 pg/NDm<sup>3</sup> at the 5% reference oxygen conditions used at CHH-Tasman.

#### **Total Reduced Sulphur**

##### ***Kawerau Mill.***

CHH Tasman replaced the lime mud filter on No. 2 Lime Kiln with a larger unit in 1995. The older unit now serves as a means to remove lime mud from the system. The larger surface area of the new unit gives better washing and better control of kiln TRS emissions.

***Comparable Mill*** Control is by use of good quality process condensates and / or fresh water in the wet scrubber and ensuring reasonably good mud washing and an adequately sized mud filter to promote the oxidation of sodium sulphide to thiosulphate, a form that does not evolve H<sub>2</sub>S in the presence of CO<sub>2</sub>, the main source of kiln TRS emissions.

***State-of-the-art Mill*** Control is achieved by excellent lime mud washing using stripped condensates or fresh water in the showers on a generously sized mud filter to oxidise sodium sulphide to the thiosulphate form to the practical maximum extent and deliver high solids, typically greater than 75% solids to the kiln.

***Gap with Other Mills*** CHH Tasman's emission performance for No. 1 and No. 2 Lime Kilns are compared in Tables 5 and 6 with two other groups of kilns, one for those using technology of the 1970s/1980s comparable to CHH Tasman and the other state-of-the-art kilns.

**Table 5 - Summary of No. 1 Lime Kiln Air Emission Performance**

| Parameter | Units<br>(a)            | Kawerau                                 | Comparable Mills<br>of Similar Age | Recent mills /<br>State-of-the-art mills           |
|-----------|-------------------------|---|------------------------------------|--|
| PM        | mg/NDm <sup>3</sup>     | 116                                     | 239-465 (b)<br>234 MACT (c)        | 239-median (b)<br>86-minimum( b)<br>/ 36(e), 436g) |
|           | Averaging<br>time       | 5 year average of<br>monthly tests, (d) | (d)                                | (d)  |
| PCDD/F    | pg TEQ/NDm <sup>3</sup> | 23                                      | 0 - 6.5 (f)                        | 89 (g) / -   |
|           | Averaging<br>time       | (d)                                     | (d)                                | (d)  |
| TRS       | mg/NDm <sup>3</sup>     | 10.1                                    | 17.7- 44 (b)                       | 10.1-median<br>5.6-min.                            |
|           | Averaging<br>time       | 5 year average of<br>24h tests          | 12h, 24h<br>(30d Norscan)          | 0.5,4,12,24h<br>(30d Norscan)                      |

Notes:

- a - Concentrations at Normal (N) Conditions of 0°C, 101.325 kPa, dry (D), and 8% reference oxygen
- b - From AMEC, reference 1.
- c - MACT: Kilns existing before 12 Sept 2004, to be in compliance by Sept 2007.
- d - Averaging time is the duration of the sampling time, typically 1h per PM sampling run, 4h per PCDD/F run
- e - MACT: New Kilns started up after 12 Sept 2004, to be in compliance by Sept 2007.
- f - From Uloth, reference 3.
- g - Tasmanian Guidelines

**Table 6 - Summary of No. 2 Lime Kiln Air Emission Performance**

| Parameter | Units<br>(a)            | Kawerau                                 | Comparable Mills<br>of Similar Age | Recent mills /<br>State-of-the-art mills           |
|-----------|-------------------------|---|------------------------------------|--|
| PM        | mg/NDm <sup>3</sup>     | 143                                     | 239-465 (b)<br>234 MACT (c)        | 239-median (b)<br>86-minimum( b)<br>/ 36(e), 436g) |
|           | Averaging<br>time       | 5 year average of<br>monthly tests, (d) | (d)                                | (d)  |
| PCDD/F    | pg TEQ/NDm <sup>3</sup> | 14                                      | 0 - 6.5 (f)                        | 89 (g) / -   |
|           | Averaging<br>time       | (d)                                     | (d)                                | (d)  |
| TRS       | mg/NDm <sup>3</sup>     | 10.7                                    | 17.7- 44 (b)                       | 10.1-median<br>5.6-min.                            |
|           | Averaging<br>time       | 5 year average of<br>24h tests          | 12h, 24h<br>(30d Norscan)          | 0.5,4,12,24h<br>(30d Norscan)                      |

Notes:

- a - Concentrations at Normal (N) Conditions of 0°C, 101.325 kPa, dry (D), and 8% reference oxygen
- b - From AMEC, reference 1.
- c - MACT: Kilns existing before 12 Sept 2004, to be in compliance by Sept 2007.
- d - Averaging time is the duration of the sampling time, typically 1h per PM sampling run, 4h per PCDD/F run
- e - MACT: New Kilns started up after 12 Sept 2004, to be in compliance by Sept 2007.
- f - From Uloth, reference 3.
- g - Tasmanian Guidelines

As can be seen, CHH Tasman's lime kiln emissions compare favourably with similar mills, and the average values are in line with typical state-of-the-art mills.

### 3.9 Power Boilers

CHH Tasman has 2 operating hogged wood waste fired power boilers and one oil fired unit that was retired prior to 2000.

No.2 Power Boiler was commissioned in 1955 and is a International Combustion water tube boiler fitted with oil firing equipment, a travelling grate for firing hog and coal, mechanical dust collector and an electrostatic precipitator. Steam generation is 68 t/h at 650psig and 400°C.

No.3 Power Boiler is a Foster Wheeler unit commissioned in 1963 equipped with fuel oil firing equipment and a travelling grate for firing hog and coal. Steam generation is 68 t/h at 650psig and 400°C.

Mention should be made of other odour sources that are associated with the steam plant. The No. 3 Turbo Generator uses geothermal steam directly to generate approximately 7.5 – 8 MW of electricity, though NST owns the geothermal assets themselves. The pre-evaps run on geothermal steam or live steam. The emissions from the pre-evaps discharge through the turbine vent. The H<sub>2</sub>S-containing exhaust steam from No. 3 Turbo Generator discharges at a high level of 57.9m above grade without treatment. All H<sub>2</sub>S in this stream comes from the borefield area. Geothermal steam is also exchanged for clean steam for use in the paper mill, and this results in H<sub>2</sub>S discharges that originate naturally from the borefield as well. Both these odour sources are unique sources at the Kawerau site and are not covered by the air consent because of their natural origins, but the steam flow and hence H<sub>2</sub>S discharge is controlled by air discharge consent which sets a geothermal steam usage limit of 9,600t/d. These sources are not considered further in this report.

The emission data for each power boiler is presented together in Tables 7 and 8 which follow at the end of this subsection.

#### Particulate Matter

**Kawerau Mill** No. 2 Power Boiler and No. 3 Power Boiler are primarily hog fuel fired. Each boiler has a mechanical collector that discharges to one chamber of the two chambers Research-Cottrell electrostatic precipitator and the treated flue gases combine downstream for discharge to the stack. The precipitator has G-Opzel type collecting plates, Dura-Trode rigid discharge electrodes, two chambers, 16 gas passages and other supporting equipment.

The boilers together consume approximately 165,000 green t/a hog fuel consisting of wood waste from chipping, bark, sawdust and shavings from the local sawmill as well as some reclaimed waste (wood billets, pallets, etc) from a dump on the mill site. Oversize material is passed through a hog for reduction to the appropriate size. Small quantities of coal are fired as supplemental fuel to meet the steam demand. No effluent treatment sludge is fired. The back-up fuel source is No. 6 heavy fuel oil (Bunker C) fuel oil. There is no capability to fire natural gas.

PM sampling is undertaken in the outlet duct of the precipitator serving each boiler. Sampling data over the last 5 years has been averaged and is presented for each boiler in tables which follow.

**Comparable Mill** For hog fuel fired power boilers of the 1970s to mid-1980s, PM control is typically by two stage mechanical collectors, such as multiple cyclones. A small minority of these mechanical collectors have a hopper shave off system that improves PM removal efficiency. Less common because of the associated wet plume is control with a wet scrubber that may be of the impingement type, or the venture-type. A number of these hog fuel fired power boilers will have had emission controls upgraded to an electrostatic precipitator as part of an upgrade to burn a higher proportion of hog fuel or as part of a major mill upgrade.

One of the sources of PM emission data from a typical "Comparable Mill" is the case of an existing mill in the US faced with meeting the new MACT Rule. The new Rule applicable to both existing and new boilers was promulgated under the National Emission Standards for Hazardous Air Pollutants on 12 Sept 2004. This requires that solid fuel fired boiler units that existed prior to that date with heat input capacities greater than 10MBtu/h adopt Maximum Achievable Control Technology (MACT) within 3 years, namely by Sept 2007. The limits specified are PM, mercury, hydrogen chloride and carbon monoxide, with the limits for existing mill being less stringent than those for new mills. Existing mills must meet a PM limit of 0.07lb/MBtu heat input which is equivalent to 79 mg/NDm<sup>3</sup> when converted to a concentration in the flue gas and converted to the Kawerau reference conditions of 8% reference oxygen.

The second source for PM emission data from a typical "Comparable Mill" is as before (AGRA Simons, 1994).

**State-of-the-Art Mill** Emission control is by a single or two chamber electrostatic precipitator with three fields in the direction of gas flow. The single chamber precipitator would be equipped with a bypass duct and gas tight dampers or a diverter damper and stub stack to allow operation on fossil fuel only in the event the precipitator required man entry for maintenance.

One of the sources of information on state-of-the-art mill PM emissions is the US MACT rule introduced on 12 Sept 2004 which is applicable to new boilers built after that date. These boilers are required to comply with the Rule within 6 months of Sept 2007 when they are started up. The limit is 0.025lb/MBtu heat input, which is equivalent to about 28mg/NDm<sup>3</sup> when converted to a concentration in the flue gas and converted to the Kawerau reference conditions of 8% reference oxygen.

A second source for state-of-the-art PM emissions are the guidelines issued in August 2004 by the Tasmanian Government that would apply to any eucalypt kraft pulp mill built in Tasmania (RPDC, 2004). The limit for power boilers is 30mg/NDm<sup>3</sup> at 8% reference oxygen by volume dry basis.

A third source for PM emissions from fairly recent mills are the tabulation of air emission permits from a significant proportion of the new and modernised pulp mills worldwide which started up in the 1990 - 1995 time period (AGRA Simons, 1994). Though now

somewhat dated, this information is included for reference to show the range of limit values that were adopted by regulatory authorities at that time.

#### PCDD/F

**Kawerau Mill** No 2 and 3 Power Boilers were sampled for PCDD/F in 2000 (CRL, 2000) and 2001 (CRL, 2001), which provide a total of three TEQ results for each boiler. Additional sampling was carried out in 2004 and the data lie within the range cited. These results are presented in Tables which follow.

**Comparable Mill** It has been known since the early 1990s (Luthe, 1993) (Välttilä, 1994) that wood waste containing chlorides or chlorinated organics even in small amounts will normally generate measurable concentrations of PCDD/F in combustion gasses. Conditions in the boiler favouring dioxin formation are the presence of fly ash and char which have a catalytic effect, residence time in the 200 - 400°C temperature range as typically found in the back passes of boilers.

Research shows that the amount of dioxin formed in a boiler tends to be dependent on the type of boiler technology used, with grate-type boilers generally having higher emissions than Bubbling Fluid Bed (BFB) or Circulating Fluid Bed (CFB) types. The grate type boiler showed 90% of the dioxin attached to the fly ash particles, while for BFB or CFB types, the corresponding level was about 0 - 20% of the grate equipped boilers, reflecting the very low carbon carryover of these fluid bed technologies. However, the dioxin content of the flue gases and ash could not be explained by the amount of chlorides introduced into the furnace, in this case, effluent treatment sludge. Balance calculations showed that while the BFB boiler destroyed PCDD/F, the CFB and grate boilers were net generators. It is noted that all three boilers studied were old and the CFB and BFB were originally designed to burn spent liquor.

Dioxin emissions from power boilers burning clean wood waste can increase as much as 10-fold or more due to co-firing of manufactured wood product residues, plywood or agricultural wastes. Dioxin emission data from 21 stack tests in the US and 16 in Canada for clean wood waste hog fuel fired power boilers was collected from various boiler types included refractory cell, traveling grate, fixed grate spreader stokers, and fluid bed furnaces. All 10 of the US boilers were equipped with multiclones for particulate emission control. Three of the boilers were also equipped with dry electrostatic precipitators, four with wet scrubbers and one with a wet scrubber followed by a wet ESP. Two had only multiclones for PM control. While the four boilers with wet scrubbers generally had lower dioxin emissions, the US researchers found it difficult to conclude that the final PM control device had any effect on the total PCDD/F emissions, because of the wide variation of emissions for a given boiler and between boilers. The range of these values converted to reference 8% oxygen by volume dry basis is 0.8 - 399.2 picogram/NDm<sup>3</sup>.

In Canada, there is limit for existing power boilers, but only for those firing salt-laden hog fuel. These boilers are found on the sea coast in British Columbia and have been shown to generally have elevated dioxin emissions. The limit to be enforced for existing boilers by 2006 is 500 pg/ NDm<sup>3</sup> at 8% oxygen by volume dry basis. Control measures include limiting the amount of salt in the hog fuel fired and firing sulphur-containing fuels which has been found to have a scavenging effect lowering the dioxins emitted.

The US MACT regulations do not limit dioxin directly, but choose to impose limits on PM to which dioxin adsorb and CO which is an indicator of good combustion.

**State-of-the-Art Mill** To breakdown dioxin in the furnace and inhibit their formation in the boiler backpasses downstream, furnace design and operation should be aimed at providing the best possible combustion with the total conversion of carbon to CO<sub>2</sub>, and chloride to hydrochloric acid (HCl). In practice, total conversion is not achievable, but a number of strategies have been identified for furnace and equipment design aimed at furthering this objective and are the improvements in technology that have occurred in the last two decades. These are:

- Maximize high flame temperature in the combustion process to minimize the carryover of char with the fly ash to avoid delayed pyrolysis of the char which functions as catalysts for the *de novo synthesis* of dioxins
- Maintain a high degree of gas turbulence in the furnace with a modern overfire combustion air system to avoid flue gas short circuiting and channelling and maximize residence time in the furnace at elevated temperature to ensure decomposition of dioxins and their precursors.
- Cool the gases leaving the furnace effectively and quickly, particularly through the 400 - 200°C range with clean heat transfers surfaces, minimize contact with soot, and provide a flue gas temperature leaving the air heater below 200°C.
- Provide the maximum practical PM removal efficiency in the emission control equipment as the dioxins and furans are adsorbed onto fly ash and char particle surfaces to a significant degree; and
- Handle the fly and furnace ash in a dry condition, and direct the ash to landfill, using water only as necessary to prevent dusting.

One of the sources of information on state-of-the-art PCDD/F emissions are the guidelines issued in August 2004 by the Tasmanian Government that would apply to any eucalypt kraft pulp mill built in Tasmania (RPDC, 2004). The limit for power boilers is 100pg/NDm<sup>3</sup> at 8% reference oxygen.

**Gap with Other Mills** The emission performance of No. 2 and No. 3 Power Boilers is summarized in Tables 7 and 8 and compared with two other groups of power boiler sources. One group is for Comparable Mills using technology of the 1970s/1980s similar to CHH Tasman and the other, newer state-of-the-art power boilers.

**Table 7 - Comparison of No. 2 Power Boiler Air Emission Performance**

| Parameter | Units<br>(a)      | Kawerau                                 | Comparable Mills<br>of Similar Age | Recent mills /<br>State-of-the-art mills         |
|-----------|-------------------|---|------------------------------------|--|
| PM        | mg/NDm3           | 60                                      | 113-387 (b)<br>78.9 MACT (c)       | 68-median (b)<br>39-minimum (b)<br>/ 28-MACT (e) |
|           | Averaging<br>time | 5 year average of<br>monthly tests, (d) | (d)                                | (d)  |
| PCDD/F    | pg TEQ/NDm3       | 53, 570, 800                            | 0.8 - 339 (f)                      | 100 (g) / -                                      |
|           | Averaging<br>time | (d)                                     | (d)                                | (d)  |

Notes:

- a - Concentrations at Normal (N) Conditions of 0°C, 101.325 kPa, dry (D), and 8% reference oxygen
- b - From AMEC, reference 1.
- c - MACT: Boilers existing before 12 Sept 2004, to be in compliance by Sept 2007.
- d - Averaging time is the duration of the sampling time, typically 1h per PM sampling run, 4h per PCDD/F run
- e - MACT: New boilers started up after 12 Sept 2004, to be in compliance by Sept 2007.
- f - From Uloth, reference 3.
- g - Tasmanian Guidelines

**Table 8 - Comparison of No. 3 Power Boiler Air Emission Performance**

| Parameter | Units<br>(a)      | Kawerau                                 | Comparable Mills<br>of Similar Age | Recent mills /<br>State-of-the-art mills         |
|-----------|-------------------|---|------------------------------------|--|
| PM        | mg/NDm3           | 52.9                                    | 113-387 (b)<br>78.9 MACT (c)       | 68-median (b)<br>39-minimum (b)<br>/ 28-MACT (e) |
|           | Averaging<br>time | 5 year average of<br>Monthly tests, (d) | (d)                                | (d)  |
| PCDD/F    | pg TEQ/NDm3       | 70, 200, 292, 750, 2510                 | 0.8 - 339 (f)                      | 100 (g) / -                                      |
|           | Averaging<br>time | (d)                                     | (d)                                | (d)  |

Notes:

- a - Concentrations at Normal (N) Conditions of 0°C, 101.325 kPa, dry (D), and 8% reference oxygen
- b - From AMEC, reference 1.
- c - MACT: Boilers existing before 12 Sept 2004, to be in compliance by Sept 2007.
- d - Averaging time is the duration of the sampling time, typically 1h per PM sampling run, 4h per PCDD/F run
- e - MACT: New boilers started up after 12 Sept 2004, to be in compliance by Sept 2007.
- f - From Uloth, reference 3.
- g - Tasmanian Guidelines

These tables show that CHH Tasman's wood waste fired power boiler PM emissions compare favourably with those of similar mills and long term average values achieve the new MACT level that existing power boilers must meet in the US by 2007. As regards PCDD/F/F, the few tests are widely spread, from moderate to very high when compared to values for uncontaminated wood waste fuel. Possible explanations for the higher PCDD/F emission levels include less than ideal boiler operating conditions such as low combustion temperature combined with wood waste that contains chlorides, chlorinated organics or other dioxin and furan precursors. It is well established that suboptimal power boiler operation which results in low combustion temperature however caused (high fuel

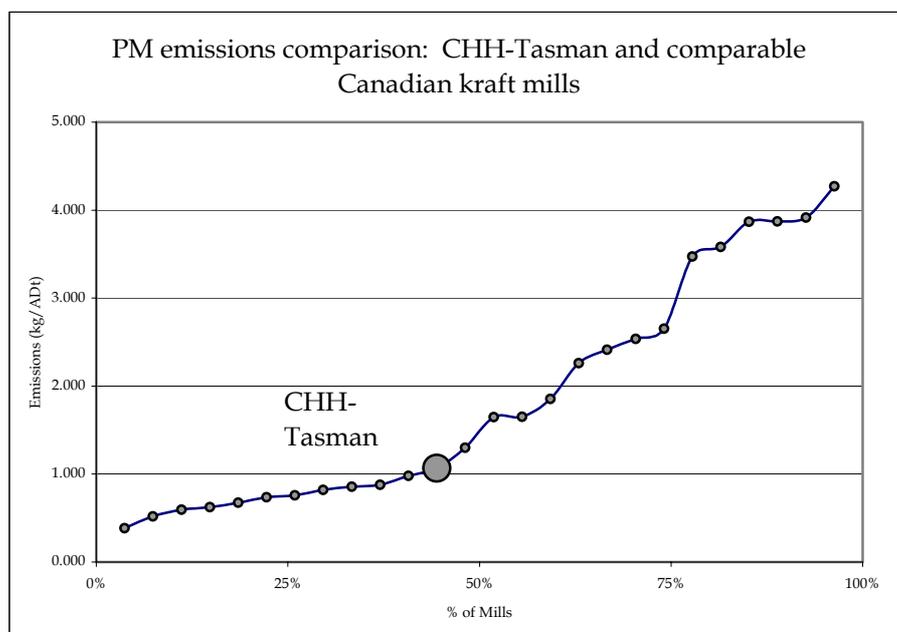
moisture, poor fuel quality / low heat content, improper excess air, poor gas mixing in the furnace) which combined with a source of chloride in the fuel fired can result in the generation of PCDD/F and create relatively high emission concentrations. Combustion of municipal solid waste typically has high PCDD/F emissions compared to other forms of solid fuel combustion because of the problem of controlling combustion with fuel that contains chlorides and is so unhomogeneous.

## 4 Site-Wide Air Emission Comparisons

Site-wide air emission data per tonne kraft production (kg/ADt) from selected Canadian market pulp and integrated kraft mills was analyzed to provide further comparison of CHH Tasman mill with other mills for total PM and TRS. The data is from the latest available National Pollution Reduction Inventory for Canadian kraft pulp mills in 2003. The data is presented in the form of cumulative probability distribution charts ranked by emission magnitude, with CHH Tasman's emissions shown as a separate data point.

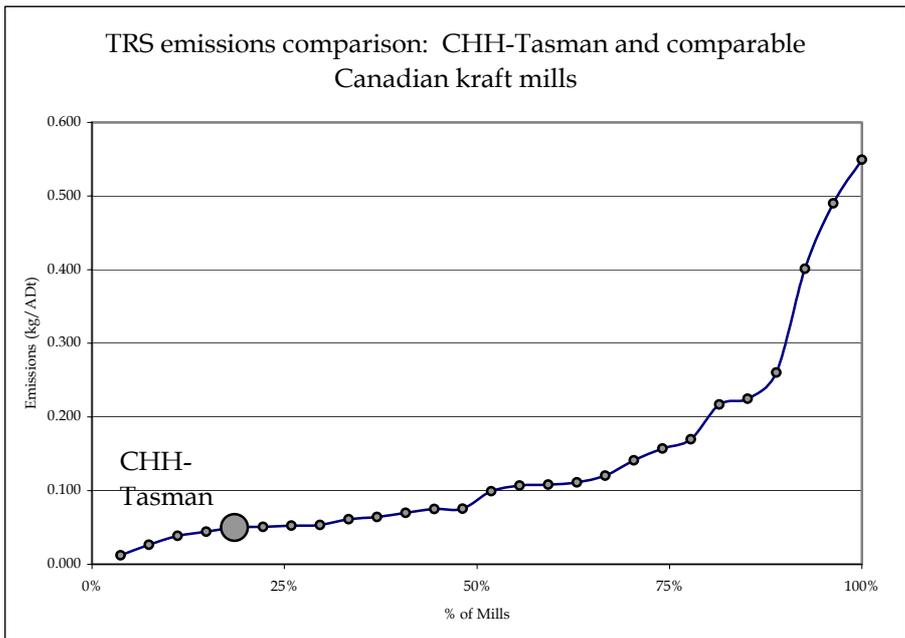
As a means to make a fairer comparison between CHH Tasman and Canadian mills, the age of the recovery boiler was used as the parameter indicative of the class of technology and age of the mill. All recovery boilers built or rebuilt since 1990 were excluded as were all mills where the recovery boilers were older than 1960. In this way newer mills and very old mills were excluded from the comparison and the list of 42 sites with kraft pulping was reduced to 26.

The results for PM are presented in Fig 1.



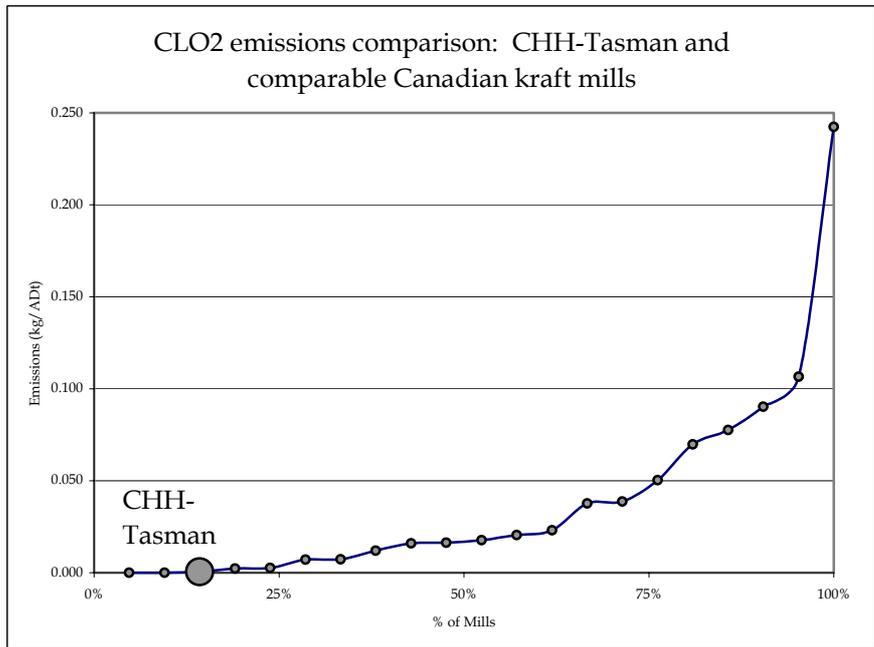
CHH Tasman with 1.067 kg PM/ADt is ranked 12<sup>th</sup> (44% percentile) at very close to the median of the 26 Canadian mills.

The results for TRS are presented in Fig 2.



CHH Tasman with 0.050 kg TRS/ADt is ranked 5<sup>th</sup> (19% percentile) of the 26 Canadian mills

The results for CLO<sub>2</sub> are presented in Fig 3.



CHH Tasman with 0.00052 kg TRS/ADt is ranked 3<sup>rd</sup> (14% percentile) of the 20 Canadian mills reporting.

## 5 References

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Välttilä, O., Jarvinen, R., Raino, K., Talka, E., *Combustion of kraft mill biosludge*, 1994.

- Appendix A  
**Glossary of  
abbreviations, terms  
and units**

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## GLOSSARY OF TERMS AND ABBREVIATIONS

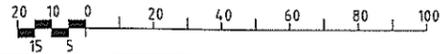
|                     |  |
|---------------------|--|
| ADMT                | air dried metric tones   |
| BLOX                | Black Liquor Oxidation   |
| CD2                 | No. 2 Continuous digester  |
| CD3                 | No. 3 Continuous digester  |
| Cl <sub>2</sub>     | Chlorine   |
| ClO <sub>2</sub>    | Chlorine dioxide   |
| NCG                 | non-condensable gas  |
| Dissolver vent      | smelt dissolving tank vent   |
| DMS                 | dimethyl sulphide  |
| DMDS                | dimethyl disulphide  |
|                     |  |
| DNCG                | Dilute non-condensable gas   |
| EBOP                | Environment Bay of Plenty  |
| EPA                 | Environmental Protection Agency  |
| HAP                 | hazardous air pollutant  |
| Hog Fuel            | bark and other wood waste  |
| HCl                 | hydrochloric acid  |
| HOCl                | sodium hypochlorite  |
| Hypo                | sodium hypochlorite  |
| kg/ADt              | kilograms per air dried (2205lb) tonne   |
| metric tonne        | 2205 lb, written t   |
| mg/NDm <sup>3</sup> | milligrams per normal (0°C, 101.325kPa) dry cubic metre  |
| mg/SDm <sup>3</sup> | milligrams per standard (20°C, 101.325kPa) dry cubic metre   |
| MACT                | Maximum Achievable Control Technology  |
| MCR                 | maximum continuous rating or nameplate capacity of a boiler  |
| NA                  | Not applicable   |
| NDm <sup>3</sup>    | Normal (N) conditions of 0°C and 101.325kPa and dry (D)  |
| NSPS                | New Source Performance Standards   |
| NST                 | Norske Skog Tasman   |
| PCDD                | Polychlorinated dibenzo-p-dioxins  |
| PCDD/F              | Polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans  |
| PCDF                | polychlorinated dibenzofurans  |
| PM                  | particulate matter   |
| Reference oxygen    | correction of emission concentration at actual oxygen content to 8% by volume dry basis for power boilers and 5% by volume dry basis for recovery boilers and lime kilns specified in CHH Tasman permits |

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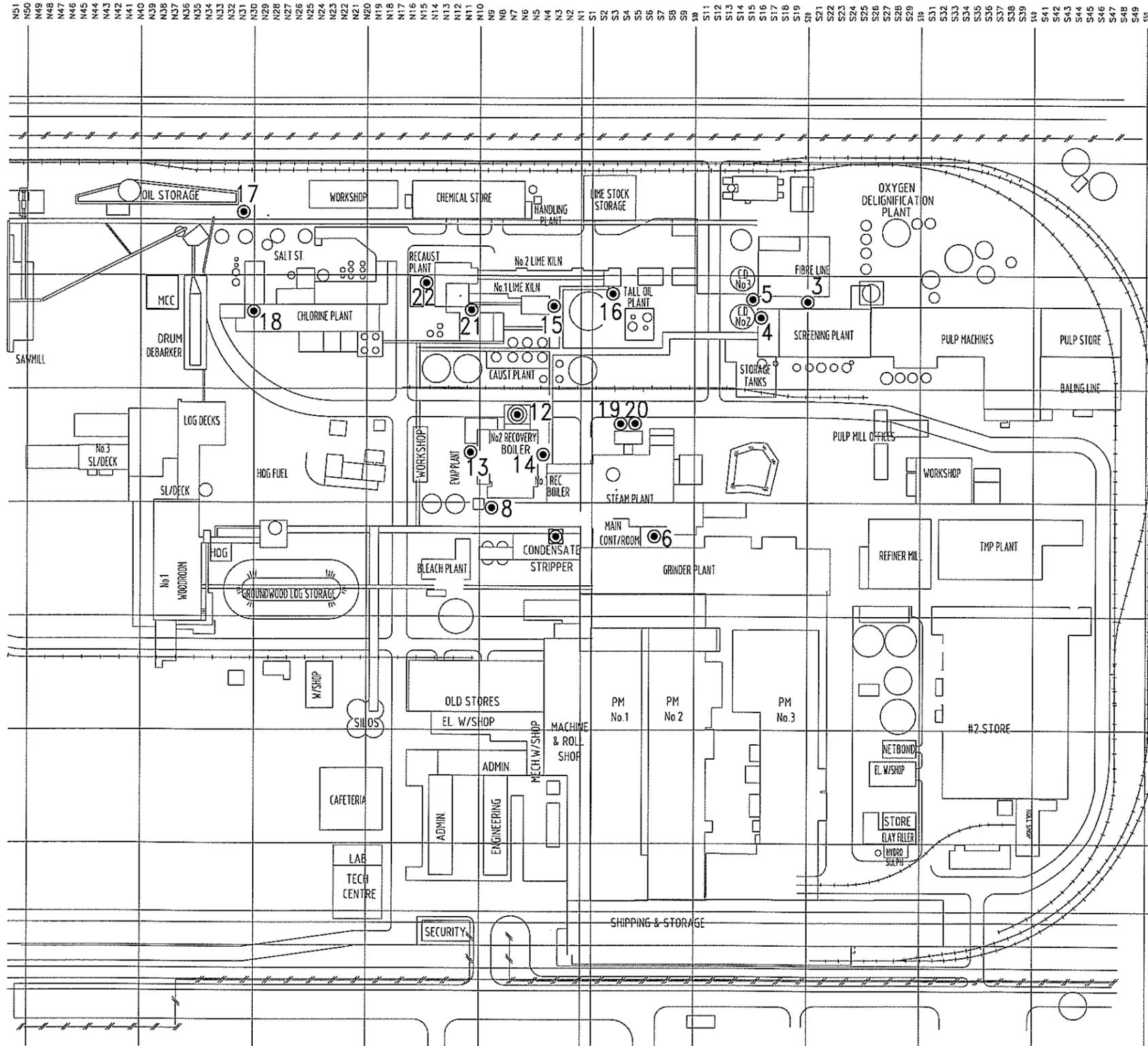
|                          |   |
|--------------------------|---|
| SBLOX                    | Strong Black Liquor Oxidation   |
| SVP                      | Single Vessel Process   |
| T                        | ton, 2000lb   |
| t                        | metric tonne, 2205lb  |
| TEQ                      | dioxin and furan mixture expressed as a single number using accepted toxic equivalence among PCDD/F congeners   |
| TRS                      | Total reduced sulphur, the odourous component of gases produced in the pulping process, comprising hydrogen sulphide, methyl mercaptan, and dimethyl sulphides. |
| $\mu\text{g}/\text{m}^3$ | micrograms per standard (20°C, 101.325kPa) dry cubic metre  |
| VOC                      | Volatile organic compounds  |

- Appendix B

## **Stack Drawing**



|                    |  |
|--------------------|--|
| REFERENCE DRAWINGS |  |
|                    |  |
|                    |  |



SCHEDULE OF STACKS  
PREPARED 21 OCTOBER 1993

| NO | AREA | PLANT                               | HEIGHT ABOVE G.L. (MM) | DIAMETER | DRAWING NUMBER                              |
|----|------|-------------------------------------|------------------------|----------|---|
| 1  | 31   | SEMI BLEACH PLANT                   | 32,051                 | 750      | D21-MP-1030                                 |
| 2  | 37   | CHP BIN CO2 (INCLUDED IN FIBRELINE) | 26,100                 | 250      | D37-MP-1014 (DELETED)                       |
| 3  | 39   | FIBRELINE                           | 32,000                 | 914      | 39-MV-1000                                  |
| 4  | 41   | CHP BIN CO2                         | 42,045                 | 300      | 41-MP-1071/E                                |
| 5  | 44   | BLEACH PLANT                        | 75,520                 | 1220     | D44-MV-1006                                 |
| 6  | 53   | GEOTHERMAL TA3 EXHAUST              | 57,912                 | 1524     | D53-2225, D53-2226                          |
| 7  | 60   | POWER BOILER NO.1                   | 54,841                 | 1812     | TD-93-CS-573                                |
| 8  | 61   | SBLOX                               | 52,544                 | 955      | 61-MP-1060                                  |
| 9  | 62   | RECOVERY BOILER NO.1                |                        |          |   |
| 10 | 62   | RB-1 SMELT (BY PASS)                |                        |          | NO1 RECOVERY BOILER STACKS DELETED 12-07-00 |
| 11 | 62   | RB-1 SMELT                          |                        |          |   |
| 12 | 62   | RECOVERY BOILER NO.2                | 57,912                 | 4267     | E62-C-3028                                  |
| 13 | 62   | RB.2 SMELT                          | 56,083                 | 1219     | D62-M3674, C62-M3671                        |
| 14 | 62   | RB.2 SMELT                          | 56,083                 | 1219     | D62-M3674, C62-M3671                        |
| 15 | 64   | LIME KILN NO.1                      | 55,600                 | 1392     | 64-ML-1001                                  |
| 16 | 64   | LIME KILN NO.2                      | 55,600                 | 1392     | 64-ML-1025                                  |
| 17 | 67   | ACID SEWER                          | 28,042                 | 500      | TD-67-CA-300, 67-ML-1010                    |
| 18 | 68   | SVP                                 | 26,060                 | 216      | TD-67-CA-300                                |
| 19 | 93   | POWER BOILERS 2                     | 58,522                 | 1905     | 93-CS-1007                                  |
| 20 | 93   | POWER BOILERS 3                     | 58,522                 | 1905     | 93-CS-1007                                  |
| 21 | 64   | LIME REBURNING PLANT                | 31,063                 | 150      | D64-M2296 (INCG MAIN VENT)                  |
| 22 | 64   | LIME REBURNING PLANT                | 30,660                 | 200      | 64-ML-1157 (SOG MAIN VENT)                  |

|     |         |   |     |     |          |      |
|-----|---------|---|-----|-----|----------|------|
| F   | -       | SEMI BLEACH PLANT CLOSED AND POWER BOILER NO.4 STACK REMOVED                  | PO  |     | 24-05-06 |      |
| E   | 6384556 | NO1 RECL. STACKS REMOVED AND CHP BIN VENT HT. / DIA. MOD'D. & DRG RE. ALTERED | GB  |     | 12-07-00 |      |
| D   | G803372 | CHP BIN CO2 DELETED   | GB  |     | 26-02-98 |      |
| C   | G803372 | GENERAL REVISIONS   | GB  |     | 07-07-97 |      |
| B   | C801477 | GENERAL REVISIONS   | GB  |     | 16-06-97 |      |
| A   | GX01024 | FOR INFORMATION   | CP  | -   | -        |      |
| REV | JOB NO. | DESCRIPTION   | DRN | CHK | APP      | DATE |

|                |                |      |          |
|----------------|----------------|------|----------|
| PROJECT NUMBER | NAME (PRINTED) | SIGN | DATE     |
| GX0104         |                |      |          |
| DESIGNED       |                |      |          |
| DRAWN          | C. POLLARD     |      | 23-06-94 |
| DRAWING CHK    |                |      |          |
| DESIGN CHK     |                |      |          |

|       |      |                           |
|-------|------|---------------------------|
| SCALE | AREA | APPROVAL FOR CONSTRUCTION |
| 1:1   |      |                           |
| AT A1 |      |                           |

**Teaman** PULP AND PAPER COMPANY LIMITED  
KAWERAU NEW ZEALAND

**MILL WIDE  
SITE PLAN  
STACK LOCATIONS**

|                |       |     |
|----------------|-------|-----|
| DRAWING NUMBER | SHEET | REV |
| 00-ML-0348     | 1     | F   |

CAD FILE: R:\\_SHARED SERVICES\DEPT\00\ML0348.DWG

DIMENSIONS IN MILLIMETRES

DO NOT SCALE

PLEASE CHECK CURRENT REVISION

08 MARCH 2002  
PLOTTED RAW DATE