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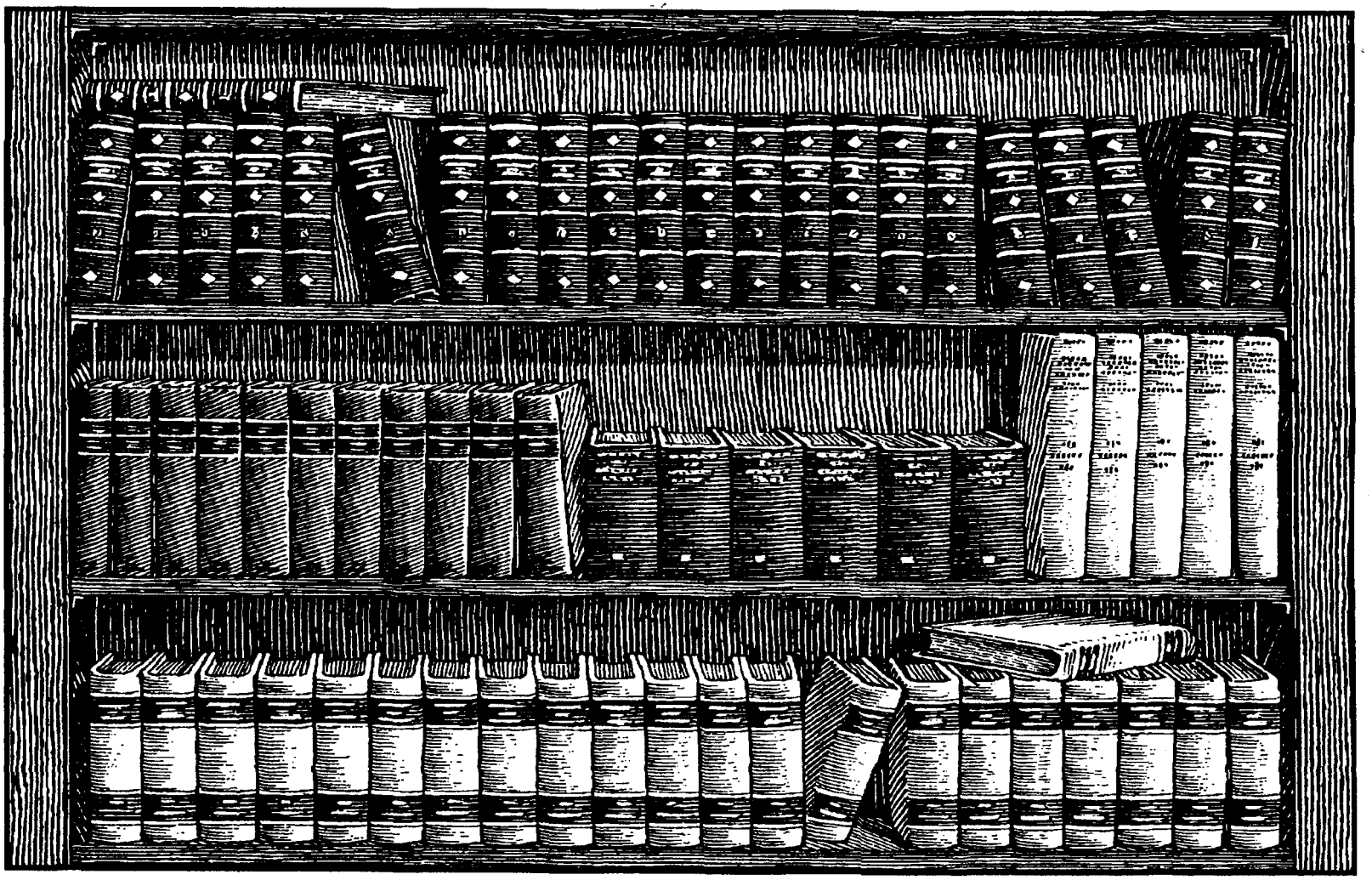
Pollution Prevention for the Kraft Pulp and Paper Industry

Bibliography



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POLLUTION PREVENTION FOR THE KRAFT PULP AND PAPER INDUSTRY

BIBLIOGRAPHY

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NUMBER	TITLE	AUTHOR	REFERENCE	SYNOPSIS
			1.0 CHIP PREPARATION	
1.1	Removal of chips thins as fines - effect on pulping variables	Pemble, G. G.	TAPPI Proceedings, Pulping Conference Book 1, 1990, pp. 61-63	In an attempt to remove as high a percentage of <4.8 mm round hole fines as possible, a 2.9 mm slotted opening was tested and later installed in our gyratory fine screens. Not only was the <4.8 mm round holes fines removal increased, but the removal of 2.9 mm "thins" brought a number of process improvements. This paper is a chronicle of mill's experience with these improvements in key pulping variables.
1.2	An automated chip quality analysis system - a tool for improving chip quality	McInnis, Dukes, Lawrence and Andrews	TAPPI Proceedings, Pulping Conference Book 1, 1990, pp. 65-76	A Gradex Particle Size Analyzer has been coupled to a PC based data information system. The PC system, utilizing standard database and graphical packages, allows easy and rapid analysis of chip quality data. This data has been organized in various forms: chip ranking, vendor update letters, trend and SPC graphical presentations to improve in-mill and purchased chip quality and to understand the impact of chip quality on mill operations.
1.3	Refining intensity, energy consumption and pulp quality in two-stage chip refining	Miles, May and Karnis	TAPPI Proceedings, Pulping Conference Book 2, 1990, pp. 681-690	Thermomechanical pulps were produced in two pilot installations. Both were conventional two-stage systems in which the first stage was pressurized and the second atmospheric. Analysis of the experimental results showed that at a given specific energy pulp quality was improved, or for a given pulp quality the energy consumption was reduced when the first stage refining was carried out at a high rotational speed or low consistency. There were indications that these benefits could be enhanced if the second stage were operated at a low refining intensity.

NUMBER	TITLE	AUTHOR	REFERENCE	SYNOPSIS
			2.0 CHEMICAL PULPING	
2.1	Soda ash - the papermaker's alternative to caustic soda	Wortley, Barbara	PIMA Magazine, March 1988	
2.2	The recovery of by-products and pulping chemicals from industrial soda bagasse spent liquors	Venter, J.S.M., and Vander Klashorst, G.H.	TAPPI Proceedings, April 1987 Environmental Conference, pp. 79-86	Large amounts of lignin and hemicellulose are dissolved during soda pulping of bagasse and other agricultural plants. The spent liquor is usually concentrated and burnt to prevent pollution. The energy balance is usually negative and soda cannot be recycled unless silica is removed.
2.3	The basics of foul condensate stripping	Burgess, T.	TAPPI Press, Environmental Issues: An Anthology of 1989, pp. 241-246	Foul condensates from the digesters and evaporators contain reduced sulfur gases and organic compounds which contribute to pulp mill water pollution in the form of BOD toxicity. They can also create odor problems in the mill and at the secondary treatment system.
2.4	Studies on alkali - oxygen-anthraquinone delignification of bagasse	Upadhyaya, Chinnapadasan, Rajan, Singh and Dutt	TAPPI Proceedings, Pulping Conference Book 1, 1990, pp. 337-343	The proposed study was undertaken to assess the suitability of bagasse by alkali-oxygen delignification process and to know the effect of anthraquinone (AQ) on pulp and paper characteristics.
2.5	Kraft pulping for the environment of the 90's	Barratt, K.	TAPPI Press, Environmental Issues: Anthology of Published Papers, 1990, pp. 44-51	This paper summarizes the latest information on the Beloit RDH system of Batch digester heat recovery.
2.6	RDH kraft pulping to extend delignification, decrease effluent, and improve productivity and pulp properties	Andrews, E.K.	TAPPI Journal, November 1989, pp. 55-61	Status of the RDH pulping process and how it compares with oxygen delignification in terms of pulp strength, pulp yield, and effluent loading.
2.7	Design considerations for condensate segregation and methanol/TRS stripping	Beckstrom, B.	TAPPI Press, Environmental Issues: Anthology of Published Papers, 1990, pp.335-345	A discussion is presented on the importance of considering a condensate stripping system as an entity of its own and not just an appendage to other equipment. The importance of condensate segregation is presented along with design principles used to optimize stripping system importance.

NUMBER	TITLE	AUTHOR	REFERENCE	SYNOPSIS
2.8	Effect of entrained black liquor carry-over on medium-consistency oxygen delignification	Miller, W.J., Lhackford, H. Jiang, and Genco, J.	TAPPI Journal, February 1991, pp. 117-122	Solids carry-over causes inefficiency in oxygen delignification, but increasing the amount of sodium hydroxide can correct the problem. The use of three stages of pre-oxygen washing and two stages of post-oxygen washing is recommended.
2.9	On-line oxygen delignification control	Anon.	TAPPI/CPPA Proceedings, 1988 International Pulp Bleaching Conference, Orlando, Florida, June 1988	Discussion of control system for oxygen delignification based on on-line Kappa number measurement. System reduced average Kappa number and production costs.
2.10	Extended delignification, an alternative to conventional kraft pulping	Mera, F.E, and Chamberlin, J.L.	TAPPI Journal, January 1987, pp. 132-136	Mill and pilot plant data for market grade bleached pulp were evaluated. The pulp quality was equivalent to or better than that of bleached pulps obtained by conventional kraft pulping and bleaching techniques. However, operating parameters favored extended cooking in the rapid displacement heating process. These parameters were lower active alkali consumption, lower bleaching chemical demand, and lower bleach plant effluent liability.
2.11	PRENOX process-experiences from a pilot plan installation	Simonson, O., Lindstrom, L.A., and Marklund, A.	TAPPI Journal, August 1987, pp. 73-76	Study showing that high-consistency treatment of pulp with NO2 and O2 before the oxygen delignification stage can produce pulp with a Kappa number of 7 and significantly reduce bleach-plant pollutants.
2.12	North America's first fully integrated, medium consistency oxygen delignification stage	Enz, S.M., and Emmerling, F.A.	TAPPI Journal, June 1987, pp. 105-112	Consolidated Paper, Inc. has installed a medium-consistency oxygen delignification reactor in the hardwood pulp line at its kraft mill in Wisconsin Rapids, Wisconsin. System has resulted in a decrease in Kappa number, increased production and brightness and a decrease in chemical consumption.
2.13	Ozone delignification of black spruce and hardwood kraft, kraft-anthraquinone, and soda-anthraquinone pulps	Liebergott, N., and van Lierop, B.	TAPPI Journal, June 1981, pp. 95-99	After ozone delignification followed by DED treatment, black spruce, and mixed hardwood kraft, kraft-AQ and soda-AQ pulps attained 89-92% brightness (ISO) and compared to conventionally bleached CEDED pulps, required less ClO2 in the third and fifth stages, had somewhat lower strength properties for black spruce but similar strength for hardwood pulps, and gave effluents and color loadings that were 60-75% lower.

NUMBER	TITLE	AUTHOR	REFERENCE	SYNOPSIS
2.14	Oxidation of pulp with NO2/O2 prior to oxygen delignification - a novel process with potentially less pollution	Brannland, R., Lindstrom, L.A., Norden, S., and Simonson, O.	TAPPI Proceedings, 1985 International Bleaching Conference	Four companies AGA, KemaNord, MoDo and Sunds Defibrator are jointly exploring a new delignification process. With this process, characterized by a pretreatment of pulp prior to oxygen delignification with a combination of NO2 and O2 it is possible to delignify softwood kraft pulp to Kappa numbers below 10. In this paper we will discuss what impact this process will have on chemical composition and environmental effects of spent liquors produced in a subsequent bleaching process. Results will be compared with those from bleaching of oxygen delignified pulp. Also matters related to working environment and emission to air will be covered.
2.15	Delignifying high-yield pulps with oxygen and alkali	Kleppe, P.J., and Storebraten, S.	TAPPI Journal, July 1985, pp. 68-73	Discussion of delignifying high-yield pulps with oxygen and alkali by using a two stage pulping process. Pulp properties, sack paper production and linerboard production are discussed.
2.16	Oxygen delignification systems: optimum design syntheses	Edwards, L., Myer, M., and Haynes, J.	TAPPI Seminar Proceedings, Bleaching and the Environment, Seattle, Washington, September 1988, pp. 333-356	Simulation and optimization techniques are used to determine the best combination of equipment and operating conditions from an oxygen delignification system including washing. Both capital costs and operating costs are considered. For example, "What is the optimum dilution factor and amount of washing equipment and how should the equipment be divided between pre and post oxygen stage washing?" Evaporator and environmental constraints are also taken into account.
2.17	Oxygen delignification technology: state-of-the-art report on advances	White, F.	Paper Trade Journal, February 28, 1982, pp. 27-30	Oxygen and ozone delignification in the bleaching of kraft pulps are compared. Medium consistency oxygen delignification of kraft pulp is described. Aspects of low cost peroxide bleaching to high brightness are covered, and hydrogen peroxide in chemical pulp bleaching is discussed.
2.18	System using medium-consistency oxygen bleaching works in Sweden	Nasman, L.E.	Pulp & Paper, October 1981, pp. 137-138	SCA mill at Ostrand has successfully run a full-scale oxygen-caustic extraction stage. The advantages of oxygen plus oxygen-extraction stage are described.
2.19	Oxygen delignification at medium consistency can raise yield, cut BOD	Markham, L.D., and Magnotta, V.L.	Pulp & Paper, October 1981, pp. 139-142	General discussion of oxygen delignification including advantages and disadvantages, process, pulp yield, and effluent reduction.
2.20	Oxygen/alkali delignification at medium consistency	Kleppe, P.J., Knutsen, P.C., and Jacobsen, F.	TAPPI Journal, June 1981, pp. 87-90	The sequence of events leading to the development of a mill-scale oxygen/alkali delignification process at medium consistency is described. The process, which takes pulp directly from the blow line of a continuous digester, is also presented.

NUMBER	TITLE	AUTHOR	REFERENCE	SYNOPSIS
2.21	Experience with extended delignification of hardwood and softwood kraft pulp in a continuous digester	Kortlainen, V.A., and Backlund, E.A.	TAPPI Journal, November 1985, pp. 70-74	A multistage continuous kraft pulping process that provides a more selective delignification than conventional kraft cooking is in commercial operation at a mill in Finland. This improved selectivity is used to lower the pulp's Kappa number, which has contributed to reductions in the consumption of bleaching chemicals, to reductions in the effluent load of the bleach plant, and to an increase in the bleach plant's production capacity. When compared at the same Kappa number, the modified pulp has a higher viscosity, better strength and consumes less bleaching chemicals than a conventional kraft pulp. Operating experiences, consumption data and pulp-quality data for hardwood and softwood kraft pulps are reported.
2.22	Nitrogen dioxide preoxidation oxygen delignification - a process for the future?	Lindqvist, B., Marklund, A., Lindstrom, L.A., and Norden, S.	TAPPI Proceedings, 1985 International Pulp Bleaching Conference, pp. 221-225	In order to produce a low Kappa number pulp after an oxygen stage, nitrogen dioxide preoxidation was superior to modification of the kraft cook, Kappa number 9-10 should be compared to 13-14 in the latter case. A number of these methods made it possible to further reduce the Kappa number to about 8 after the oxygen stage. Kappa number reduction from 17-9, the first figure representing a conventionally cooked and oxygen bleached kraft pulp, decreased the consumption of active chlorine up to 55%. COD, BOD_6 and total organic chlorine were reduced with 55%, while color was reduced with 75%.
2.23	Oxygen delignification systems: synthesizing the optimum design	Meyers, M., Edwards, L., and Haynes, J.	TAPPI Journal, April 1989, pp. 131-135	The authors used computer simulation to synthesize the best configuration of washing equipment and determine the optimum dilution factor for a typical oxygen delignification system.
2.24	Modified kraft cooking - ways of application	Sandstrom, P.E., Parming, A.M., Soderqvist, Lindblad, M., and Teder, A.	TAPPI Seminar Proceedings, Bleaching and the Environment, Seattle, Washington, September 1988, pp. 279-286	Modified kraft cooking is based on principles that originate from the kinetics of delignification and carbohydrate degradation. Some of the principles contradict others, so it is therefore necessary to optimize process conditions to gain a net improvement in pulping selectivity. This paper presents how different ways of applying the principles can be evaluated using a mathematical model of continuous kraft pulping. Mill trials and laboratory investigations show that correctly applied, the principles result in a process that both reduces bleach plant effluent and operating costs while maintaining the pulp quality. The modified kraft cooking process can probably be even further improved based on advancing knowledge in the field of pulping chemistry.
2.25	Two case studies on the cold blow technique for batch kraft pulping	Sjodin, L., and Pettersson, B.	TAPPI Journal, February 1987, pp. 72-76	The ASSI Karlsborg mill is the first to practice extended delignification and cold blow process techniques in its batch digester plant, and the NCB Dynes mill started up a completely new batch cold blow digester plant recently.
2.26	Rapid Displacement Heating in Batch Digesters	Swift, L.K., and Dayton, J.S.	Pulp & Paper Canada, 89:8, pp. T264-T270	Rapid Displacement Heating (RDH) has now reached full commercial operation in two mills. In addition to dramatic digester area steam savings these mills have experienced reduced soda loss off brown stock washers; reduced evaporator load lower strong black liquor viscosities; increased digester production and improved pulp quality.

NUMBER	TITLE	AUTHOR	REFERENCE	SYNOPSIS
2.27	Dioxin/furan in-mill source studies at Consolidated Papers, Inc.'s kraft division	Weinbauer, J., and Gilbert, F.A.	TAPPI Proceedings, 1989 Environmental Conference, April 1989, pp. 359-372	Impact of oxygen delignification on hardwood bleach line reviewed.
2.28	Modified continuous cooking	Dillner, B.	Paper presented at Kamyr, Inc. Low Chlorine Bleaching Seminar, Atlanta, 1987-12-08	Modified continuous cooking implies a con/counter-current process where the alkali concentration is lower than normal viscosity, lower Kappa number, equal or better strength and results in a reduction of the effluent load by 25 to 30%.
2.29	Oxygen delignification	Backlund, A.	Paper presented at Kamyr, Inc. Low Chlorine Bleaching Seminar, Atlanta, 1987-12-08.	Paper presents information relative to oxygen delignification. Installations, costs, environmental effects and discussion of high and medium consistency systems are presented.
2.30	RDH pulping - better pulp properties through improved selectivity	Swift, L.K.	Unpublished, available from author of Beloit Corporation	The steam savings capability of the new RDH cooking technology has been well documented. New studies are surfacing which are beginning to explain why RDH cooking produces pulp of significantly higher strength characteristics than other processes and further more, why RDH cooking can be extended to extraordinarily low Kappa levels.
2.31	Peroxide delignification of unbleached chemical pulp by minox process	Carles, J.E., Lemoyne, H., and Logan, W.R.	TAPPI Proceedings, 1980 Pulping Conference, Atlanta, GA, pp. 325-332	Unbleached chemical pulp can be delignified by hydrogen peroxide in an alkaline medium. Laboratory results obtained on bisulfite and kraft pulps are described. Using this process on kraft pulp a reduction by 45% of the bleach plant effluent color has been achieved, together with savings in overall bleaching operation costs.
2.32	New catalyst improves polysulfide liquor makeup, O2 delignification	Lightfoot, W.E.	Pulp & Paper, January 1990, pp. 88-93	Paper deals with polysulfide cooking and its impact on the recovery boiler. Use of polysulfide liquor makeup enables mills with limited recovery boiler capacity to employ oxygen delignification. Costs are provided which show that the ROI for the process is on the order of 6-7 months.
2.33	PRENOX - oxidation of pulp with nitrogen dioxide and oxygen prior to oxygen delignification could reduce pollution	Brannland, R., and Simonson, O.	Swedish Pulp & Paper Journal No.2, 1986, pp. 48-50, 53-54	Findings of pilot plant investigations in a mill in Sweden using PRENOX process is discussed. PRENOX process reduced Kappa no. in pulp. BOD,COD and TOCl are reduced with decreased Kappa no. Increased washing and chlorine dioxide substitution further reduced TOCl.
2.34	Reduce TOCl with OxO process	Lachenal, D., and Muquet, M.	CPPA Annual Meeting Preprints, 75B, Montreal, Que., February 2-3, 1989, pp. 187-192	Findings of OxO process investigations presented. OxO process consists of oxygen delignification followed by low charge of chlorine followed by oxygen extraction stage. OxO process can be optimized to reduce chlorine requirement. Comparison with chlorine dioxide bleaching processes reported.

NUMBER	TITLE	AUTHOR	REFERENCE	SYNOPSIS
2.35	Mill experience of oxygen delignification	Kiumra, M.	Japan TAPPI Journal, 42:1, January 1988, pp. 52-55	Oxygen delignification in a mill in Japan reduced Kappa No. by 49%. Chlorine consumption and COD in bleaching process reduced by 30% and 50% respectively.
2.36	Pretreatment of pulps with chlorine before oxygen delignification	Soteland, N.	Nordic Pulp & Paper Research Journal, October 1988, pp. 124-127	Slight chlorination of pulp oxygen delignification reduces Kappa number significantly at mill in Oslo, Norway. Results in low effluent COD, TOCl and reduced mutagenicity.
2.37	What's hot in pulping? extended delignification	Renard, J.J.	American Papermaker, 51:3, March 1988, pp. 50-52	Modifications implemented at a mill in the digester operations to install extended delignification process is described. Developments in chemical pulping alternatives to the kraft process are briefly discussed.
2.38	Extended delignification and its potential for environmental improvements	Blomberg, B., and Hartler, N.	Nordic Pulp & Paper Research Journal No. 4, December 1986, pp. 25-29	Improved selectivity in kraft pulping process is discussed. Most important parameter for controlling selectivity is the lignin concentration in the cooking liquor during final phase of cook. Swedish process discussed, which results in a low concentration of lignin in the liquor, therefore a smaller bleaching chemical requirement.
2.39	In-Plant process alternatives for minimizing discharges of AOX	Earl, P.F., and Reeve, D.W.	Third Colloquium on Pulp and Paper Mill Effluents, Toronto, Ontario, February 14-15, 1989	Process alternatives for lowering the lignin content in pulp, better washing techniques and chlorine dioxide substitution during bleaching are discussed.

NUMBER	TITLE	AUTHOR	REFERENCE	SYNOPSIS
			3.0 PULP WASHING	
3.1	How to select the optimum pulp washing system	Cleveland, F.C. and Johnston, D.G.	TAPPI Journal, February 1985, pp. 70-73	Selecting a pulp washing system for a particular kraft process, whether greenfield or a renovation project, is a challenge facing consultants and mill personnel alike. The problem is magnified because of the variety of washing systems and their numerous applications in today's market. This paper attempts to reduce a potentially complex decision-making process to a series of logical, common sense steps for choosing the optimum washing system for a particular mill process.
3.2	Channeling and displacement washing of wood pulp fiber pads	Lee, R.F.	TAPPI Journal, November 1984, pp. 100-103	Microscopic channeling is the primary mechanism controlling longitudinal mixing during displacement washing. Trace quantities of high-molecular-weight polymer in the wash liquor can improve displacement efficiency by reducing channeling. The popular, diffusion-like models for describing longitudinal mixing in a fibrous pad are inadequate to account for many of the phenomena of channeling. More rigorous models based upon the mechanism of channeling are required to adequately interpret laboratory data and scale up these data for design purposes.
3.3	Improving brownstock washing through pulp mat modeling	Kouris, Michael	TAPPI Journal, Vol. 67, No. 2, pp. 119-121	
3.4	Pulp washing with screw presses	Egenes and Barbe	TAPPI Proceedings, Pulping Conference Book 2, 1990, pp. 551-575	A model derived to predict the washing efficiency of a displacement washing screw press is presented. We assess the relative importance of the operating variables on the washing efficiency of the press. Results obtained from the mill trials with hardwood and softwood BCTMP pulps are subsequently correlated with the theoretical predictions.
3.5	Washing for Low Bleach Chemical Consumption	Stromberg, C.	TAPPI Press, Environmental Issues: Anthology of Published Papers, 1990, pp. 230-238	Laboratory results are used to explain the different organic solids washing results displayed by different types of washers.
3.6	Rapid caustic extraction before an oxidative extraction stage	Histed, J.S. and Canovas, R. Vega	TAPPI Journal, July 1989, pp. 165-170	Rapid caustic extraction, using residual chemicals from an (E+O) stage, can be achieved in seconds by displacement on a multistage washer. This process decreases caustic consumption, and low AOX (absorbable organic halogens) in the effluents.
3.7	The principles of pulp washing	Crotogino, R.H., Poirier, N.A., and Trinh, D.T.	TAPPI Journal, June 1987, pp. 95-103	A review of pulp-washing operations, dilution/extraction, displacement washing, and parameters governing washer performance.

NUMBER	TITLE	AUTHOR	REFERENCE	SYNOPSIS
3.8	Optimizing the wash water rate of counter-current washing systems	Nierman, Herbert H.	TAPPI Journal, March 1986, pp. 122-124	The Norden efficiency can be used to predict the performance of counter-current pulp washers, but reliable values are required. When Norden efficiency values are calculated from test data on operating systems, the results are too frequently unbelievable. The reliability of these same test results can be significantly improved by using a data adjustment technique which takes into account all of the available information.
3.9	A unified treatment of brownstock washing on rotary filters	Cullinan, Harry T. Jr.	TAPPI Journal, August 1986, pp. 88-94	Countercurrent washing of pulp on rotary filters is a mass transfer process amenable to analysis by the classical techniques of nonequilibrium staged operations. Such analysis establishes the connections among the overall, stage, and local efficiencies and the underlying mass transfer rate in the wash zone. Performance and design equations result that they are simple and straightforward. Associated graphical depictions of the calculation scheme aid in visualizing the concepts. Methods that are currently accepted fit into this analysis in different ways. The result make clear where fundamental research ought to be focused.
3.10	A method for quantifying pulp washer performance that does not use flow rate measurements	Oxby, Paul W., Sandry, Thomas D., and Kirkcaldy, David M.	TAPPI Journal, August 1986, pp. 118-119	
3.11	A new type of hood for bleach-plant washers	Bowen, G.L. and Dix, K.A.	TAPPI Journal, May 1990, pp. 239-242	
3.12	Medium-consistency pulp washer generates superior washing efficiency	Pikka, Olavi E., Himanen, Juuso, Ala-Kaila, Kari, and Coffey, Kenneth	TAPPI Journal, March 1990, pp. 121-126	The MCDD washer has successfully been introduced in the oxidative extraction stage of hardwood pulp bleaching, and its efficiency has exceeded the performance values of a vacuum drum filter.
3.13	The drum displacer - a new approach to brownstock washing	Perkola, Markku, Sundqvist, Harry, Pikka, Olavi, Qvintus, Harri, and Sainiemi, Jukka	TAPPI Journal, February 1989, pp. 91-95	A drum displacer is a multi-stage pulp washer that enables the washing stages to be carried out in a single drum.
3.14	Online entrained-air measurement for brownstock-washer defoamer control	Dougherty, Steve J.	TAPPI Journal, January 1989, pp. 50-54	A control system that meters defoamer based on measurement of entrained air can reduce defoamer consumption by 40%.

NUMBER	TITLE	AUTHOR	REFERENCE	SYNOPSIS
3.15	Optimization of filter washer operation and control	Han, Yushan and Edwards, Lou	TAPPI Journal, June 1988, pp. 101-104	To minimize total dissolved solids carryover from brownstock washing for a given shower flow, drum vacuum is the most important operating variable.
3.16	Advanced control for brown-stock washers	Bender, Greg, Richard, Larry, and Dorn, Walt	TAPPI Journal, December 1988, pp. 115-118	The control strategy, based on a mathematical model, has reduced process variations and carryover of black-liquor solids. Mill productivity has increased by 10% since the system was started up.
3.17	Filtration theory as applied to the dimensioning of flat band washers	Hagen, Nils and Berg, Jan-Erik	TAPPI Journal, June 1989, pp. 93-96	The ratio between washing time and dewatering time on a flat band washer is proportional to a permeability constant times the ratio of wash liquor volume to filtrate volume in the dewatering zone.
3.18	Rapid caustic extraction of chlorinated pulp	Histed, J.A. and Canovas, R. Vega	TAPPI Journal, March 1988, pp. 157-160	Up to 94% of the lignin that can be removed in the first caustic extraction stage of a conventional process can be removed rapidly from well-chlorinated pulp with two countercurrent displacements with caustic. The time per displacement can be as short as 1.7 s. A slight loss in extraction efficiency is more than made up by improved washing efficiency. On a commercial scale, the chlorinated pulp can be formed into a sheet, washed, extracted twice, and washed three times on a six-stage horizontal washer. Caustic requirements are 2.3 that of a conventional extraction. Energy requirements are lower than in a conventional bleachery. This technology also presents an opportunity to lower the capital cost of a bleachery.
3.19	Automated control of washer shower water at ITT Rayonier	Sande, W.E., Oestreich, M.A., Poplasky, M.S., and Stewart, J.R.	TAPPI Journal, March 1988, pp. 93-97	Simple, low-cost, automated shower-water control systems on two unbleached-stock washer lines have provided substantial savings in evaporator steam, chemicals, and secondary treatment costs.
3.20	Horizontal washing at Campti, Louisiana	Morgan, Larry	PIMA Magazine, August 1988, p. 30	Larry Morgan describes another means to conserve energy by the proper selection of a washing system in a linerboard mill upgrade.
3.21	NDC pulp washer gauge can save $300,000 annually		PIMA Magazine, March 1988, p. 21	
3.22	Optimized pulp cleaning takes discipline, organization	Franko, Andrew, and Talbert, Ronald	PIMA Magazine, February 1988, pp. 29-30	

NUMBER	TITLE	AUTHOR	REFERENCE	SYNOPSIS
3.23	Some bleach plant modifications to reduce the amount of toxic substances in pulp and filtrate	Edwards, L., Myers, M., and McKean, B.	TAPPI Seminar Proceedings, Bleaching and the Environment, Seattle, Washington, September 1988, pp. 328-332	This report discusses the benefits of increasing the amount of lignin removed from the brownstock pulp through more efficient washing.
3.24	Effects of brownstock washing on the formation of chlorinated dioxins and furans during bleaching	Hise, R.G.,and Hintz, H.L.	TAPPI Journal, January 1990, pp. 185-190	Poor brownstock washing led to increased levels of PCDDs and PCDFs in softwood pulps after chlorination stage and in the final effluent. Additional washing in the laboratory with copious amounts of aqueous ethanol decreased chlorinated dioxins and furans by 80%. These results demonstrate the presence of solvent-extractable precursors for PCDD/Fs associated with this unbleached pulp. Also found that spiking unbleached pulp with higher than normal levels of defoamers used had no significant effect on the formation of PCDD/Fs after bleaching.
3.25	New pressurized compaction filter lowers operating and capital costs	Tait, D.	Pulp & Paper, November 1985	Pulp washer with compaction baffle and pressurization permits low-level installation, lower power consumption, and greater efficiency.
3.26	Brownstock showers reduce dioxin and more	Reynold, G.	CPPA Proceedings, 76th Annual Meeting Technical Section, Montreal, Quebec, February 1-2, 1990, pp. A237-A240	Dioxin generation and soda loss can be reduced through improved brownstock washing. The most economical way to achieve this improved washing is through the proper application of the shower filtrate. This paper will discuss the characteristics of he state-of-the-art shower pipe system, a case history on improved washing through the use of this system, and the effect of shower performance on the reduction of dioxin.
3.27	Efficient post oxygen washing - crucial for low bleach plant emissions	Lindstrom, L.A., and Norden, S.	APPITA 1990 Conference, New Zealand, April 1990	Oxygen delignified pulp with a Kappa number of 17.7 was bleached in a C50/D50EoD sequence. Wash losses, measured as COD, were varied from 0-20 kg/bdt. At optimum bleaching conditions, the incremental increase of active chlorine due to increased carry-over was estimated at 0.5-0.6 kg act. Cl/bdt. AOX discharge increased about 40% at 20 kg COD/bdt compared with completely washed pulp. The sum of tri- and tetra-chlorophenolic compounds formed during bleaching, was roughly doubled at a high wash loss compared with completely washed pulp.

NUMBER	TITLE	AUTHOR	REFERENCE	SYNOPSIS
				4.0 BLEACHING
4.1	How bleaching hardwood kraft pulp with oxygen affects the environment	Jones, A.R.	TAPPI Journal, December 1983, pp. 42-43	We have found the environmental impact of oxygen-bleached hardwood kraft pulp to compare favorably with that of an existing CEDED sequence. First, the effluent volume can be reduced to 4,000 gal/ton. Second, the BOD_5 loss is only 2.3 that of the conventional CEDED line. Third, effluent color is only 15% of the color load from the more conventional process. Because of its low environmental impact, and OC/DED bleach sequence is the process we have selected for our new greenfield mill at Eastover, South Carolina.
4.2	Substituting chlorine dioxide for chlorine	Pyrke, Douglas C.	TAPPI Journal, October 1989, pp. 147-155	Increasing chlorine dioxide substitution minimizes bleaching chemical consumption, decreases bleaching costs, and improves bleach plant effluent quality. It also minimizes the formation and discharge of chlorinated organic compounds.
4.3	Factors that affect the generation of chloroform in bleaching	Crawford, Robert J., and Stryker, Margeret N.	TAPPI Journal, November 1989, pp. 151-159	Bleachery filtrate mixing and pH adjustment in the mill effluent treatment system affect the formation of chloroform. In laboratory experiments, the pH adjustment of chlorination-stage filtrate resulted in chloroform generated through this process will depend on the specific bleaching conditions in the chlorination-stage and on the pH of the combined mill sewer. In some cases, this effect may account for a significant fraction of the chloroform in the influent to wastewater treatment systems.
4.4	Chlorinated organic matter in bleached chemical pulp production	Earl, Paul F., and Reeve, Douglas W.	TAPPI Journal, October 1989, pp. 183-187	Softwood kraft pulps were chlorinated at low and medium consistency in the laboratory, covering a wide range of chlorination levels, with and without chlorine dioxide substitution. The filtrates from the chlorination and extraction stages were analyzed for organically bound chlorine (AOX) and solvent-extractable organically bound chlorine (EOX). AOX formation decreased when mixing was improved but EOX was unchanged. Consistency had little effect. At 50% chlorine dioxide substitution in the C stage, (C+E)-stage AOX formation fell by 40%. AOX and EOX formation were proportional to the amount of elemental chlorine in the chlorine and chlorine dioxide consumed. AOX and EOX formation increased dramatically with extensive delignification. Equations were developed to estimate the amount of AOX and EOX formed, based on the elemental chlorine in the oxidant consumed by the pulp.
4.5	Minimizing the formation of chlorinated organic material through controlled chlorination in the production of high quality softwood kraft pulp	Annergren, G. Rees-Anderson, A.M., and Lindblad, P.O.	TAPPI Proceedings, April 1987 Environmental Conference, pp. 313-318	Spent liquors from the chlorination and alkali extraction of an oxygen prebleached softwood kraft pulp were investigated with respect to environmental papermeters such as TOCl, chlorinated phenolic compounds some of which are lipophilic, other lipophilic compounds and mutagenicity. The chlorine ratio (% available chlorine/Kappa number) was varied within the range of 0.05 and 0.5. In some experiments, chlorine was partially substituted for chlorine dioxide. The results show that the parameters vary considerably with variations in the chlorine ratio and that therefore possibilities exist to minimize chlorinated organic compounds through controlling the chlorination.

NUMBER	TITLE	AUTHOR	REFERENCE	SYNOPSIS
4.6	Effect of brownstock washing on formation of chlorinated dioxins and furans during bleaching	Hise, R. and Hintz, H.	TAPPI Press, Environmental Issues: An Anthology of 1989, pp. 123-129	The effect of brownstock washing on formation of polychlorinated dibenzo-p-dioxins (PCDDs) and furans (PCDFs) was evaluated in laboratory studies and mill trials. Poor brownstock washing led to increased levels of these materials in softwood pulps after the chlorination stage and in the final effluent.
4.7	Impact of high chlorine dioxide substitution for chlorine on the oxygen delignified pulp at Espanola	Munro, Chandrasekaran, Cook and Pryke	TAPPI Press, Environmental Issues: An Anthology of 1989, pp. 187-198	With the prime objective of eliminating polychlorinated dioxins and furans in the bleached pulp and effluent, E. B. Eddy Forest Products Ltd. at Espanola embarked on a mill trial to increase the chlorine dioxide substitution level in the softwood chlorination stage from 10% to 50% of the total equivalent chlorine applied. OC_DE_oHD is the bleaching sequence used. Four levels of substitution were studied with respect to their impact on pulp quality, effluent characteristics and bleaching cost.
4.8	Influence of chlorine ratio and oxygen bleaching on the formation of PCDFs and PCDDs in pulp bleaching	Rappe, Christopher, and Glas, Bo	TAPPI Journal, April 1989, pp. 147-153	In a laboratory bleaching study, we assessed the influence of the chlorine ratio and oxygen bleaching on the amounts of polychlorinated dibenzofurans (PCDFs) and polychlorinated dibenzo-p-dioxins (PCDDs) formed. A significant factor affecting the amounts of PCDF and PCDD is the chlorine ratio. On well-washed laboratory pulp, oxygen bleaching has little or no effect. The beneficial effect of oxygen bleaching on the amounts of PCDFs and PCDDs observed in mill-scale studies is therefore likely the result of the much greater efficiency in pulp washing through the oxygen bleaching stage.
4.9	Reinforcement of oxygen-alkali extraction with hydrogen peroxide or hypochlorite	Bourson, L., Lachenal, D., and de Choudens, C.	TAPPI Journal, July 1986, pp. 90-93	Small amounts of hydrogen peroxide or hypochlorite (up to 5 kg/metric ton of pulp) were added in the oxygen extraction stage of various bleaching sequences: C/DE_oDED, C/DE_oD, CE_oHD, and OC/DE_oD. Two kg of H_2O_2/metric ton of o.d. pulp made it possible to save up to 3.5 kg of ClO_2/metric ton of o.d. pulp. With 5 kg of NaOCl added, the additional ClO_2 reduction attained was 5 kg/metric ton of o.d. pulp. The effect of O_2 and H_2O_2 or NaOCl was roughly additive. Also, it is better to introduce H_2O_2 in the E_o stage of an OC/DE_oD sequence than in the oxygen stage. Experiments carried out on three different pulps showed that the advantages imparted by E_o (i.e. reduction of the operating cost, improvement of pulp viscosity, opportunity of shortening the bleaching sequences, and the possibility of increasing the pulp output) are enhanced by combining H_2O_2 or Hypochlorite with oxygen.
4.10	The fraternity gathers at the chateau: the 1985 International Pulp Bleaching Conference	Pyrke, Douglas C.	TAPPI Journal, August 1985, pp. 145-147	

NUMBER	TITLE	AUTHOR	REFERENCE	SYNOPSIS
4.11	Pretreatment of kraft pulp is the key to easy final bleaching	Fossum, M., and Marklund, Ann	TAPPI Journal, November 1988, pp. 79-84	Low values of total organic chlorine (0.5 kg/metric ton) were reached with a combination of extended dilignification to Kappa numbers below 10 and a high chlorine dioxide fraction in the prebleaching.
4.12	Chlorinated organic matter in bleached and chemical pulp production	Earl, Paul F., and Reeve, Douglas W.	TAPPI Journal, January 1990, pp. 179-183	Fifty percent chlorine dioxide substitution decreased the total amount of chlorinated phenolic compounds and the amount of tri- and tetrachlorinated phenolic compounds in chlorination and extraction stage effluents. Improved chlorination stage mixing also decreased the formation of tetrachlorinated phenolic compounds. Increased consistency showed no increased consistency resulted in a decrease in the total amount of chlorinated phenolic compounds. Chloroform formation in the chlorination stage was decreased by improved mixing, by increased consistency, and by 50% chlorine dioxide substitution.
4.13	Oxygen bleaching of kraft pulp: high consistency vs. medium consistency	Idner, Kristina	TAPPI Journal, February 1988, pp. 47-51	Pulp viscosity at a given degree of delignification is slightly higher for medium consistency bleaching than for high-consistency oxygen bleaching.
4.14	Reactions of nitrated kraft lignin in an alkaline oxygen bleaching stage	Lindeberg, Otto, and Walding, Jan	TAPPI Journal, October 1987, pp. 119-123	Pretreatment of kraft pulp with NO_2/O_2 under acid conditions allows for an extended delignification in a following oxygen bleaching stage without extensive loss of viscosity. To find an explanation for the beneficial effect of the pretreatment, experiments with nitrated kraft lignin and nitrated lignin model compounds of the nonphenolic, B-aryl ether type have been carried out. The results show that the presence of nitrated lignin in the oxygen bleaching of softwood kraft pulp leads to a decrease in carbohydrate depolymerization. Furthermore, nitration of aromatic nuclei in the lignin results in faster alkaline hydrolysis of aldyl aryl ether bonds. The combination of these effects may provide an explanation for the increased selectivity (viscosity at a given Kappa number) obtained with an NO_2/O_2 pretreatment.
4.15	Substituting chlorine dioxide for elemental chlorine makes the bleach plant effluent less toxic	Axegard, Peter	TAPPI Journal, October 1986, pp. 54-59	A full scale mill trial shows there are two principal ways of reducing the consumption of elemental chlorine by using more chlorine dioxide when bleaching to full brightness.
4.16	Effects of oxygen extraction on organic chlorine contents in bleaching plant effluents	Hong, P., Shin, Nam Hee, and Chang, Hou-min	TAPPI Journal, June 1989, pp. 157-162	An unbleached kraft pulp and an oxygen-prebleached kraft pulp were chlorinated at various chlorine dosages. The chlorinated pulps were extracted under conditions for alkaline extraction (E and oxygen-alkali extraction (EO).

NUMBER	TITLE	AUTHOR	REFERENCE	SYNOPSIS
4.17	Low AOX, possibilities and consequences	Basta, Holtinger, Hook and Lundgren	TAPPI Press, Environmental Issues: An Anthology of 1989, pp. 139-148	Various laboratory and mill experiments were carried out using oxygen-prelignified, kraft softwood pulp in an effort to lower the AOX level through the reduction or elimination of chlorine in the bleaching sequence. This must be achieved in a way which is as cost-effective as possible, while still maintaining a high brightness in a high quality pulp. The possibilities and consequences of the three different approaches will be discussed.
4.18	Environmental compatible bleaching of chemical pulp	Brunsvik, Grundelius, Kordes and Swan	TAPPI Press, Environmental Issues: An Anthology of 1989, pp. 149-152	This paper deals with the problems of minimizing the formation of chlorinated organic compounds during the bleaching process. It points out the different measures taken in the Stora Cell mills to reduce chlorination of organic substances and clarifies the consequences for the pulp quality. Finally, some of the chlorinated organic compounds in the effluent discharge are identified or characterized.
4.19	Manufacture of bleached aspen market pulp without the use of chlorine or chlorine dioxide	Ng, D., Tichy, J., and Wong, A.	TAPPI Press, Environmental Issues: An Anthology of 1989, pp. 199-202	The neutral sulphite-anthraquinone (NSAQ) process can be used to produce a high-yield and high-brightness pulp from aspen wood. Bleaching of this NSAQ aspen with oxygen and hydrogen can yield a 85+ pts brightness pulp. The use of Cl_2 and ClO_2 is not required. Physical properties of the O_2/H_2O bleached aspen NSAQ pulp are comparable to those of conventional bleached aspen kraft pulp.
4.20	High efficiency chlorine dioxide bleaching	Seger, Chang and Jameel	TAPPI Press, Environmental Issues: An Anthology of 1989, pp. 211-217	A process to improve the efficiency of chlorine dioxide bleaching has been developed to produce pulps with higher brightness at equal chlorine dioxide usage.
4.21	Peroxide bleaching reduces dioxin formation	Reid, Billmark and Sutton	TAPPI Notes, Oxygen Delignification Symposium, 1990, pp. 85-89	This paper describes the effect that peroxide has on discharges, operations, and pulp quality. Hydrogen peroxide may be used in the E_o stage to reduce the chlorine required in the C_D stage.
4.22	Cost effective AOX reduction	Cook, Eagle and Gough	TAPPI Notes, Oxygen Delignification Symposium, 1990, pp. 91-99	The addition of peroxide to the oxygen reinforced caustic extraction stage can reduce the quantity of chlorine and hypochlorite used in the chlorination stage giving a significant reduction in AOX discharge at break-even cost. The effectiveness in the mill was found to be greater than could be measured in laboratory testing. The addition of oxygen and caustic soda to the brown stock entering the bleach plant can also give a significant reduction in AOX discharge via the reduced use of active chlorine in the chlorination stage. This process is capable of giving a reduction in the total bleaching cost and can be installed at low cost with a rapid pay-back time.

NUMBER	TITLE	AUTHOR	REFERENCE	SYNOPSIS
4.23	Hydrogen peroxide reinforced extraction lowers chlorinated organics and color in bleach plant effluent	Klein, Meng, Jameel and Sundaram	TAPPI Proceedings, Pulping Conference Book 2, 1990, pp. 829-835	The capability of hydrogen peroxide and oxygen in the E_1 stage to produce pulps of low Kappa factors while maintaining good pulp quality was examined in laboratory studies and mill trials.
4.24	Chlorinated organic matter in bleached pulp - effect of important process variables	Annergren, Osterberg and Linblad	TAPPI Press, Environmental Issues: Anthology of Published Papers, 1990, pp. 27-36	The objectives in the first part of our studies were to control the brightness reversion in a kraft mill producing bleached birch pulp by achieving a low EOCl level in the pulp. The second part of the study has been a laboratory investigation of both the non-extractable OCl and EOCl of softwood and birch kraft mill pulps.
4.25	Overview of emerging technologies in pulping and bleaching	Bowen and Hsu	TAPPI Press, Environmental Issues: Anthology of Published Papers, 1990, pp.69-84	This article provides an overview of extended delignification technologies, including cold blow cooking, rapid displacement heating and modified continuous cooking, oxygen delignification, high chlorine dioxide substitution, split addition of chlorine/pH control, E_o and E_{op} extraction and non-chlorine bleaching.
4.26	Evolution of bleach plant design practice to minimize environmental impact	Shackford, L.	TAPPI Press, Environmental Issues: Anthology of Published Papers, 1990, pp. 180-188	This report presents an overview of areas of focus for bleach plant effluent control.
4.27	Pirsonite deposits in green liquor processing	Frederick, Jr., W.J., and Krishnan, Rajeev	TAPPI Journal, February 1990, pp. 135-140	Pirssonite deposits are a persistent problem in green liquor processing. The extent of this problem is related to the solubility behavior of pirssonite, but it also depends on the design of the green liquor process equipment and control system. Perssonite deposits form at total titratable alkali (TTA) concentrations that correspond to the solubility limit for Na_2CO_3 in sodium salt solutions when $CaCO_3$ is present. Ineffective mixing in the dissolving tank also can contribute to the problem. Perssonite deposits can be minimized by keeping the average TTA below 90% of the TTA at perssonite saturation, controlling TTA variability, allowing some lime mud to be carried over with the weak wash, minimizing the calcium input to the soda cycle, providing adequate mixing for the dissolving tank, maintaining a high green liquor temperature throughout the process, and providing positive flow in green liquor lines where stagnation or low flow can otherwise occur.
4.28	The recycling of acidic bleach plant effluents and their effect on preparing white liquor	Teder, Ants, Anersson, Urban, Littecke, Katarina, and Ulmgren, Per	TAPPI Journal, February 1990, pp. 113-120	The impact of chlorinated compounds could be reduced if the acidic effluent from the pre-bleaching stage was used to wash the pulp before bleaching and then used in preparing the white liquor.

NUMBER	TITLE	AUTHOR	REFERENCE	SYNOPSIS
4.29	Technologies for reducing dioxin in the manufacture of bleached wood pulp	U.S. Congress Office of Technology Assessment	OTA-BP-O-54, Washington, DC, U.S. Government printing office. May 1989	Alternative technologies using oxygen as a pretreatment to chlorine bleaching and improved delignification that removes more of the potential reactants from the wood can reduce the amount of dioxin in bleached pulp. Substituting other bleaching chemical for chlorine also shows promise for reducing the amount of dioxin produced in the bleaching process should regulation be required. This study provides an assessment of these technologies: it does not address the policy issues related to regulating dioxin in paper products and controlling environmental release.
4.30	Dissolution of lignin from kraft pulp after treatment with nitrogen oxides	Chang, Yu, and Eckert	Journal of Wood Chemistry and Technology, 1990, pp. 311-330	Laboratory experiments show that pretreatment with NO_2, including heating and ripening at 5% consistency and 90°C for 3 hours in the presence of NO_3- and H+ led to a dissolution of approximately 50-60% of the lignin in unbleached kraft pulp. Only 5-15% were dissolved when the treatment was terminated after heating to 90°C. An extensive fragmentation of the lignin during the ripening explains the extensive delignification in acid medium. Fractionated dissolution of the remaining lignin by alkaline extraction gave fractions with small variation in N-contents (2.9-3.4%) and hydrophilicity. The last fraction exhibited the highest sorption of water vapor. The delignification was related to the decrease in molecular size during the pretreatment and during subsequent alkaline treatments.
4.31	Effect of alkaline extraction of ozone-bleached pulp on brightness and bleachability	Lindholm, C.A.	Journal of Pulp and Paper Science, November 1990, pp. 190-195	The effect of alkaline extraction on the brightness and bleachability of ozone and oxygen-ozone bleached softwood kraft pulp was investigated. Ozone bleaching reduces the light absorption coefficient linearly as a function of the Kappa number. Alkaline extraction increases the light absorption coefficient by 1.3...2.0m_2/kg, if compared at a certain Kappa level. As a result, ZE- and OZE- bleached pulps are 4...9 brightness units darker than corresponding Z- and OZ- bleached pulps. Alkaline extraction also reduces the brightness level that can be attained in a subsequent chlorine dioxide stage if starting from a certain Kappa level.
4.32	P&P's annual bleaching survey: capital expenditures increasing	Ducey, M.J.	TAPPI Proceedings, International Pulp Bleaching, June 1988	Discussion of control system for oxygen delignification based on on-line Kappa number measurement. System reduced average Kappa number and production costs.
4.33	Oxygen bleaching practices and benefits - an overview	Tench, L, and Harper, S.	TAPPI Proceedings, 1987 International Oxygen Delignification Conference	A list of the world wide oxygen delignification installations and a summary of the experience gained to date are presented. Pulp quality, environmental benefits, chemical savings, the impact on recovery and energy consumption, high vs. medium consistency delignification and washing and screening considerations are discussed.

NUMBER	TITLE	AUTHOR	REFERENCE	SYNOPSIS
4.34	Effect of prebleaching conditions on the performance of short sequences for oxygen bleached kraft pulp	Annergren, G.E., Lindstrom, L.A., Lindblad, P.O., and Norden, S.	TAPPI Proceedings, International Pulp Bleaching Conference, June 1988, pp. 37-46	Important prebleaching conditions have been studied for short sequence bleaching both in the laboratory and in mills. The studies concerned mainly oxygen bleached kraft pulp but certain comparisons have been made with unbleached kraft pulp. There were two reasons for dealing with prebleaching in this case. A short sequence gives higher weighting to each stage which calls for a particular optimization of the prebleaching. On the other hand, environmental concerns aim at a low formation of chlorinated organics through a reduced chlorination. The general opinion is that a high chemical charge is required in the chlorination of a short sequence. However, our results indicate that this is not true for normal levels of final brightness and that commercial operation with a substantial restricted chlorination is possible. The reinforcement of the alkaline extraction is very important in this context.
4.35	Pulping bleaching concerns focus on ClO_2 generation, effluent	Ducey, M.J.	Pulp & Paper, June 1987, pp. 89-92	Article takes a comprehensive look at the current mill chemical consumption patterns, new supplier products and their markets and the latest developments from a number of North American research institutions, and provides some brief facts on worldwide chemical pulp production and growth over the past 12 months.
4.36	Chlorine dioxide substitution reduces the load of TOCl	Axegard, P.	TAPPI Proceedings, Pulping Conference, November 1987, pp. 105-110	Laboratory bleaching experiments have been carried out on an industrial oxygen delignified softwood kraft pulp at different ClO_2 - substitution levels. Parameters studied were prebleaching efficiency, final brightness, formation of chlorate as well as chlorinated organics. The formation of TOCl, EOCl, AOX, highly chlorinated phenolics and chloroforms is reduced with reduced Cl2 consumption.
4.37	Influence of bleaching chemicals and lignin content on the formation of polychlorinated dioxins and dibenzofurans	Axegard, P., and Renberg, L.	Chemosphere, (Dioxin 88)	The determination of chlorinated dibenzo-p-dioxins and dibenzofurans in pulp and aqueous filtrate from pulp bleaching showed that the most important variable is the consumption of molecular chlorine (Cl2) expressed as the ratio between chlorine and the lignin content (Cl2-multiple). The formation of the dioxins and dibenzofurans increased drastically above a certain critical level and below this level the formations were very low. No significant difference between oxygen dilignified and non-oxygen delignified softwood kraft pulp could be established.
4.38	Results of on-site pilot plant studies of the SLC Extraction Process	Elton, E.F.; Parkinson, J.R.	TAPPI Proceedings, 1987 Pulping Conference, pp. 673-678	The SLC (suppressed lignin condensation) extraction process was pilot tested on hardwood and softwood kraft pulp in two separate mills. Reported results were decreased CEK number and decreased steam, hypochlorite (47%), and chlorine (10%) usage.
4.39	Use of hypolite bleach in short sequence pulp bleaching	Hurst, M.M., Sturik, T.S., and Duff, A.	TAPPI Proceedings, 1987 Pulping Conference, pp. 15-19	Paper discussed brightness, viscosity ad chloroform formation when replacing peroxide or hypochlorite with hypolite bleach, during pulp bleaching.

NUMBER	TITLE	AUTHOR	REFERENCE	SYNOPSIS
4.40	Efforts in chemical pulp bleaching technology emphasize cutting costs	Ducey, M.J.	Pulp & Paper, July 1986, pp. 47-50	Article presents a summary of Pulp & Paper's third annual survey of bleaching equipment. Finds fewer new systems; emphasis is on washing, process control, chemical additions. Oxygen delignification is the number one choice of mills installing new systems.
4.41	Curtailing dioxin formation-ramifications for chemical pulp bleaching	Berry, R.M., et al.	Dioxin '89, September 1989	
4.42	Oxygen bleaching processes	McDonough, TJ.	TAPPI Journal, June 1986, pp. 46-52.	Paper discusses many aspects of oxygen delignification, high and medium consistency, selectivity and protectors, pretreatment with nitrogen oxides, and process fundamentals. Also discusses oxygen extraction and low-pressure oxygen bleaching.
4.43	Complete effluent recycling in the bleach plant with ultrafiltration and reverse osmosis	Dorica, J, Wong, A., and Garner, B.C.	TAPPI Proceedings, 1985 Pulping Conference, p. 590	A membrane filtration process was studied for the treatment of bleach plant effluents using ultrafiltration and reverse osmosis. The objective was removal of color, organic compounds, and chloride ions. The filtration process design and costs are presented.
4.44	Toward preventing the formation of dioxins during chemical pulp bleaching	Dorica, J., Wong, A., and Garner, B.C.	TAPPI Proceedings, 1985 Pulping Conference, p. 590	Suitable combinations of chlorine multiple and CLO2 substitution which lead to low or undetectable levels of TCDD and TCDF have been found to be more effective than the reverse mode of addition for reduction of chlorinated dioxins and furans. Increasing the C-stage pH and decreasing its consistency also appears to be beneficial. Minimizing the levels of the precursors, dibenzodioxin (DBD) and dibenzofuran (DBRF), was confirmed as being important for curtailing TCDD and TCDF formation. In particular, oxygen delignification was found to be advantageous, not because it removes lignin but because it decreases the precursor levels.
4.45	Oxidative bleaching - a review, part I: delignification	Liebergott, N., and van Lierop, B.	Pulp & Paper Canada, September 1986, pp. 58-62	Literature relating to the use of oxidative chemicals in the delignification and brightening operations of pulp bleaching is reviewed. Experimental data on the use of oxygen, ozone and chlorine dioxide in the chlorination stage, and hypochlorite, peroxide and oxygen in the extraction stages are also presented.
4.46	Worldwide E_o installations survey	Reeve, D.W.	TAPPI Journal, November 1985, pp. 142-143	*World wide survey of E_o (use of oxygen in the extraction stage of* chemical pulp bleaching) installations.
4.47	The future of bleaching	Reeve, D.W.	TAPPI Journal, June 1985, pp. 34-37	Summary of what is taking place in bleaching, what are the economic influences and what is predicted to happen in the near future.

NUMBER	TITLE	AUTHOR	REFERENCE	SYNOPSIS
4.48	Oxidative extraction at Halsey Mill cuts hypochlorite consumption	Ducey, M.J.	Pulp & Paper, October 1984, pp. 118-119.	Discussion of how an oxidative extraction system having a high-shear mechanical mixer repaid its capital costs within one year. System installation considered a success.
4.49	Tutorial - non-chlorine bleaching of chemical pulp	Liebergott, N., van Lierop, B., Garner, B.C., and Kubes, G.J.	TAPPI Proceedings, 1987 Environmental Conference, pp. 303-312	Two bleaching sequences were developed for a kraft pulp (Kappa #30.6) that avoid chlorine-containing compounds by using only oxygen (O), ozone (Z), sodium hydroxide (E), hydrogen peroxide (P), and sodium hydrosulphite (Y). Effluents were 40-60% lower in color than those obtained from a conventional C/DEDED sequence. The oxygen stage may be done at medium (7%) or high (25%) consistency. After the sequence OZEP, the pulps had a brightness of 80-86% ISO. In the sequence ZOP, the final brightness could be improved by 10 points if the ZO bleached pulps were washed with effluent from the Z stage. Semi-bleached pulps from both sequences achieved a brightness of 88-90% on final-stage bleaching with hydrosulphite. The strength properties of pulps bleached by these novel sequences and by conventional C/DEDED, OZEPY and ZOPY sequences was evaluated.
4.50	Final bleaching of kraft pulps delignified to low Kappa number by oxygen bleaching	Fossum, G., Lindqvist, B., and Persson, L.E.	TAPPI Journal, December 1983, pp. 60-62	Discussing of pretreatment kraft pulp with nitrogen dioxide and oxygen prior to oxygen bleaching. Chemical demand, pulp viscosity, strength and yield and bleach effluents from pretreated sequence is compared to conventional oxygen bleaching.
4.51	Short sequence bleaching with oxygen: part II	Schleinkofer, R.W.	TAPPI Proceedings, 1982 Pulping Conference, pp. 303-308	Laboratory bleaching data from the sequences C/D-E-D-E-D, O-C/D-E-D, C/D-E-Eo-D, O-C/D-Eo-D, and C/D-Eo-D-E-D are compared for two softwood kraft pulps. Costs, Kappa number, viscosity, brightness, energy consumption, and effluent properties are compared.
4.52	Automated ClO_2 generation improves bleaching, cuts effluent	Evans, J.C.W.	Pulp & Paper, February 1983, pp. 69-71	Discussion of continuous monitoring and control for a chlorine dioxide generator.
4.53	Technical consequences of new knowledge on prebleaching with a high fraction of chlorine dioxide	Germgard, U.	TAPPI Journal, December 1982, pp. 81-83	Prebleaching of softwood kraft pulp with chlorine dioxide and low fraction of chlorine has been studied in the laboratory under well-controlled bleaching conditions. This paper concentrates on the influence of the chlorine fraction and of a preceding oxygen bleaching stage. The technical consequences are discussed, particularly for the case where an oxygen bleaching stage precedes a pure chlorine dioxide prebleaching stage.
4.54	Oxygen bleaching system operating well at Union Camp's Franklin Mill	Smith, K.E.	Pulp & Paper, October 1982, pp. 90-93	Overview of oxygen bleaching system at Union Camp's Franklin mill. Process is a four stage OC/DED sequence reporting a reduced chemical and water usage and improved effluent treatment.

NUMBER	TITLE	AUTHOR	REFERENCE	SYNOPSIS
4.55	Bleaching technology review: recent developments, future trends	Macleod, M.	Pulp & Paper, October 1982, pp. 61-65	Discussion of chlorination issues, chlorine free bleaching, sequence modifications, optimizing sequences without oxygen and displacement bleaching, and closed cycle systems. Total organic chloride generated by various sequences is presented.
4.56	Relative rates of consumption of chlorine and chlorine dioxide during (D+C) bleaching of softwood kraft pulp	Germgard, U., Teder, A, and Tormund, D.	TAPPI Journal, May 1982, pp. 124-126.	Experiment presenting the relationship between consumption of chlorine dioxide and chlorine during (D&C) bleaching.
4.57	Short sequence bleaching with oxygen: part I	Schleinkofer, R.W.	Pulp & Paper Canada, 83:11 (1982)	Two unbleached kraft pulp samples, one hardwood and one softwood, produced by two eastern Canadian mills, were bleached in the laboratory by the sequences C/DEDED, OC/DED and OC/DEoD. Fully bleached pulps of 90 ISO brightness were obtained with the sequence OC/DEoD at substantial savings in chemical cost compared to sequence C/DEDED, and strength properties were almost identical. Energy balances show very small differences in net steam and power demand.
4.58	Developments in chlorine dioxide bleaching	Reeve, D.W., and Rapson, W.H.	TAPPI Journal, September 1981, pp. 141-143	Discussion of increased replacement of chlorine by chlorine dioxide in the first stage, Dc-C serial bleaching, and chlorine in chlorine dioxide bleaching. A comparison of bleaching sequences with respect to chemical usage, energy required, and inflation of chemical and energy costs is provided.
4.59	Medium-consistency oxygen bleaching - an alternative to the high-consistency process	Nalman, L.E., and Annergren, G.E.	TAPPI Journal, April 1980	Medium-consistency oxygen bleaching has been examined both in the laboratory and on a pilot-plant scale and has been found to give very *encouraging results in terms of delignification and chemical* consumption. Discussion of the laboratory and pilot plant studies and commercial application is provided.
4.60	Oxygen bleaching shows potential for reducing costs and effluent problems	Chang, H.M.	Pulp & Paper, March 1980, pp. 87-91	Discussion of the oxygen bleaching process, advantages and disadvantages, new processes being implemented, dissolved oxygen displacement delignification process (DODEL), and low and medium-consistency oxygen bleaching.
4.61	Oxygen bleaching shows potential for reducing costs, effluent problems	Almberg, L., Jamieson, A., and Waldestam, S.	Pulp & Paper, March 1980, pp. 92-95	Capital and operating costs, energy consumption, and degree of pollutant reduction are compared for oxygen bleaching and biological treatment.
4.62	Mill experience with oxygen and hydrogen peroxide bleaching stages	Helmling, O., Suess, J.U., Meier, J, and Berger, M.	TAPPI Journal, July 1989, pp. 55-61	Discussion of using hydrogen peroxide in both delignification and extraction stages of bleaching and of reinforcing stages with oxygen and hydrogen peroxide. Reinforcing the EO stage with hydrogen peroxide (EOP) is economical and gives better pulp qualities. EOP can be used efficiently as a first bleaching stage in sulfide pulp mills.

NUMBER	TITLE	AUTHOR	REFERENCE	SYNOPSIS
4.63	Split addition of chlorine and pH control for reducing formation of dioxins	Hise, R.G.	TAPPI Journal, December 1989, pp. 121-126	Process modifications in the chlorination stage produce high brightness, high viscosity pulps with dramatically reduced levels of 2378-TCDD and 2378-TCDF, and can be implemented faster and more economically than other techniques.
4.64	Bleaching and the environment	Kringstad, K.P., de Sousa, F., Johansson, L., Kolar, M.C., and Swanson, S.E.	Addendum to paper presented at the TAPPI/CPPA 1988 International Pulp Bleaching Conference, Orlando, Florida, June 1988.	Paper discusses the formation of dioxins in the kraft bleaching process and measures to decrease or eliminate such formation.
4.65	Influence of chlorine ratio and oxygen bleaching on the formation of PCDFs and PCDDs in pulp bleaching, Part 2: a full mill study	Kringstad, K.P., Johansson, L., Kolar, M.C., de Sousa, F., Swanson, S.E., Glas, B., and Rappe, C.	TAPPI Journal, June 1989, pp. 163-170	We studied the effect of low-chlorine bleaching on the formation of polychlorinated dibenzofurans and polychlorinated dibenzo-p-dioxins (PCDFs and PCDDs) in full mill-scale experiments. An oxygen-bleached softwood kraft pulp with a Kappa number of 19.5 was bleached using 33.3 kg of Cl2 and 6.2 kg of ClO_2 per ton of pulp in the first stage. A similar pulp was bleached using a mixture of 19.3 kg Cl2 and 12.5 ClO_2 per ton of pulp. The amounts of PCDF and PCDD dropped strongly in bleaching at the low chlorine ratio. The concentration of PCDFs and PCDDs in general was only slightly above the detection limits in the pulp as well as in the total effluent. These results confirm those of the laboratory study (Part 1) which suggested that the chlorine ratio used in the first bleaching stage is important in the formation of PCDFs and PCDDs.
4.66	Bleaching and the environment	Kringstad, K.P., and Lindstrom, K.	TAPPI Proceedings, 1988 International Pulp Bleaching Conference, Orlando, Florida	Combinations of treatment of effluents in an aerated lagoon, the use of oxygen bleaching, partial replacement of chlorine by chlorine dioxide and/or applying low chlorine ratio bleaching in combination with reinforced alkaline extraction may yield effluents which meet advanced requirements regarding protection of fish and other organisms living in pulp mill receiving water against toxic effects; and according to all present knowledge, reduce chances of any widely spread detrimental environmental effects of chlorinated organic materials.
4.67	Oxygen bleaching, today's standard for pollution abatement - PRENOX next to come?	Lindblad, P., and Norden, S.	The Fifth Technical Seminar at Sunds Defibrator Proceedings, Sundsvall, June 1988.	Paper discusses modified cooking, oxygen delignification and PRENOX. Information is presented related to Kappa numbers, AOX, TOCl and costs.
4.68	Direct biological bleaching of hardwood kraft pulp with the fungus coriolus versicolor	Paice, M.C., Jurasek, L., Ho, R., Bourbonnais, R., and Archibald, F.	TAPPI Journal, May 1989, pp. 217-221	Researchers at PAPRICAN screened various microorganisms and found that Coriolus versicolor can bleach hardwood kraft pulp by up to 15 percentage points with a drop in Kappa number from 11.6 to 7.9. The bleaching effect of C. versicolor appears to be limited to hardwoods since experiments with spruce pulp failed to increase brightness.

NUMBER	TITLE	AUTHOR	REFERENCE	SYNOPSIS
4.69	Operational experiences from a new chlorination control system based on on-line measurements of Kappa number	Soderberg, J., Almberg, M., Kubulnieks, E., Lundqvist, S.O., and Lowenberg, C.	TAPPI Journal, November 1988, pp. 145-149	In a new control system for chlorination, the change of active chlorine is based on on-line measurement of the Kappa number of the pulp entering the bleach plant. The control system also accounts for variations in production, temperature, etc. The Kappa number after the alkali extraction stage is also measured on-line. The control system is installed in a bleach plant for softwood kraft pulp, where the residual chlorine has decreased, and the working conditions have improved. The control system is flexible during operation under various bleaching conditions.
4.70	Advances in bleach plant design lower capital and operating costs	Tait, D.H.	Pulp & Paper, January 1986, pp. 70-72	Improved washing and mixing technologies reduce chemical consumption without offsetting power usage and effluent increases.
4.71	Bleaching of kraft pulp without formation of dioxins	Vaheri, M., et al.	Dioxin '89, September 1989	
4.72	Alternate process for bleaching could help in reducing TOCls, dioxin	Galluch, R.J.	Pulp & Paper, September 1989, pp. 145-147	Monox-L technology, successful in five plant trials, maintains pulp quality similar to that produced with chlorine dioxide.
4.73	Monox-L for decreasing AOX and/or dioxin	Hurst, M.M.	CPPA Proceedings, 76th Annual Meeting Technical Section, Montreal, Quebec, February 1-2, 1990, pp. B313-B314	Monox-L is a cost effective bleaching agent which can significantly reduce the levels of both AOX and dioxins produced as compared to conventional bleaching sequences.
4.74	Non-chlorine bleaching of MCC-pulp	Dillner, B., Larsson, L.O., and Tibbling, P.	TAPPI Proceedings, 1989 Pulping Conference, Seattle, Washington	The paper discusses how a combination of modified continuous cooking (MCC) and oxygen delignification gives a pulp of sufficiently low Kappa number (13) for final bleaching without the use of elementary chlorine. MCC oxygen pulp has been bleached D(EO)DD and D(EOP)DD to 90% + ISO brightness with retained strength characteristics. The effluent load from the D(EOP)DD sequence is expected to be very low, the measured AOX being only 0.9-1.0 kg/ADMT.
4.75	Monox-L information and data	Quantum Technologies, Inc.		Information and data related to the use of Monox-L as a bleaching chemical, including BOD, COD, color, TOCl, AOX, chloroform and dioxin effluent data, capital and O&M costs and energy requirements.
4.76	Mill trials of substantial substitution of chlorine dioxide for chlorine: part II	Pyrke, D.C.	Pulp & Paper Canada, 90:6, 1989, pp. 93-97	Recent trials in market softwood kraft pulp mills situated on the B.C. coast and in the southern U.S. have shown that increasing chlorine dioxide substitution from 10 to 30 percent in the chlorination stage decreases bleaching chemical consumption and bleaching cost while maintaining pulp quality. Bleaching chemical savings of C$1.50 to 2.50 per ton were achieved.

NUMBER	TITLE	AUTHOR	REFERENCE	SYNOPSIS
4.77	Modifying the bleaching process to decrease AOX formation	Liebergott, N., van Lierop, B., Nolin, A., Faubert, M., and Laflamme, J.	CPPA Proceedings, 76th Annual Meeting Technical Section, Montreal, Quebec, February 1-2, 1990, pp. B229-B238	This report describes the effects of E_o, E_{op} and O delignification and of a wide range of chlorine dioxide substitution to 70%, which produced less chlorinated phenolic compounds in the bleach effluents. The BOD and COD in the effluent decreased only with very high chlorine dioxide substitution levels.
4.78	Mill trials of substantial substitution of chlorine dioxide for chlorine	Pyrke, D.C., Francis, R.C., and Reeve, D.W.	TAPPI Proceedings, 1985 Pulping Conference, pp. 543-551	Three mill trials have recently been conducted in Canada where ClO2 substitution was raised to the 30-50% range. Total equivalent chlorine and caustic consumption decreased significantly in all three mills resulting in savings of $1.55, $1.94 and $2.36 CDN/ADT. Pulp quality parameters were unchanged: strength, cleanliness and brightness. Bleach plant effluent color and BOD_5 were significantly decreased: Toxicity test results were somewhat erratic but decreased toxicity was indicated.
4.79	Mill trials of substantial substitution of chlorine dioxide for chlorine - part III: medium consistency	Rempel, W., Pyrke, D.C., and Ouchi, M.D.	Unpublished	A recent trial at a market softwood kraft pulp mill on the west coast of British Columbia with a medium consistency chlorination stage has shown that increasing ClO2 substitution from 5 to 50% decreases bleaching chemical consumption, bleaching cost, and improves pulp quality. Discharges of chlorinated organic compounds, including PCDDs and PCDFs, from the pulp mill to the receiving water have been decreased by over 50%. PCDDs and PCDFs in bleached pulp have also been decreased substantially.
4.80	NO2 treatment of kraft pulp followed by oxygen bleaching - influence of black liquor	Samuelson, O., and Ojteg, U.	TAPPI Journal, February 1990, pp. 141-146	Kraft pulp from softwood containing large amounts of black liquor was delignified by oxygen bleaching following pretreatment with nitrogen dioxide. The alkaline pulp was treated with NO2 for a few minutes at a high or medium consistency. After ripening for 180 minutes the pulp was oxygen bleached. A Kappa number of 3.5 was obtained even when the pulp contained 43 kg of solids from the black liquor per 100 kg pulp.
4.81	Technologies for reducing dioxin in the manufacture of bleached wood pulp - background paper	Office of Technology Assessment, Washington, D.C.	Library of Congress, Catalog Card No. 89-600719	Discussion of alternative technologies to reduce formation of dioxin in bleached pulp. Oxygen pretreatment for delignification and substituting other chemicals for chorine are evaluated.
4.82	Hydrogen peroxide in alkaline extraction improves pulp quality	Hook J., Meuller, L., and Wallin, S.	Nordisk Cellulosa 2, No. 2, March 1985, pp. 47-50	Several bleach plants are using hydrogen peroxide in the alkaline extraction stage. Advantages and disadvantages of this practice are discussed.
4.83	Reduced discharge of TOCl with a hot (EO) stage	Sjoblom, K., and Hardmeier, P.	TAPPI Proceedings, 1988 International Pulp Bleaching Conference, Orlando, FL, June 5-9, 1988, pp. 263-270	Chlorine consumption can be reduced by increased temperature in the EO stage. For a given pulp and bleaching sequence, a TOCl level can be achieved for a minimum total consumption of chlorine dioxide in the hot EO stage. If economics permit, peroxide added to the EO stage at 75 C can substitute for an EO stage at 90 C.

NUMBER	TITLE	AUTHOR	REFERENCE	SYNOPSIS
4.84	Environmentally friendly (bleaching) processes of the future	Axegard, P.	TAPPI Proceedings, 1989 Bleach Plant Operations Seminar, Charleston, SC, March 5-9, 1989, pp. 195-200	Overview by STFI on ways of reducing TOCl in bleach plant effluents such as extended delignification, oxygen delignification, chlorine dioxide substitution and oxygen extraction. Discussion on treatment of bleach plant effluent using recycling, membrane filtration and biological processes.
4.85	Bleaching plants for the 90's	Idner, K.	Swedish Pulp & Paper Journal, No. 1, 1987, pp. 50-52	Review of alternatives for reducing TOCl in bleach plant effluents to meet regulatory requirements, demands for lower production costs, and improves pulp quality. Operating costs are predicted to be lowered by increased use of process control equipment and fewer bleaching stages.
4.86	Effect of chlorine dioxide substitution on bleaching efficiency and the formation of organically-bound chlorine	Axegard, P.	TAPPI Proceedings, 1986 Pulping Conference, Toronto, October 26-30, 1986, Book 1, pp, 179-186	Investigation of two alternatives for decreasing the consumption of chlorine by using more chlorine dioxide in the bleaching sequence. Advantages of replacing the Cl with ClO2 at different stages of the sequence, and ratios of formation of different chlorates with decreased Cl consumption are discussed.
4.87	Hydrogen peroxide technology for chlorine reduction	Anderson, J.R., and Carmichael, D.L.	CPPA Proceedings, 76th Annual Meeting Technical Section, Montreal, Quebec, February 1-2, 1990, pp. B209-B216	A technology for chlorine reduction involving the use of hydrogen peroxide in conventional alkaline extraction stages is described. Mills that have used peroxide have achieved chlorine reductions of 20-35% and have shifted operations into a "no detectable dioxin" regime. This use of hydrogen peroxide is emerging as an alternative technology for reduction in chlorine consumption. In addition it has been shown to work in combination with other chlorine reduction technologies to achieve very significant reductions in AOX level.
4.88	Methods to minimize the formation of lipophilic chloro-organics in bleaching	Axegard, P.	TAPPI Proceedings, 1988 Pulping Conference, New Orleans, LA, pp. 307-314	Conventional, oxygen dilignified and PRENOX treated softwood kraft pulps have been bleached in the laboratory. The consumption of Cl2 and the ClO2 substitution level were varied over a large range. AOX is reduced linearly with a decreased consumption of the elemental chlorine in molecular Cl2 and ClO2. Chlorinated phenolics were found to be affected strongly by the Cl2 consumption. Below a Cl2 multiple of about 0.05 virtually no highly chlorinated phenolics could be found.
4.89	Environmental aspects of short-sequence bleaching	Suss, J.R., Eul, W.L., Nimmerfroh, N., and Meier, J.	TAPPI Proceedings, 1990 Environmental Conference, Seattle, Washington, April 9-11, 1990, pp. 503-513	Low Kappa factor chlorination, recommended to decrease the amount of halogenated compounds in the effluent, results in insufficient delignification. The results of studies show that the application of oxygen delignification is more effective in reducing halogenated compounds than chlorine dioxide substitution. Very low levels of halogenated compounds are the result of high-intensity oxygen delignification followed by chlorine dioxide and hydrogen peroxide treatment.

NUMBER	TITLE	AUTHOR	REFERENCE	SYNOPSIS
4.90	AOX reduction in bleach plant effluent using enhanced oxidation	Smith, P.W.	TAPPI Proceedings, 1990 Environmental Conference, Seattle, Washington, April 9-11, 1990, pp. 769-772	The use of second generation enhanced oxidation processing (EOP) designed to reduce chlorinated phenolics (AOX) in bleach plant effluent was studied. Mill trials were conducted in order to optimize treatment alternatives under varying production conditions. Appropriate amount of high intensity ultraviolet light together with chemical oxidants (ozone and H2O2) were applied to reliably reduce influent AOX levels from 3.5-4.0 kg/ton to 2.5 and 1.5 kg/ton.
4.91	Hydrogen peroxide addition to Eo bleaching stages is beneficial	Althouse, E.B.	Pulp & Paper, June 1988, pp. 68-70	The addition of both peroxide and oxygen in the first extraction stage will allow improved production at very low capital costs. Benefits include a decrease in the E stage Kappa of 10-25% with an increase in brightness of 5-15 points.
4.92	Kraft mill bleach plant effluents: recent developments aimed at decreasing their environmental impact, part 1	Heimburger, S.A., Blevins, D.S., Bostwick, J.H., and Donnini, G.P.	TAPPI Journal, October 1988, pp. 51-59	A review of developments in the technology of pulping and bleaching has demonstrated new ways to decrease the formation of chlorinated organic materials. A review of the composition of bleach plant effluents and effluent treatment methods was also studied.
4.93	Kraft mill bleach plant effluents: recent developments aimed at decreasing their environmental impact, part 2	Heimburger, S.A., Blevins, D.S., Bostwick, J.H., and Donnini, G.P.	TAPPI Journal, November 1988, pp. 69-78	In Part 1, processes that reduce the chemical demand of pulp by lowering the Kappa number prior to bleaching were investigated. These methods included extended delignification and oxygen delignification. In Part 2, other approaches such as chlorine dioxide substitution, oxygen extraction, hydrogen peroxide reinforcement, ozone and alternative bleach schemes without chlorine are examined. Treatment methods including biological and physical/chemical are also investigated.

NUMBER	TITLE	AUTHOR	REFERENCE	SYNOPSIS
			5.0 CHEMICAL RECOVERY	
5.1	Burning non-condensible gases.	Burgess, T.	TAPPI Press, Environmental Issues: An Anthology of 1989, pp. 247-248	Non-condensible gases (NCG) containing reduced sulfur gases (TRS) are now collected and burned in kraft pulp mills as a method of reducing mill odor. These gases are burned in lime kilns, boilers and incinerators. None of these is a perfect place to burn NCG, as each has advantages and disadvantages.
5.2	Characterizing emissions from a modern kraft recovery furnace	Oscarsson, B., Bentley, Keith M., and Hood, Sarah W.	TAPPI Proceedings, 1991 Environmental Conference Book 2, pp. 1053-1060	A new kraft recovery boiler was started up at Georgia-Pacific's Woodland, Maine mill in August 1989. Continuous emissions monitors were installed for sulfur dioxide (SO_2), oxides of nitrogen (NO_x), total reduced sulfur (TRS), carbon monoxide (CO), and opacity. This paper describes the design considerations for meeting very stringent emissions limits, the interrelationship of the pollutants, and operating experience in achieving day-to-day compliance.
5.3	NOx reduction from a recovery boiler by injection of an enhanced urea solution (NOxOUT PROCESS)	Lovblad, R., Moberg, G., Olausson, L. and Bostrom, C.	TAPPI Proceedings, 1991 Environmental Conference Book 2, pp. 1071-1075	After a preliminary study of different NOx reduction techniques, Sodra Skogsagarna commissioned a full scale test of the NOxOUT process in the existing recovery boiler at Monsteras from Gotaverken Energy in cooperation with Petrokraft. The project has shown that thermal reduction of nitrogen oxides using the NOxOUT process can successfully be applied to recovery boilers. More than 60% reduction was achieved despite the low NOx level without treatment. No disturbances or other negative effects on the operation of the recovery boiler was observed during the test run. No negative effects in the chemical recovery cycle was observed during the test runs.
5.4	Determination of black liquor calorific value	Chao, E.E., McDonald, K.L., and Garby, A.C.	TAPPI Journal, June 1984, pg. 112	
5.5	Ultrafiltration studies on a kraft black liquor	Hill, Marquita, and Fricke, Arthur L.	TAPPI Journal, June 1984, pp. 100-103	In this study, ultrafiltration was used as a means to separate kraft black liquor components into high and low molecular weight fractions. Ultrafiltration effectively removed inorganic salts and organic acids from black liquor as well as a portion of the molecules absorbing in the ultraviolet. When a membrane with a nominal molecular weight cutoff of 100 was used, the low molecular weight lignin-like molecules removed into the ultrafiltrate had a different pattern of light absorption than the lignin left behind in the cell, and there was a difference in the sulfur and carbohydrate content of these fractions.

NUMBER	TITLE	AUTHOR	REFERENCE	SYNOPSIS
5.6	Lignin recovery from kraft black liquor: preliminary process design	Loutfi, Hassan, and Blackwell, Brian	TAPPI Journal, January 1991, pp. 203-210	A process design and a capital cost estimate were prepared for a lignin recovery process. The process includes CO_2 precipitation, lignin separation, acid washing, and product drying. The process equipment was sized to recover 9.5% of the lignin originally present in the black liquor for a typical kraft mill producing an annual average of 700 a.d. tons/day. The economic evaluation was based on the sale of 21% of the recovered lignin as a specialty chemical, with the remainder used as fuel for the lime kiln. A computerized mass balance was developed to examine the impact of lignin total installed capital cost of about $19 million (Canadian) and a pay-back time of four years.
5.7	Kraft lignin: a potential fuel for lime kilns	Richardson, B., and Uloth, V.C.	TAPPI Journal, October 1990, pp. 191-194	As the lignin moisture content increased from 0% to 50%, the amount of fossil fuel displaced by a constant dry weight of lignin decreased by only 6-7%
5.8	Chemical Recovery Update - International Chemical Recovery Conference, New Orleans (Summaries of conference papers)		TAPPI Journal, Vol. 68, No. 4	
5.9	Gasification of black liquor char with CO_2 at elevated pressures	Frederick, William J., and Hupa, Mikko M.	TAPPI Journal, July 1991, pp. 177-183	The kinetics of gasification of black liquor chars with carbon dioxide were studied under pressurized conditions (1-30 bar) and 600-800°C. The rate of gasification was found to be slightly less than first order in CO_2, and the rate of gasification was strongly inhibited by CO. As pressure was increased, CO inhibition more than offset the effect of CO_2 on the gasification rate. The net impact was that the rate of gasification at constant CO/CO_2 ratio decreases by a factor of 4.6-6 as total pressure increases from 1 bar to 30 bar. The rate of gasification with CO_2 is temperature sensitive, increasing by more than a factor of 10 with a 100°C increase in temperature. The reactivity of different kraft chars is not the same. In experiments with chars from three liquors, the rate varied by a factor of two at identical gasification conditions.
5.10	Alternative kraft recovery processes	Empie, Jeff H.	TAPPI Journal, May 1991, pp. 172-276	

NUMBER	TITLE	AUTHOR	REFERENCE	SYNOPSIS
5.11	Computer modeling and design of a fluidized bed dryer for kraft black liquor	Sell, Nancy J., and Clay, David T.	TAPPI Journal, June 1991, pp. 177-179	The solids content of concentrated black liquor is a critical parameter in the design and operation of a kraft recovery boiler. The trend today is to go to higher solids content to increase the effective capacity of the boiler and potentially to improve its performance. A fluidized bed dryer achieved 95% dried solids in laboratory tests. The fluidized bed dryer was mathematically modeled using the IPC MAPPS computer program. MAPPS was originally designed for calculating mass and energy flows, but its overall structure makes it ideal also for equipment design. Process design parameters are summarized for a fluidized bed black liquor dryer supporting an equivalent increase of 182 a.d. tons of pulp per day.
5.12	Vaporization from alkali carbonate melts with reference to the kraft recovery furnace	Cameron, J.H.	Journal of Pulp and Paper Science, July 1988, pp. 76-81	This paper examines the processes responsible for fume generation in the draft furnace. Fume generating under oxidizing conditions was found to be an order of magnitude greater than under strongly reducing conditions. Addition of sodium hydroxide to the sodium carbonate-sulphide melt did not increase the fuming rate. Potassium and chloride levels in kraft furnace fume are lower than values calculated from equilibrium data; however, if the enhanced vaporization of sodium due to oxidizing conditions is taken into consideration, the low potassium and chloride levels in the fume can be explained. Raoult's law gives an accurate description of sodium chloride vaporization from a sodium carbonate-sulphide-chloride smelt under oxidizing conditions.
5.13	Tampella recovery system for small-scale pulp mills	Rimpi, P. and Hopia, R.	Pulp and Paper Canada, 1987, pp. 286-289	Tampella has developed a recovery system compromising the liquor burning in a package recovery boiler and the chemical conversion for sodium-based cooking processes. It is aimed at small scale pulp mills and for mills where the recovery boiler is a bottle neck.
5.14	Pyrolysis gas explosions	Grace, Thomas	PIMA Magazine February 1991, pp. 49-50	Pyrolysis gases are combustible gases that are produced when black liquor is dried and heated. Pyrolysis of one gallon of 65% solids black liquor could produce as much as 50 cubic feet of combustible gas. Pyrolysis gas formation is an inherent part of black liquor burning and normally causes no problems. Formation and burning of pyrolysis gases is responsible for most of the heat released as black liquor burns. The gases burn as soon as they are released, forming the fireball that can be seen in the furnace.

NUMBER	TITLE	AUTHOR	REFERENCE	SYNOPSIS
5.15	Agitation helps mill raise storage capacity and recover chemicals	Ramos, J.	Pulp and Paper, August 1988, p. 14	Simpson Paper Co. manufactures nearly 270,000 metric tons per year of pulp and 290,000 metric tpy of paper at its Pasadena, Texas mill. As part of its liquor storage system, the mill uses a 48 ft deep, 114 ft diameter API (American Petroleum Institute) tank to store black liquor derived from its pulping process. The liquor is then routed to recovery boilers where chemicals used in the treatment of woodchips are extracted.
5.16	Black liquor solids content	Grace, Thomas	PIMA Magazine	
5.17	Biomass gasification project gets funding to solve black liquor safety and landfill problems	Black, Norman P.	TAPPI Journal, February 1991, pp. 65-68	System forms no smelt and makes clean fuel gas that can be burned in inexpensive, gas-fired power boilers, calciners, or gas turbines.
5.18	High-solids black liquor combustion - Tampella's Super Combustion system	Hyoty, P.A., and Ojala, S.T.	TAPPI Journal, January 1988, pp. 108-111	A system of firing black liquor at 80% dry-solids content is in commercial operation and has total operator acceptance.
5.19	Black liquor combustion research		TAPPI Journal, Vol. 67, No. 7	
5.20	Kraft Black Liquor Cooperative Program reports progress	Harrison, Ray E.	TAPPI Journal, November 1987, pp. 145-147	
5.21	Desilication of black liquor: pilot plant tests	Kopfmann, K., and Hudeczek, W.	TAPPI Journal, October 1988, pp. 139-147	The tests have enabled the design and construction of a large industrial plant for processing rice straw and bagasse using the soda process.
5.22	Evaporator vapor sampling	Pelkey, Edward R., Nd Schluter, Jill L.	TAPPI Journal, December 1988, pp. 227-228	
5.23	Entrained black liquor solids and viscosity selectivity in oxygen delignification reinforced with hydrogen peroxide	Parthasarathy, V.R.	TAPPI Journal, September 1990, pp. 243-247	Results are reported from a study on the effects of entrained black liquor solids on the rate of delignification and on the viscosities of loblolly pine kraft pulps delignified with oxygen and oxygen reinforced with hydrogen peroxide (PO). The amounts of entrained solids ranged from 0 to 85 kg/o.d. metric ton of pulp is beneficial, increasing the rates of oxygen delignification and PO delignification. However, black liquor solids entrained with the pulp affected the pulp viscosity. The overall selectivities (Kappa number vs. viscosity) of oxygen and PO-bleached pulps were slightly lower for pulps with entrained solids. Using hydrogen peroxide (0.5% on pulp) to reinforce the oxygen stage has yielded pulps lower in Kappa number and equal in viscosity to oxygen-delignified pulps.

NUMBER	TITLE	AUTHOR	REFERENCE	SYNOPSIS
5.24	The influence of chlorides on the fireside behavior in the recovery boiler	Hupa, M., Backman, R., Skrifvars, B-J., and Hyoty, P.	TAPPI Journal, June 1990, pp. 153-158	Increasing the chloride content in the black liquor has various effects on the fireside behavior of the recovery boiler. Chlorides tend to become enriched in the gas phase, depending mainly on bed temperature. The most important chlorine-containing compounds in the gas phase are NaCl(g), KCl(g), and HCl(g). HCl(g) may cause rapid corrosion on steel surfaces by forming volatile $FeCl_2$(g). Chlorides strongly affect the behavior of the dust in the flue gas channel. The essential parameters governing the superheater fouling and corrosion are the sticky temperature T_{15} and the flow temperature T_{70}. These temperatures are influenced by the chlorides. Also, the sintering rate of solid dust deposits in the boiler bank and economizer is increased when the chloride content of the dust increases.
5.25	Preparation of kraft lignin from black liquor	Kim, Hongkyu, Hill, Marquita K., and Fricke, Arthur L.	TAPPI Journal, December 1987, pp. 112-116	The purity of lignin precipitated at low pH from kraft black liquor was examined along with the factors that improve purity. The recovery of lignin by precipitation was also evaluated in an attempt to optimize recovery at high purity. The lignin preparation methods used were compared for their precision by using ion chromatographic, UV-visible spectrophotometric, and inductively coupled plasma spectrometric (ICP) analytical methods.
5.26	Feasibility study: black liquor gasification and use of the products in combined-cycle cogeneration	Kelleher, E.G.	TAPPI Journal, April 1984, pp. 114-117	A study of kraft black liquor gasification was sponsored by the U.S. Department of Energy. The results of a small-scale experimental evaluation by Rockwell International, using its Molten Salt Gasification Process, are used in computer simulations of a complete steam and electric power supply system. This power system is a combined-cycle system based on a coal and bark fired combination boiler and a gas turbine. Capital and operating costs were compared. Based on this limited feasibility study, the system appears to have potential in energy efficiency, economics, and safety.
5.27	Black liquor gasification and use of the product gases in combined-cycle cogeneration - Phase II	Kelleher, E.G.	TAPPI Journal, November 1985, pp. 106 - 110	Bench-scale and pilot-scale tests of kraft black liquor gasification have been completed in a study cosponsored by the U.S. Department of Energy. These tests of gasification with air confirm the feasibility of obtaining product gases with a higher heating value sufficient for firing in a standard gas-compressor-turbine-expander set. The overall process has the potential for higher efficiency, lower costs, modularity, and elimination of the explosion potential associated with the Tomlinson furnace.
5.28	International Chemical Recovery Conference, New Orleans	Summaries for Conference Papers	TAPPI Journal, Vol. 68, No. 4, pp. 31-35	

NUMBER	TITLE	AUTHOR	REFERENCE	SYNOPSIS
				6.0 RECAUSTICIZING
6.1	Combustion of lignin in a pilot lime kiln	Richardson, B., Watkinson, A.P., and Barr, P.V.	TAPPI Journal, December, 1990, pp. 133-137	Dried lignin powder can be satisfactorily burned in a pilot lime kiln either on its own or in conjunction with natural gas.
6.2	Substitution of oil by hogged fuel in a kraft process lime sludge kiln	Rowe, Ian G.	TAPPI Journal, February 1984, pp. 86-90	Hogged fuel, typically at 55% moisture content, was combusted in a wet-cell burner and the flue gases applied to a lime sludge kiln. Up to 78% oil substitution was achieved, consistent with satisfactory lime quality and availability. Specific energy consumption was high because heat transfer was less efficient. Computer simulation techniques were used to develop parameter profiles throughout the kiln and to predict optimal performance. Optimized kiln conversion was shown to be economically advantageous if hogged fuel is available for $7.00/m^3$ or less, assuming an oil price of $30/bbl ($0.189/L).
6.3	Closing up the kraft mill chemical balance: alternative caustic sources	Lindberg, H., Edwards, L. and Saltin, G.	TAPPI Proceedings, 1991 Environmental Conference Book 1, pp. 53-58	With the current costs for sodium hydroxide and sodium carbonate and if kiln capacity is available, it may be economical for some mills to change from sodium hydroxide to sodium carbonate for kraft mill make up. Electrodialysis of R8 spent salt is undergoing pilot plant testing in Finland. It converts R8 spent salt to sodium hydroxide and sulfuric acid. Recycling first extraction stage (E1) filtrate to chemical recovery eliminates about 35% of the total sodium makeup required in a kraft mill. At present, E1 filtrate recycle can only be considered on an environmental basis.
6.4	New opportunities for TRS reduction in stack emissions	Stuplich and Swedock	TAPPI Press, Environmental Issues: An Anthology of 1989, pp. 253-254	The paper is a progress report on the new direction we've seen in TRS control and reduction. During work with lime mud conditioners, we've found what we consider to be a new control mechanism for the reduction of TRS emissions.
6.5	Evaluation of oxidized white liquor as an alkali source	Alaya, Magnotta, Zierdt, Zanchin and O'Ceerny	TAPPI Notes, Oxygen Delignification Symposium, 1990, pp. 153-161	The technical and economic aspects of using oxidized white liquor in oxygen delignification stages are reviewed. Oxidized white liquor is compared to other alkali sources through a review of the existing literature, new laboratory work, and mill experience. An economic comparison is made between the OXPRO system, which oxidizes white liquor with oxygen, and an air oxidation system. Other end uses for oxidized white liquor, such as extraction stages and scrubbers, are reviewed.
6.6	Kraft lignin: a potential fuel for lime kilns	Richardson and Uloth	TAPPI Proceedings, Pulping Conference Book 1, 1990, pp. 451-455	A computer program was developed to facilitate mass and energy balances about a lime kiln and to assess the potential effects of fossil fuel replacement with lignin.

NUMBER	TITLE	AUTHOR	REFERENCE	SYNOPSIS
6.7	Lime kiln emission control	Kiiskila, E.	TAPPI Press, Environmental Issues: Anthology of Published Papers, 1990, pp. 410-415	The formation of TRS, dust, SOx and NOx as well as their theoretical formation mechanism are discussed. The measured emission levels and the ways to influence their formation are presented based on industrial experiences. The ability of flue gas cleaning systems to handle these compounds is discussed.
6.8	Quick kiln retrofits for TRS improvement	Ryan, M.	TAPPI Press, Environmental Issues: Anthology of Published Papers, 1990, pp. 459-461	A laboratory scale kiln was studied to determine the best position in a production unit rotary lime kiln to place a Turbushield gas mixer for reduction of TRS emissions.
6.9	Lime kiln energy conservation - Have we forgotten the I.D. fan?	Perry, R.E.	TAPPI Journal, June 1989, pp. 243-246	
6.10	Evaluating the energy performance of a lime kiln	Hsieh, C.L.	TAPPI Journal, Vol. 66, No. 9	A procedure for evaluating the energy performance of a lime kiln has been developed. It is based on chemical species balances, thereby avoiding the usual difficulties and errors in trying to measure lime mud and product lime flows. Together with other readily obtainable kiln data, complete material and energy balances can be calculated, giving both the total energy requirement for producing a ton of lime and the distribution of this energy. This latter information can indicate where possible energy savings can and should be made. The procedure was tested in a kraft mill with satisfactory results.

NUMBER	TITLE	AUTHOR	REFERENCE	SYNOPSIS
				7.0 POWER GENERATION
7.1	Emissions from a wood-boiler equipped with a direct contact fuel dryer	Campbell, Ken C., and Caron, Andre L.	TAPPI Proceedings, April 1987 Environmental Conference, pp. 143-145	The Boise Cascade mill at West Tacoma, Washington has recently installed a fluidized bed fuel dryer to compliment its hog fuel fired boiler. The objective was to reduce the moisture content of the fuel fired, improve combustion and heat recovery efficiency of the unit, thus substantially reducing the firing rate of auxiliary fuel. The dryer was successful in accomplishing the above. Due to improved efficiency of the boiler, some changes in the emission of particulate, nitrogen oxides, carbon monoxide and total gaseous non-methane organics would be expected. Summarized will be the results of surveys conducted to better understand the above.
7.2	Agricultural use of wood ash as a fertilizer/liming material	Naylor, Lewis M., and Schmidt, Eric J.	TAPPI Proceedings, April 1986 Environmental Conference, pp. 157-165	Paper mill wood-derived boiler ash was mixed with two acid soils at rates equivalent to 0, 2.24, 4.5, 9.0, 17.9, and 35.9 metric ton/ha in a soil incubation study to evaluate changes in extractable nutrients and soil pH. Levels of extractable P, K and Ca were increased linearly with application rate. Soil pH was increased linearly with the logarithm of the application rate. The ash was compared with commercial potash fertilizer and agricultural limestone. The equivalent neutralizing value was about half of that for agricultural limestone.
7.3	Achieving hog fuel handling system cleanliness with an integrated dust control program	Cobb, W., and Termine, F.	TAPPI Proceedings, April 1987 Environmental Conference, pp. 137-141	Excessive dust generated from the hog fuel handling system at Smurfit Newsprint's Newberg, OR mill was costing the company $270,000 a year in lost fuel and increased waste treatment costs. In addition to being a general nuisance, the dust created a hazardous working environment, increased cleaning costs, and reduced equipment reliability and lifetime. After a complete system survey was conducted, mechanical, chemical, and operations changes were made to reduce carryback of the hog fuel and the amount of fugitive dust. The shrouds and the implementation of a foam dust control program vastly improved the cleanliness of the hog fuel handling system.
7.4	Hogged fuel boiler ash physical and chemical characteristics and their influence on design and operation of a woodwaste landfill	Edens, Mark H., and Hannah, Mark A.	TAPPI Proceedings, 1991 Environmental Conference Book 2, pp. 849-863	Daishowa America Company operates a telephone directory paper mill in Port Angeles, Washington, that produces approximately 75 cubic meters per day of hogged fuel boiler ash. The mill was purchased by Daishowa in early 1988. The ash had been disposed of by the previous owners of the mill at a privately owned landfill since 1982. Daishowa purchased this landfill in late 1988 and upgraded the site to meet regulatory requirements. Analysis of physical and chemical characteristics of the hogged fuel boiler ash suggested the ash has a low moisture holding capacity and would produce a leachate that could impact groundwater quality. Ash characteristics guided preparation of a site development and operations plan that includes recommendations for interim temporary cover for leachate control. Since implementation of the plan in 1989, groundwater monitoring results demonstrate that site operation and development is not causing significant impacts to groundwater quality near the site.

NUMBER	TITLE	AUTHOR	REFERENCE	SYNOPSIS
7.5	Fast-track development of a lined woodwaste/ash landfill in Washington state	Springer, Elaine T., and Jones, Brian D.	TAPPI Proceedings, 1991 Environmental Conference Book 2, pp. 865-877	This paper describes how a conceptual plan was prepared for the Shotwell Landfill and how Phase 1 was developed and in operation within 15 months of project inception. The new facilities included a temporary synthetic cover over an existing 2.5 ha sludge landfill; a new 2.25 ha composite-lined landfill cell; leachate, stormwater, and groundwater collection and disposal; a lined leachate lagoon and truck load facility; groundwater monitoring wells; and an operations and closure plan. This paper describes unusual technologies utilized at the site, constraints, and permitting challenges associated with the fast-track schedule.
7.6	Bubbling bed units for waste fuel consumption in the pulp and paper industry	Ganga, R. C.	TAPPI Proceedings, 1991 Environmental Conference Book 1, pp. 405-411	Many combustion waste fuels lend themselves to bubbling bed fluid bed combustion applications. The goals of this paper will be to generally introduce some of the companies that provide small fluid bed technologies, to describe the technical approach each company takes and to present relevant experience where possible including a discussion of projects completed and fuel consumed. Although most of the major boiler vendors also offer small units for waste consumption the focus here will be on less well known or smaller vendors.
7.7	Environmentally sound power generation	Accortt and Collins	TAPPI Press, Environmental Issues: An Anthology of 1989, pp. 233-239	The design, start-up, and operation of a 300,000 lb/hr boiler followed by a spray dry scrubber and electrostatic precipitator for air quality control are described.
7.8	Applications of Federal Republic of Germany flue gas cleaning technology to U.S. pulp and paper industry	Keen and Helmenstein	TAPPI Press, Environmental Issues: Anthology of Published Papers, 1990, pp. 397-409	This paper will present historical costs of flue gas cleaning technology for NOx and SOx as a function of boiler type including pulverized coal, fluidized bed and stoker firing. A comparison of FRG emission standards with pending US standards will be included.

NUMBER	TITLE	AUTHOR	REFERENCE	SYNOPSIS
			8.0 WASTEWATER TREATMENT	
8.1	Treatment of effluents from the pulp and paper industry by chemical coagulation	Almemark, M., Eriksson, G, and Hagerstedt, L.E.	TAPPI Seminar Proceedings, Bleaching and the Environment, Seattle, Washington, September 1988, pp. 251-272	This paper deals with chemical coagulation of bleach plant effluents with alum followed by incineration of the sludge and acid recovery of the coagulants. Costs are projected for full scale operation.
8.2	Bench scale study of dioxins and furan (2378-TCDD and 2378-TCDF) treatability in pulp and paper mill wastewaters	Amendola, G.A, Bodien, D.G., and Handy, R.E. Jr.	TAPPI Journal, December 1989, pp. 189-194	The principal objectives of this study were to determine the solid and liquid phase distribution of 2378-TCDD and 2378-TCDF in untreated, partially treated and treated process wastewaters from pulp and paper mills; and to determine whether chemically assisted clarification (CAC) might be a feasible alternative for removing those compounds from internal mill and total mill process wastewater. Results of bench scale studies indicate that from 30% to 40% of the 2378-TCDD and 2378-TCDF is present in the solid phases of internal mill samples; greater than 90% in aeration basin effluents; and from 40% to 75 % in final effluents. CAC proved to be effective at removing 2378-TCDD and 2378-TCDF from internal mill wastewaters, however, less cost effective than providing improved treatment in existing secondary treatment facilities.
8.3	Screening study of the treatability of dioxins and furans in bleach plant filtrates and mill wastewaters	Barton, D.A., McKeown, J.J., and Brunck, R.A.	NCASI 1989 West Coast Regional Meeting, October 4, 1989	Unpublished report consists of tables used for presentation at NCASI 1989 West Coast Regional Meeting.
8.4	Some aspects on biological treatment of bleached pulp effluents	Boman, B., Frostell, B., Ek, M., and Erikson, K.E.	Nordic Pulp and Paper Research Journal, 1-1988, pp. 13-18	The article describes the most important methods presently used for external treatment of bleach plant effluents. They are in most cases designed to reduce BOD and are not very effective in reducing AOX. None of the biological methods currently used can degrade high molecular mass material. The possibility of using special fungi, able to attack the high molecular mass chlorinated lignins, is discussed. Anaerobic dechlorination is also mentioned. A combination of physical/chemical methods and biological treatment is proposed for the development of new purification processes. A combined process with ultrafiltration and effective biological treatment is estimated to give at least 95% reduction of BOD and 70-90% reduction of COD and AOX.

NUMBER	TITLE	AUTHOR	REFERENCE	SYNOPSIS
8.5	Organic halide in kraft mill wastewaters: factors affecting in-mill formation and removal by biological treatment	Bryant, C.W. and Amy, G.L.	TAPPI Proceedings, 1988 Environmental Conference, pp. 435-438	Chlorine is used as a pulp bleaching agent, resulting in the formation of various organochlorine compounds that range from simple chlorophenols to higher molecular weight chlorolignin compounds. In addition to persisting in the environment, some of these compounds exhibit toxicity or mutagenicity. Recent work has focused on the use of the total organic halide (TOX) parameter for measuring the totality of these compounds.
8.6	Design, startup, and operating experience for an expanded ASB treatment system at Champion's Pensacola Mill	Hilleke, J., Koelsch, S., and Arceneaux, D.	TAPPI Journal, September 1989, pp. 111-117	In December 1986, Champion completed the conversion of its Pensacola kraft mill to 100% bleached pulp and paper operation. New pine and hardwood bleach lines were set up, along with an oxygen delignification sequence. To successfully operate the converted mill in compliance with new permit conditions, the project included major modifications to the waste treatment system.
8.7	Pilot plant trials for LRP, a new process for precipitating organic material	Hynninen, P.	TAPPI Journal, February 1989, pp. 167-170	The lignin removal process (LRP) is a new method for precipitating dissolved or colloidal organic material of high molecular mass from fibrous waste sludge. Effluents successfully treated have been taken from bleaching plants, barking rooms and fiberboard mills from white water systems of some paper and fiberboard mills and from CTMP mills. Pilot plant trials at a kraft pulp mill and at a fiberboard mill produced results similar to those obtained by chemical precipitation and by the previous laboratory tests. The pilot plant results support ideas for the design of LRP effluent treatment plants. LRP is simple and inexpensive to incorporate into existing mechanical and biological treatment and the method is ready for industrial use.
8.8	Ultrafiltration of bleach plant effluent	Jonsson, A.S.	Nordic Pulp and Paper Research Journal, 1-1987, 23-29	An up-to-date evaluation of capacity and retention of new membranes with regard to bleach plant effluents has been made. The results from a trial of seven reverse osmosis, ultrafiltration and microfiltration membranes are reported. The trial has even included membranes not yet commercially available. The trial has demonstrated that some of the tested membranes could probably combine a satisfactory flux and an acceptable retention. A rough estimate of the costs shows that treatment of the E-stage effluent with ultrafiltration could be performed within a total cost of approximately 25 SEK per ton of pulp.
8.9	Dechlorination of high-molecular-weight chlorolignin by the white-rot fungus P. Chyrsosporium	Pellinen, J., Joyce, T.W., and Chang, H.M.	TAPPI Journal, September 1988, pp. 191-194	Dechlorination of chlorolignin in pulp bleaching wastewater was studied using the white-rot fungus P. chrysosporium immobilized on a rotating biological contactor. The total organic chlorine content of chlorolignin decreased almost by 50% during one day of treatment. The corresponding amount of inorganic chloride was liberated into the solution. Correlation studies suggested that dechlorination, decolorization, and degradation of chlorolignin (as COD decrease) are metabolically connected, although these processes have different rates. Size exclusion chromatography showed that polymerization took place in the early stage of the treatment. Low-molecular weight degradation products were not observed.

NUMBER	TITLE	AUTHOR	REFERENCE	SYNOPSIS
8.10	Membrane filtration as a technique for effluent control in pulp and papermaking	Thorsell, L. and Orchard, T.	TAPPI Seminar Proceedings, Bleaching and the Environment, Seattle, Washington, September 1988, pp. 227-243	Paper presents information related to membrane filtration (ultrafiltration and reverse osmosis). Applications, installations and costs are presented.
8.11	New flocculation process portends progress in color, dioxin removal	Mass, R.P. and Neal, J.P.	Pulp & Paper, September 1989, pp. 154-158	Article discusses how Hansel process removed 90 to 95 percent of lignin, tannins, and dioxin from secondary treated bleached kraft mill wastewater.
8.12	Development and implementation of a wastewater control strategy for APM Maryvale		TAPPI Proceedings, April 1987 Environmental Conference, pp. 1-5	
8.13	Anaerobic/aerobic treatment of kraft pulping wastes	Qiu, Rongchu, Benjamin, M.M.,and Ferguson, J.F.	TAPPI Proceedings, April 1987 Environmental Conference, pp. 165-172	A study of combined anaerobic pretreatment and aerobic post treatment was conducted with kraft evaporator condensate and caustic extraction stage bleaching effluent. In addition, the transformations and removal of sulfur compounds from the KEC and changes in molecular size fraction of organic carbon and organic chlorine were measured. Results indicate that the combined waste is amenable to anaerobic treatment with removal of a large fraction of the BOD.
8.14	A review of sludge landfilling practice at selected sites in the U.S. pulp and paper industry	Miner, Reid A.	TAPPI Proceedings, April 1987 Environmental Conference, pp. 187-191	In 1986 NCASI collected and detailed design information from 21 landfills receiving pulp and paper mill sludge, and designed since 1977. Discussions at a 1986 NCASI Special Technical Session on Pulp and Paper Special Technical Session on Pulp and Paper Mill Sludge Landfill Design and Operation provided additional information. This paper contains the results of NCASI's information gathering effort. Included are discussions of the design of liners, bottom and internal drainage blankets, leachate collection pipes, and landfill cover materials. Several important operational considerations are also reviewed.
8.15	Anaerobic treatability testing of Canadian pulp and paper mill wastewaters	Hall, E.R., and Cornacchio, L.A.	TAPPI Proceedings, April 1987 Environmental Conference, pp. 235-239	The anaerobic treatability of wastewaters from several pulp and paper mills was assessed using chemical and batch biological testing procedures. The results allowed the identification of candidate wastewater with the highest priority for further process development studies, and indicated the potential for applying anaerobic treatment technology in the Canadian pulp and paper industry.

NUMBER	TITLE	AUTHOR	REFERENCE	SYNOPSIS
8.16	Utilization of ASB solids for reclamation of final landfill cover and amendment of forest soils	Wilson, S.A., Rahe, Terry, and Sorenson, Thor	TAPPI Proceedings, April 1987 Environmental Conference, pp. 283-287	Approximately 6,000 dry tons of ASB solids were dredged and applied over a two year period. Project objectives included beneficial use of solids as a soil amendment on forest land and reclamation of landfill cover in addition to bringing ASB effluent back into compliance. Beneficial effects were noted in the productivity of vegetative cover and in the fertility status of site soils. Metals concentration in site soils increased significantly due to solids application but did not exceed regulatory thresholds.
8.17	An evaluation of wastewater treatment plant capacity and expansion requirements	Herman, D.M., and Hegg, D.E.	TAPPI Proceedings, April 1986 Environmental Conference, pp. 241-247	In order to accommodate production expansions, a study was completed to evaluate wastewater treatment plant capacity and determine upgrade requirements. The methods used include full scale evaluations, pilot plant studies and computer modeling. Expansions which will be made to the wastewater treatment plant include additional aeration, expanded dewatering capacity (including another dewatering press and increased polymer storage and delivery systems) more nutrient feed capacity, a new mix tank/splitter box prior to the primary clarifiers and modifications to the aeration basin influent feed system.
8.18	Primary and secondary sludge disposal by spray irrigation	Eck, Thomas H.	TAPPI Proceedings, April 1986 Environmental Conference, pp. 107-116	Southeast Paper Manufacturing Company in Dublin, Georgia produces 85-90 TPD of primary/secondary sludge from deinked newsprint pulp. Initial disposal at mill startup in 1979 was in a lagoon. Investigation of alternative disposal methods included dewatering, anaerobic digestion, and various land application techniques. The sludge was difficult and expensive to dewater and anaerobic digestion appeared impractical. Land application experiments indicated spray irrigation of the sludge was an acceptable disposal method and had reasonable costs. A permit was obtained from Georgia EPD. Operating conditions and experiences are reviewed. The investigation, permitting, and monitoring requirements are also presented.
8.19	Composting of a combined RMP/CMP pulp and paper sludge	Campbell, A. Engebretson, R. and Tripepi, B.	TAPPI Proceedings, 1991 Environmental Conference Book 2, pp. 727-737	A composite, primary and secondary sludge (3:1) from a RMP/CMP pulp and paper mill producing newsprint was composted using a static pile, forced aeration process in two 1,700-L insulated reactors. One reactor controlled temperature at < or = 60°C and moisture content at 60%, whereas the other reactor controlled only temperature at < or = 60°C. The raw sludge was non-hazardous and could be easily composted without a bulking agent or urea amendment. In summary, a primary-secondary mechanical pulp and paper mill sludge was rapidly composted into a material suitable for safe, beneficial use in agricultural and horticultural applications.
8.20	The efficacy of enhanced photo-oxidation for the reduction of TOCl, color, and toxicity in mill aqueous effluents	Higashi, Cherr and Crosby	TAPPI Proceedings, 1991 Environmental Conference Book 1, pp. 73-83	We have been investigating heterogeneous photooxidation of BKME using UV light and TiO2 photocatalyst coupled with standard and nonstandard analyses for TOCl, color, and aquatic toxicity of treated effluent. Therefore, using the best present conditions, dark brown effluent can be converted by heterogeneous photooxidation to a clear, colorless, and odorless solution lacking chloroform and low in aquatic toxicity, resin acids, and HMM in less than 30 minutes.

NUMBER	TITLE	AUTHOR	REFERENCE	SYNOPSIS
8.21	Treatment technologies for organochlorine-containing sludges and concentrates from external treatment of pulp and paper wastewaters	Almemark, M., Finnveden, G., and Frostell, B.	TAPPI Proceedings, 1991 Environmental Conference Book 1, pp.103-113.	Literature data and results from current Swedish research have been used to compile characteristics of and disposal methods for sludges and concentrates from external treatment of wastewaters from the pulp and paper industry.
8.22	Recent developments in the anaerobic treatment of pulp and paper industry wastewaters	Rintala, J.A., Sierra-Alvarez, R., Field, J.A., van Lier, J.B., and Lettinga, G.	TAPPI Proceedings, 1991 Environmental Conference Book 2, pp. 777-785	An aerobic treatment has been shown to be an effective, cost-saving method for reducing the organic pollution load of various types of forest industry waste streams including condensates, recycling paper wastewaters and (thermo-)mechanical pulping effluents. However, anaerobic treatment of more complex forest industry wastewaters (e.g., effluents from processes involving chemical treatments and debarking wastewaters) is often troublesome due to the presence of toxic and recalcitrant organics, high concentrations of sulfur, and in some cases high wastewater temperatures. Several measures which can be applied to render these wastewaters more amenable to anaerobic treatment are discussed.
8.23	Papermill sludge as a valuable fuel	Linderoth, C. E.	TAPPI Proceedings, 1991 Environmental Conference Book 1, pp.393-395	Disposal of primary clarifier and secondary biological sludge is a major problem in many mills in the pulp and paper industry. By properly dewatering the sludge, it can be made into a valuable fuel instead of being just a waste product, thus partially replacing other fuels for steam production in the mill. Thermal drying by utilizing the heat available in boiler flue gases can be a suitable alternative to, or compliment to mechanical dewatering. Two principally different systems are presented. One system utilizes flue gases off an existing bark fired boiler to redry the sludge prior to combustion in the boiler. The other system utilizes a portion of the dried sludge in a suspension burner to provide the necessary drying heat. Theoretical and practical results are discussed.
8.24	Optimization of biological treatment systems for enhanced removal of AOX and chlorophenolic compounds	Randle, W., Hall, E., and McKinlay, A.	TAPPI Proceedings, 1991 Environmental Conference Book 1, pp. 433-443	Laboratory scale treatability studies were undertaken to monitor and optimize the efficiency of biological treatment processes for removing chlorinated organic material from wastewaters discharged by bleached kraft pulp mills. The performance of an activated sludge system and an aerobic stabilization basin were compared to that of a facultative (anaerobic/aerobic) stabilization basin, in terms of AOX (Adsorbable Organic Halogen), chlorophenolics and volatile chlorinated organics removal efficiencies.

NUMBER	TITLE	AUTHOR	REFERENCE	SYNOPSIS
8.25	Reduction of chlorinated organics in pulp and paper mill effluent	Blake, N. and Zuncich, J.	TAPPI Proceedings, 1991 Environmental Conference Book 1, pp. 445-452	Laboratory and full scale testing was performed to evaluate the feasibility of decreasing total chlorinated organic material in pulp and paper mill effluent via chemical treatment to reduce total suspended solids, and/or via bio-augmentation. Laboratory precipitation and bio-augmentation testing was performed on aeration basin effluent from several mills. Full-scale testing examined AOX levels before and after bio-augmentation treatment of aeration basin effluent.
8.26	Ultrafiltration in the concentration of toxic organics from selected pulp and paper effluents	Zaidi, A., Buisson, H. and Sourirajen S.	TAPPI Proceedings, 1991 Environmental Conference Book 1, pp. 453-468	Under the WTC study on UF, several commercial membranes have been characterized using uniform protocols, and their performance has been evaluated to determine their effectiveness for separating selected organics from pulp and paper mill effluents. They include chlorinated phenolics, lignins, resin acids and dichlorodimethylsulfone. This paper presents the results from the WTC's work completed to date, and provides an overview of the published information on the use of UF for removing organics from pulp and paper mill effluents.
8.27	Physical/chemical treatment of bleach-plant effluents with the emphasis on chemical coagulation	Almemark, M. and Ekengren, O.	TAPPI Press, Environmental Issues: An Anthology of 1989, pp.27-39	Chemical coagulation vs. ultrafiltration. Ultrafiltration gives much the same treatment results for extraction effluents as chemical coagulation, at least in terms of some parameters. It has until now been difficult to control membrane filtrate chlorination and total bleach effluents. Research and development is in progress, however, and preliminary results are promising.
8.28	Combined biological and chemical treatment of kraft bleach plant effluent	Roy-Arcand, L., Archibald, F. and Briere, F.	TAPPI Press, Environmental Issues: An Anthology of 1989, pp. 67-74	Many approaches to color and toxicity removal from dilute bleach plant effluent have been tried but the problem still remains for many mills. The present study investigated the ability of ozone and the white-rot fungus Coriolus versicolor to reduce E1BE color and toxicity, separately and in sequence.
8.29	Indirect steam gasification of paper mill sludge waste	Swamy, Warren and Mansour	TAPPI Press, Environmental Issues: Anthology of Published Papers, 1990, pp. 362-370	Experimental tests were conducted to assess the performance of an indirectly-heated, fluidized bed, sludge gasification process employing pulse enhanced heat transfer. This procedure is anticipated to reduce the amount of dioxin formation which has caused concern regarding the uncontrolled emissions from incineration systems.
8.30	Sludge dewatering and incineration at Westvaco, North Charleston, SC	James and Kane	TAPPI Press, Environmental Issues: Anthology of Published Papers, 1990, pp. 380-389	Once the new dewatering system stabilized several trials were completed on the No. 4 Power Boiler to examine the effect of the sludge content, in a fuel consisting of bark, chip fines, and sludge, on thermal efficiency and boiler operation.
8.31	Sludge burning in fluidized bed boilers	Louhimo and Mullen	TAPPI Press, Environmental Issues: Anthology of Published Papers, 1990, pp. 416-431	The basic design of fluidized bed boilers and the criteria for sludge as fuel are discussed and examples of both new and retrofit units are provided.

NUMBER	TITLE	AUTHOR	REFERENCE	SYNOPSIS
8.32	Sludge incineration: "The European Experience"	Mooney and Helmenstein	TAPPI Press, Environmental Issues: Anthology of Published Papers, 1990, pp. 432-440	An overview of sludge burning technology and selected case histories are presented to illustrate both the state of the art for burning sludge and the effects of the regulations on both design and cost.
8.33	Incineration of briquetted and unbriquetted sludge	Sell, Jayne and Doshi	TAPPI Press, Environmental Issues: Anthology of Published Papers, 1990, pp. 445-458	Pilot scale tests of two methods of processing sludge prior to burning in a hog fuel boiler were compared: screw press dewatering, and screw press dewatering followed by briquetting and drying.
8.34	Rapid caustic extraction before an oxidative extraction stage	Histed, J.A., and Canovas, R. Vega	TAPPI Journal, July 1989, pp. 165-170	Rapid caustic extraction, using residual chemicals from an (E+O) stage, can be achieved in seconds by displacement on a multistage washer. This process decreases caustic consumption in the (E+O) stage by about one-third. The use of a multistage washer after the (E+O) stage results in further savings of bleach chemicals in the succeeding bleach stages. This technology can be combined with simplified (D/E/D) bleaching, high-substitution sequential chlorination, and oxygen prebleaching. At low capital cost, a bleachery can be built that has low chemical usage, low energy requirements, low chlorine consumption, and low AOX (absorbable organic halogens) in the effluents.
8.35	Dechlorination and decolorization of high-molecular-weight chlorolignin from bleach plant effluents by an oxidation process	Sun, Y.B., Joyce, W., and Chang, H.M.	TAPPI Journal, September 1989, pp. 209-213	The total organic chlorine and color of the high-molecular-weight chlorolignin form spent alkali extraction-stage effluent were effectively removed by an oxygen oxidation process. Under the best conditions, about 70-80% of the TOCl and 60-70% of the color were removed in less than one hour. A process combining ultrafiltration, oxidation, and biological treatment could be an effective, economical option to remove TOCl and color from spent alkali extraction effluent.
8.36	Treating bleaching effluent for suspended solids and color	Garcia-Heras, J.L., and Forster, C.F.	TAPPI Journal, September 1989, pp. 199-206	The paper discusses a study of the main characteristics of a coagulation system to remove chromophoric compounds from a bleach plant wastewater by iron and calcium cations. The treatment was successful, with a color removal of 99% with an iron dose of 6-7 moles/m3, the residual suspended solids were low (about 10 mg/l), but the residual turbidity (5-10 NTU) was higher than the initial value, and the sludge volume was high (over 20%).
8.37	Ultrafiltration for removing color from bleach plant effluent	Lundahl, H., and Mansson, I.	TAPPI Journal, April 1980, p. 97	Paper discusses ultrafiltration for the removal of color from bleach plant effluents.

NUMBER	TITLE	AUTHOR	REFERENCE	SYNOPSIS
8.38	Dechlorination and biological treatment of chlorinated organic substances	Bottoer, J., Patzold, J., Krause, T.H., and Schempp, W.	International Symposium on Wood Pulping Chemicals Proceedings, Paris, April 27-30, 1987, Vol. 1, pp. 171-174	Treatment of bleach plant effluent by dechlorination, UV and biological processes reduced AOX by 60%. Post treatment using aerobic fixed-bed reactor reduced AOX by over 90%.
8.39	Effects of secondary treatment on AOX levels in kraft mill effluents	Dubelsten, P., and Gray, N.C.C.	CPPA Proceedings, 76th Annual Meeting Technical Section, Montreal, Quebec, February 1-2, 1990, pp. A317-A324	Curtailing the release of chlorinated bleaching effluent into the environment has become a major challenge for the Canadian pulp and paper industry. It is possible that this may be achieved, in part, with secondary effluent treatment. Aerated lagoons are capable of reducing chlorinated phenolics by 20-60% and AOX by up to one third. Improved removal efficiencies of 75-95% for the chlorinated phenolics and 50-65% for AOX have been observed with activated sludge treatment.
8.40	On-site evaluation of a teflon-based ultraviolet light system and hydrogen peroxide for the degradation of color and chlorinated organics in Pine E_o from kraft mill bleach plant effluents	Smith, J.E., II, and Frailey, M.M.	TAPPI Proceedings, 1990 Environmental Conference, Seattle, Washington, April 9-11, 1990, pp. 101-110	Data collected from laboratory and field investigations showed that the UV hydrogen peroxide process could successfully and economically remove color from Pine Eo filtrate. The reactions were found to be dependent on both the intensity of UV applied to the system as well as on the concentration of hydrogen peroxide used. An overall 80% reduction in apparent color and 85% reduction in AOX was achieved at operating costs competitive with other technologies. The process did not produce a sludge.

NUMBER	TITLE	AUTHOR	REFERENCE	SYNOPSIS
			9.0 PAPERMAKING	
9.1	The impact of OSHA formaldehyde regulations on Longview Fibre Company	Elliott, R. and Drapeau, W.	TAPPI Press, Environmental Issues: An Anthology of 1989, pp. 305-306	
9.2	Lower emission urea formaldehyde resins	Martinez, E. and Chan, L.	TAPPI Press, Environmental Issues: An Anthology of 1989, pp. 307-314	Lower "free formaldehyde" urea-formaldehyde type resins were prepared by different chemical reaction. Emissions of formaldehyde from these resins and treated paper have been evaluated. The results show that urea-formaldehyde resins having lower formaldehyde emissions can be prepared without significant loss in wet strength efficiency.
9.3	Water reuse program James-River Corporation, Curtis Division	Gremban, Edward G.	TAPPI Proceedings, April 1987 Environmental Conference, pp. 71-77	A study was made of the reuse of paper machine water within the system. The reuse of the machine water was determined for the complete paper making process, starting with stock preparation. The required equipment water was implemented. It was determined that this reuse of water reduced mill operating costs and resulted in substantial savings.
9.4	Wet strength resin chemistry and regulatory considerations	Delaney, M.	TAPPI Press, Environmental Issues: An Anthology of 1989, pp. 301-303	An overview of the chemistry involved in the finding of a wet strength resin containing little or no free formaldehyde will be presented, with attention to typical performance characteristics and appropriate applications. How these resin systems may be affected by pending and future regulations will also be mentioned.

NUMBER	TITLE	AUTHOR	REFERENCE	SYNOPSIS
			10.0 GENERAL PLANT	
10.1	Complying with the kraft pulping process new source performance standard at five West Coast locations	Caron, Andre L.	TAPPI Journal, November 1989, pp. 101-105	A review of the CEMS records from five lime kilns located at West Coast mills revealed improved adherence to new source performance standards.
10.2	Reducing waste at Longview Fibre Co.	Whitford, Alan and Frase, Steve	TAPPI Journal, March 1990, pp. 167-169	Ways to reduce waste include washing slaker rejects, recycling wash thinner from the paint shop, burning primary and secondary clarifier sludge in the hogged fuel boilers, and improving savealls in the paper mill.
10.3	Progress in reducing water use and wastewater loads in the U.S. paper industry	Miner, Reid and Unwin, Jay	TAPPI Proceedings, 1991 Environmental Conference Book 2, pp. 639-647	An important and ongoing part of NCASI's investigative program involves the periodic collection and organization of information characterizing the wastes and emissions from the U.S. paper industry. In this report, information is summarized which documents the industry's progress in reducing water use, raw waste loads, and final effluent loads. In addition, the industry's sludge generation rates and increased reliance on beneficial uses for wastewater treatment sludges are documented.
10.4	Recycling/ waste minimization - one mill's success story	Edgarley, Willson	TAPPI Proceedings, 1991 Environmental Conference Book 2, pp. 649-652	The following is an overview of the recycling/waste minimization program at the James River Corporation Camas, Washington paper mill. Numerous areas of opportunity for savings are identified. Guidelines for a recycling program are presented. The development of the mill's solid waste segregation program and a list of a number of elements which made the program successful will be described.
10.5	Used oil recycling at the Champion Mill in Pensacola, Florida	Dail, H.A. and Dortch, T.	TAPPI Proceedings, 1991 Environmental Conference Book 2, pp. 653-656	Champion's Pulp and Paper Mill in Pensacola, like other similar facilities, has come to recognize that unmanaged used oil is both a cost and a regulatory liability. Better management of our waste oil has resulted from a reorganized maintenance program that has, as its primary emphasis, an ongoing education program and a focus on the needs of the front-line lubrication mechanics. Unlike in the past, almost all of our used oil is now accepted for recycling and the cost of managing the waste oil has been reduced significantly. An additional benefit is that this enterprise has provided the mill with a less expensive alternative fuel source that was not originally anticipated.
10.6	Means to reduce effluent pollution of kraft pulp mills	Gullichsen, J. E.	TAPPI Proceedings, 1991 Environmental Conference Book 1, pp. 185-190	Process internal measures alone will not be sufficient to reach acceptable levels. External effluent treatment will always be required. Internal abatement measures should concentrate on reducing pollution potential at the very source but also on improving the conditions for efficient external treatment.

NUMBER	TITLE	AUTHOR	REFERENCE	SYNOPSIS
10.7	Feasibility of municipal wastewater reuse at a bleached kraft mill	Harrington, Tantalo, Henry, Merry and Ongerth	TAPPI Proceedings, 1991 Environmental Conference Book 1, pp. 197-221	A study of the feasibility of reusing municipal wastewater in the Simpson Tacoma bleached kraft mill. This paper will report the results of this study and comment on the application of these conclusions to the paper industry in general.
10.8	Biofiltration - an innovative control technology for odors and air toxics	Leson, G., Rickun, J., and Henson, M.	TAPPI Proceedings, 1991 Environmental Conference Book 1, pp. 349-354	Odorous and/or toxic air contaminants are released from several processes in pulp and paper mills, including reduced sulfur compounds (RSC) from kraft pulping, chloroform and formaldehyde. More stringent emissions control requirements for air toxics and an increasingly environmentally conscious public could, in the future, require additional control of these emissions. In many cases, however, the use of conventional air pollution control technologies will result in high costs if large air flow rates have to be treated.
10.9	Development of toxic air pollutant emissions for thirteen pulp and paper mills in Wisconsin	Fisher, P., Foster, J. and Deb, K.	TAPPI Proceedings, 1991 Environmental Conference Book 1, pp. 469-481	Toxic air pollutant emission inventories for combustion sources, pulp and papermaking operations, storage tanks, and coal. Combustion related emissions were based upon published emission factors, fuel analyses, and stack tests spanning a wide spectrum of fuels used in the pulp and paper industry. The paper also discusses development of chloroform emissions from pulp bleaching, wastewater treatment plants, and treatment of incoming water, and formaldehyde emissions from the application of wet strength resins and combustion of fossil fuels.
10.10	Environmental in-plant control opportunities for the kraft process	Kilborn, Jack F.	TAPPI Proceedings, April 1987 Environmental Conference, pp. 65-69	Pulp and paper mills have often tolerated undesired water consumption, chemical and raw material reclaim, and by-product recovery levels because of limited availability of capital, and because the return on investment for "fine tuning" plant operations and processes do not meet a corporate specified "hurdle rate." Because of continued tightening of mandatory environmental limits, there are overlooked opportunities for achieving returns on investment with fewer dollars than would be spent on "end-of-pipe" treatment.
10.11	"Environmentally friendly" processes in the future	Axegard, P.	TAPPI Press, Environmental Issues: An Anthology of 1989, pp. 133-138	The future "environmentally friendly" system will probably use a combination of the following steps: modified kraft cooking, oxygen delignification, replacement of chlorine with chlorine dioxide, oxidative extraction, anaerobic/aerobic external treatment, membrane filtration, ozone combined with chlorine dioxide and bleach plant effluent burnt in the chemical recovery. Continued R&D is necessary.
10.12	Selective oxidation for cost-effective odor control and waste minimization	Joyce, W.	TAPPI Press, Environmental Issues: Anthology of Published Papers, 1990, pp. 390-396	An evaluation was made on the effectiveness of oxidation and precipitation to prevention of sulfide generation each with respect to hydrogen sulfide control, obtaining compliance under the new OSHA regulations, and the effect on dewatering operations.

NUMBER	TITLE	AUTHOR	REFERENCE	SYNOPSIS
10.13	Stock preparation energy-saving measures produce rapid payback	Strobel, S., Kohrs, M., and Siewert, W.H.	Pulp & Paper, April 1988, pp. 49-52	Pumps and refiners are the largest energy consumers in a typical paper mill; operating at the highest efficiencies is imperative.
10.14	Technical and economic aspects of measures to reduce water pollution caused by the discharges from the pulp and paper industry	COWI consult	EEC-Contract B6612-551-88 Final Report, November 1989	The report is a study of the technical and economical aspects of measures to reduce water pollution caused by the discharges of the pulp and paper industry. It is intended to be a development document for a future EEC Directive regulating aqueous discharges from this industry.
10.15	New opportunities for in-plant reduction of pollutants through process changes	Renard, J.J., Phillips, R.B., Jameel, H., and Rudie, A.W.	TAPPI Journal, August 1981, pp. 51-54	Four process options, including medium-consistency oxygen delignification, low-Kappa-number kraft/AQ pulping, chlorine dioxide substitution, and caustic extraction in the presence of oxygen (E_o stage), were compared in terms of production cost, environmental impact, and product quality. The oxygen-based options were identified as the most cost effective options to reduce the pollution load of a bleached kraft mill through process modification.
10.16	Industry's effluent problems spawn new engineering technology, design	Galloway, L.R., Helminen, P.I., and Carter, D.N.	Pulp & Paper, September 1989, pp. 91-97	Article reviews development of environmental regulations for Sweden, Canada and U.S. Also reviewed are in-plant and external technologies installed to reduce the discharge of chlorinated organics. These include extended delignification, oxygen delignification, advanced pulp washing, ClO2 substitution, reduced water usage and biological wastewater treatment.
10.17	Closed cycle technology report	Jain, A.K.	NCASI Report, September 1988	This report is an assessment of the current state of knowledge of various closed cycle technologies. Technologies included are Rapson-Reeve process, Billerud-Uddeholm and other resin processes, activated carbon absorption, chemical coagulation, ultrafiltration and reverse osmosis. The report also includes information on the problems encountered with implementing these technologies, and recommends the areas of research that could be pursued under the R & D program.