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EMISSION SCENARIO DOCUMENT ON NON-INTEGRATED PAPER MILLS

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EMISSION SCENARIO DOCUMENT ON NON-INTEGRATED PAPER MILLS

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EXPLANATORY NOTES

Purpose and background

This OECD Emission Scenario Document (ESD) is intended to provide information on the sources, use patterns and release pathways of chemicals used at Non-integrated Paper Mills, to assist in the estimation of releases of chemicals into the environment.

This ESD should be seen as a 'living' document, which provides the most updated information available. As such, an ESD can be updated to take account of changes and new information, including those from the industry area in countries other than the lead (Canada). Users of the document are encouraged to submit comments, corrections, updates and new information to the OECD Environment, Health and Safety Division (env.riskassessment@oecd.org). The comments received will be forwarded to the OECD Task Force on Environmental Exposure Assessment, which will review the comments every two years so that the lead country can update the document. The comments will also be made available to users within the OECD web-site (www.oecd.org/env/riskassessment).

How to use this document

The user of this ESD needs to consider how the information contained in the document covers the situation for which they wish to estimate releases of chemicals. The document could be used as a framework to identify the information needed, or the approaches in the document could be used together with the suggested default values to provide estimates. Where specific information is available it should be used in preference to the defaults. At all times, the values inputted and the results should be critically reviewed to assure their validity and appropriateness.

Coverage

This ESD provides information on chemicals used at non-integrated paper mills. This ESD was developed along with two sister documents, an ESD on Kraft Pulp Mills, and an ESD on Recovered Paper Mills. Although they were designed as stand alone documents, by their nature they represent different phases of the life cycle of paper products. The ESD on Kraft Pulp Mills represents the production stage when pulp is first produced. This ESD on Non-integrated Paper Mills is representative of the industrial phase of the life cycle, when the pulp is converted to paper and/or board products. The ESD on Recovered Paper Mills is illustrative of the recovery stage, when paper products are recovered, reworked and recycled back into the community. To cover the entire life cycle of each of these pulp and paper mill types would be quite lengthy and impractical.

Other ESDs relating to the Pulp and Paper Industry have previously been developed in Europe. These include the EU document, "IC-12, Pulp Paper and Board Industry – Assessment of the Environmental Release of Chemicals Used in the Pulp, Paper and Board Industry." Other related documents are specific to the use of biocides in the Pulp and Paper Industry. These include the European Commission "Harmonization of Environmental Emission Scenarios for Slimicides" (Product Type 12; 2003) and

“Emission Scenario Document for Biocides Used in Paper Coating and Finishing” by Tissier and Migné (Product Type 6, 7, and 9; 2001). The first-mentioned document covers additives used in printing and writing papers, tissue paper, newsprint, as well as cardboard, carton, packaging and wrapping paper. There is thus some overlapping with the ESDs developed for Non-integrated Mills and Recycle Mills, in terms of material covered. However, none of the European ESDs deal with Kraft pulping, due to the nature of the pulp and paper industry in Europe. Kraft pulping is much more prevalent in North and South America and the Scandinavian countries than in continental Europe.

How this document was developed

This document was produced by Environment Canada and overseen by the OECD Task Force on Environmental Exposure Assessment, along with two sister documents aforementioned. The general information about the processes and chemicals used is derived from literature data and several reports from the European Union and the United States. The emission estimation methods given in this ESD are based on those developed by the OECD with parameter defaults reflecting Canadian operations.

The first draft was circulated to the Task Force in March 2003 and developed through the meetings of the Task Force in 2003 and 2004. The revised draft was circulated to the OECD member countries and posted on the OECD web-site in December 2004, with requests for comments and information by May 2005. Comments were received from the United States, Sweden and Finland. The comments received suggested further improvement of the ESD by recommending additional sections (e.g., sample calculations and data gaps), additional/updated information (e.g., function of each type of listed chemical agents and sources of wastewater), specific industry information (e.g., relationship between different types of mills and wastewater treatment practices adopted by the Canadian industry), editorial changes and points of clarification (e.g., cross-reference to other ESDs; addition to glossary; basis for tonnage values used). All these comments were addressed in this document.

This document is published on the responsibility of the Joint Meeting of the Chemicals Group and Management Committee of the Special Programme on the Control of Chemicals of the OECD.

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1 – INTRODUCTION

1. The purpose of this emission scenario document (ESD) is to provide a realistic worst-case emission scenario for chemicals used at non-integrated paper mills. The general information about the processes and chemicals used is derived from literature data and several reports from the European Union and the United States. The emission estimation methods given in this ESD are based on those developed by the Organization for Economic Cooperation and Development with parameter defaults reflecting Canadian operations.

2. This ESD on Non-integrated Paper Mills was developed in 2004 along with two sister documents, an ESD on Kraft Pulp Mills, and an ESD on Recovered Paper Mills. Although they were designed as stand alone documents, by their nature they represent different phases of the life cycle of paper products. The ESD on Kraft Pulp Mills represents the production stage when pulp is first produced. This ESD on Non-integrated Paper Mills is representative of the industrial phase of the life cycle, when the pulp is converted to paper and/or board products. The ESD on Recovered Paper Mills is illustrative of the recovery stage, when paper products are recovered, reworked and recycled back into the community. To cover the entire life cycle of each of these pulp and paper mill types would be quite lengthy and impractical.

3. Other ESDs relating to the Pulp and Paper Industry have previously been developed in Europe. These include the EU document, "IC-12, Pulp Paper and Board Industry – Assessment of the Environmental Release of Chemicals Used in the Pulp, Paper and Board Industry." Other related documents are specific to the use of biocides in the Pulp and Paper Industry. These include the European Commission "Harmonization of Environmental Emission Scenarios for Slimicides" (Product Type 12; 2003) and "Emission Scenario Document for Biocides Used in Paper Coating and Finishing" by Tissier and Migné (Product Type 6, 7, and 9; 2001). The first-mentioned document covers additives used in printing and writing papers, tissue paper, newsprint, as well as cardboard, carton, packaging and wrapping paper. There is thus some overlapping with the Canadian ESDs developed for Non-integrated Mills and Recycle Mills, in terms of material covered. However, none of the European ESDs deal with Kraft pulping, due to the nature of the pulp and paper industry in Europe. Kraft pulping is much more prevalent in North and South America and the Scandinavian countries than in continental Europe.

2 – CANADIAN NON-INTEGRATED PAPER SECTOR

4. The pulp and paper industry produces commodity grades of wood pulp, primary paper products, and paperboard products. Most pulp is produced for the purpose of subsequent manufacture of paper and board products (European Commission, 1999, p.10). Some is destined for other uses such as thick fibreboard or products manufactured from dissolved cellulose.

5. Pulp and paper mills may be integrated or non-integrated. Integrated mills produce both pulp and primary paper products (USEPA, 1995, p.4). Non-integrated mills include pulp mills and paper mills. Pulp

mills only produce pulp (unbleached to full bleached) which is sold on the open market or shipped via pipe, conveyor, truck, train, or ship to other mills for the production of a final product. In contrast, paper mills only produce paper products from purchased and/or recycled pulp.

6. Newsprint and printing and writing paper are the major paper products produced in Canada. Over the years of 1999-2001, newsprint accounted for 55% of the total paper production that averaged at 16.2 million tonne/yr and printing and writing paper accounted for 37%, as given in Table 1 (Lockwood-Post Directory, 2002). It should be noted that a significant portion of newsprint was produced from recycled paper at recovered paper mills (deinking plants) instead of from virgin fibre at non-integrated paper mills.

Table 1 – Paper Production in Canada

Type of Paper	**Annual Production (1000 tonne/yr)**		
	1999	**2000**	**2001**
Newsprint	9,204	9,222	8,516
Printing and writing	5,748	6,313	6,105
Kraft packaging paper	534	531	519
Tissue and specialty	664	652	688
Total	**16,150**	**16,718**	**15,828**

Source: Lockwood-Post Directory, 2002.

7. The provincial breakdown of the paper production is not available at the time of preparing this document, but it is believed that Quebec is the province with the highest paper production in Canada. This is reflected by the production statistics given in Table 2 (Quebec Forest Industry Council, www.cifq.qc.ca). Quebec was ranked first in terms of the total production and followed by British Columbia and Ontario. The other provinces accounted for about 20% of the total.

Table 2 – Production of Pulp, Paper and Paperboard in Canada

Province	Pulp, Paper and Paperboard **(1000 tonne/year)**		Newsprint **(1000 tonne/year)**	
	2000	2002	2000	2002
Quebec	10,206	10,032	3,848	3,726
British Columbia	8,424	7,393	1,428	1,171
Ontario	6,471	5,991	1,924	1,595
Other Provinces	7,098	6,702	2,022	1,973
Total	**32,199**	**30,118**	**9,222**	**8,465**

Source: Quebec Forest Industry Council, www.cifq.qc.ca

3 – NON-INTEGRATED PAPER MANUFACTURING PROCESS

3.1 – Process Description

8. Figure 1 shows a typical process for non-integrated paper mills. It consists of three sections: 1) stock preparation; 2) papermaking; and 3) broke recycle (European Commission, 1999, p.308; Hagemeyer et al., 1992, p.187). Water and wastewater treatment and power boilers are commonly integral parts of a

non-integrated paper mill. The code used in Figure 1 for chemicals added in various pulp and paper operations is given in Table 3. It should be noted that these chemicals are provided for the pulp and paper industry as a whole and not all of them are necessarily used by non-integrated paper mills.

9. Wastewater streams from the process are generally sent to an on-site wastewater treatment system before discharged to a receiving water body. These streams include the wastewater collected from paper machines and the excess water removed from save-alls.

10. As part of the Canadian Fisheries Act, the 1992 Pulp and Paper Effluent Regulations were enacted to set allowable limits on BOD, suspended solids and LC_{50} toxicity values in mill effluents. Today almost all Kraft mills have primary and secondary treatment facilities to meet these targets, as do non-integrated and recycle mills, before discharging to a receiving body of water, be it river, lake, marine or estuary. Only one Kraft mill in Canada is releasing into a town's sewer system (after aerated lagoons). Many board mills (recycle mills) located in large urban centres release to the municipal sewer system following on-site primary treatment.

Table 3 – Pulp and Paper Chemicals

Code Used in Figure 1	Chemical	Function
1	Cooking aids/chip penetrants	Helps increase Kraft cooking yield.
2	Boilouts/cleaners	Removal of organic and inorganic deposition in chests and piping during major cleanups, in combination with an acid or caustic soda.
3	Scale control	Agent to prevent or delay inorganic scale formation.
4	Foam control	Prevention or control of foam in chests, washers and paper machines.
5	Washing/drainage aids	Improves throughput efficiency of brown stock washers.
6	Pitch/stickies control	Control and/or prevention of pitch and pitch-like substances from depositing out in system and/or causing quality problems in the finished pulp or sheet.
7	Clarification aids	An organic or inorganic substance to help in clarification of influent or effluent water.
8	Lime mud dewatering aids	Agent to increase lime mud solids prior to firing at lime kiln.
9	Tall oil separation and acidulation aids	Agent to increase separation yield of tall oil from black liquor at the skim tank in the evaporator train.
10	Turpentine separation aids	Agent to increase separation yield of turpentine from digester relief gases after the separation process.
11	Microbiological control	Substance to control microbiological organisms and the problems they cause (slime, off-odours, corrosion, quality defects).
12	Felt conditioners	Agent to clean felts or condition felt surface to prevent deposition. Applied continuously or in batch fashion.
13	Retention/drainage aids	A flocculant and/or coagulant to aid in the separation of fibre from water at the paper or pulp machine, in save-all and clarifiers, etc.
14	Air pollution control	Agents added to help separation process in wet scrubbers.
15	Condensate treatment	Agents added to prevent return line corrosion in boiler systems.
16	Boiler water treatment	Agents added to prevent water side corrosion problems in boiler systems.
17	Corrosion inhibitors	Filming or sequestering agents to prevent corrosion in various parts of the pulp making process.
18	Settling aids	The use of flocculants in green and white liquor clarifiers.
19	Nutrients	Sources of nitrogen and phosphate to stimulate microbial action in

Code Used in Figure 1	Chemical	Function
		effluent treatment.
20	Sludge conditioners	Flocculants, coagulants or combinations thereof to increase solids content of sludges in wastewater treatment systems.
21	Odour control	A substance added in wastewater treatment to control off odours caused by microorganisms.
22	Colour control	Usually, an agent added to remove/reduce colour in pulp or paper mill effluent.
23	Starch/sizes	Used to impart water repellency and stiffness to the paper product.
24	Wet strength agents	Agent added to improve wet strength of sheet of paper or board.
25	Dry strength agents	Agent added to impart dry strength of paper or board.
26	Dyes/dye fixatives/fluorescent whites	Agents added to give desired colour and reflectance to a sheet of paper.
27	Charge control	Agent added to help neutralize anionic trash in a paper machine system.
28	Fillers	Inorganic compounds added to paper machine stock to impart desired quality of opacity, printability and/or brightness to sheet.
29	Chelants/sequestrants	Agents used to control undesired metal ions.
30	Emulsifiers	Agent added to improve water solubility or miscibility of a particular component.
31	Antiskid agents	A substance, usually sprayed on at the dry end of a paper/board machine, added to promote stackability of board products, by increasing surface friction.
32	Save-all polymers	Coagulant or flocculant added to improve separation of fibre from white water at save-all.
33	Formation aids	Added at paper machine to improve sheet formation and uniformity.
34	Latex	Part of a specialty paper coating formulation surface treatment.
35	Surfactants/repulping aids	Agents added at the repulper to facilitate pulp slurry formation.
36	Dispersing agents	Agent added to improve water solubility of a hydrophobic constituent, to prevent agglomeration and deposition in a paper machine system.
37	Deinking aids	Agents added to help deinking of printed papers.
38	Soap/fatty acids	Agents used for deking newsprint and magazines.
39	Barrier chemistry	Agents added at machine to make sheet of paper impervious to various liquids.
40	Bleaching chemicals	Any chemical added alone or in combination with others to improve sheet brightness via oxidative or reductive mechanism.

3.1.1 – Stock Preparation

11. In the stock preparation section, raw materials are made suitable for forming into a sheet of paper through a sequence of pulping-screening-cleaning-refining (European Commission, 1999, p.308; Hagemeyer et al., 1992, p.187). Raw materials can be virgin fibres, recovered fibres, or their mixtures. They are placed into a pulper and prepared as a pumpable slurry. Impurities are removed from the slurry by screening and centrifugal cleaning. Refining may also be used to improve the bonding ability of individual fibres.

12. There are two types of stock preparation systems: 1) common stock refining; and 2) separate stock refining (Hagemeyer et al., 1992, p.216-221). In a common stock refining system, refining is carried out in a simple line of chests and refiners. Different furnishes are blended in a blend chest or a furnish

pulper and processed as a mixture through refiners. In a separate stock refining, each furnish is processed in a separate preparation line and delivered to a separate storage chest. Different furnishes are then mixed in mixing chests.

3.1.2 – Papermaking

13. Refined furnish is converted into paper through a paper machine. The most common design of paper machines is the Fourdrinier type (USEPA, 1995, p.35). In a Fourdrinier system, a pulp slurry is deposited onto a moving forming belt and water is removed by gravity, vacuum chambers, and vacuum rolls. The water removed is normally recycled to the slurry deposition step because of its high fibre content. The continuous sheet is then pressed between a series of rollers to dry and compress fibres. Modern paper machines are now using twin wire designs.

3.1.3 – Broke Recycle

14. Paper waste generated from a paper machine, known as broke, is normally recycled within a mill. In most operations edges of the paper web are continually trimmed with cutting water jets and collected into a couch pit (European Commission, 1999, p.312). Broke may be re-pulped immediately or stored and re-introduced to the process at a later date. Coloured or coated broke is recycled if possible but sometimes needs to be bleached or chemically treated before being reused in the process.

15. A typical broke cycle involves collection, pulping, cleaning, and mixing with stock pulp. Broke collected from a paper machine is first transported quickly to a dry end pulper and stored in a broke chest (Hagemeyer et al., 1992, p.162). It is then pulped and cleaned. Additional thickening and high-density storage may be required, depending upon the machine production rate. The cleaned broke is finally sent to mixing chests to blend with stock pulp prior to feeding to the paper machine (European Commission, 1999, p.312-314).

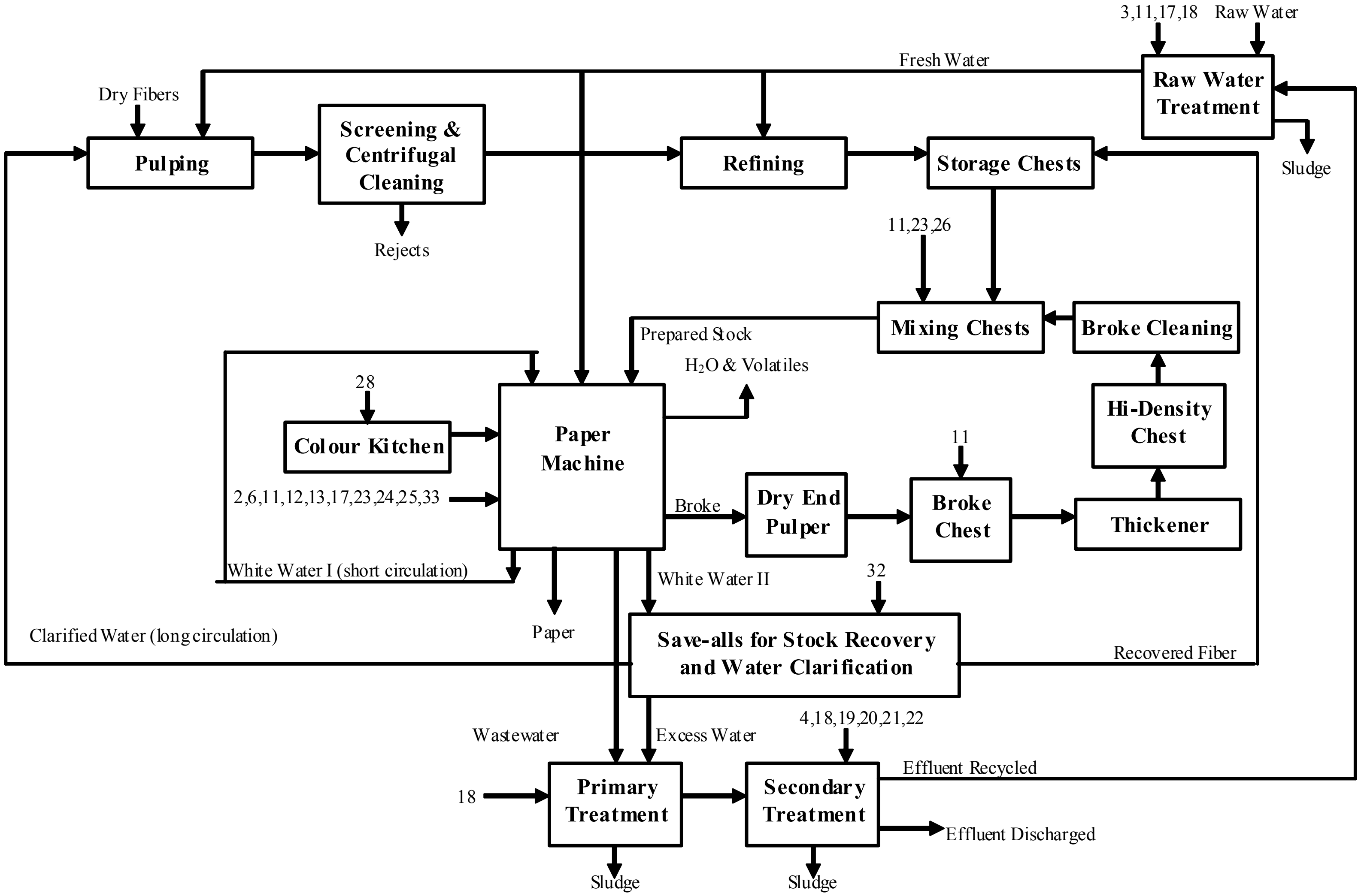

Figure 1 – Typical Process for Non-integrated Paper Mills

(Code for chemicals can be found in Table 3)

3.2 – Chemical Use

16. Chemical agents commonly used for papermaking consist of many categories and each category contains a range of chemicals, as summarized in Table 4.

Table 4 – Chemicals Used in Papermaking

Category	Code Used in Figure 1	Type	Example
Sizes	23	Rosin-based sizes	tall oil rosin, wood rosin, gum rosin
		Wax-based sizes	
		Cellulose-reactive sizes	
Wet strength resins	24	Water-soluble polymers	urea-formaldehyde (U-F), melamine-formaldehyde (M-F), polyamide-epichlorohydrin (PAE), dialdehyde starch (DAS), polyamine-epichlorophydrin (polyamine), polyacrylamide-glyoxal (PAMG), quaternary ammonium epoxide (base-reactivated amine polymer-epichlorohydrin)
		Water-dispersible latexes	polyethylenimine (PEI), chitosan, carboxymethylcellulose (CMC)
Dry strength resins	25	Natural polymer-based derivatives	starch derivatives
		Synthetic polymers	co-polymers of acrylamide and cationic monomers such as diallyl dimethyl chloride, co-polymers of acrylamide and an anionic monomer such as potassium acrylate
Dyes	26	Basic dyes	chlorides, hydrochlorides, sulphates and oxalates of color bases
		Acid dyes	sodium, potassium or ammonium salts of colour acids
		Direct dyes	salts of dye acids
		Colored pigments	clay, titanium dioxide, alumina hydrate, calcium carbonate
Fluorescent whites	26	Inorganic salts	alum
Retention aids (flocculation aids)	13	Inorganic salts	alum
		Organic polyelectrolytes	starch
Drainage aids	13		alum, cationic guar, cationic starch
		Synthetic polyelectrolytes	polyamide/amines (PAA), polyacrylamide copolymers (PAM), polyethyleneimines (PEI)
Formation aids	33	Natural water-soluble polymers	mannogalactan gums (guar), deacetylated karaya gums, carboxymethyl cellulose, hibiscus root, okra pod
		Synthetic water-soluble polymers	polyethylene oxide, polyvinyl alcohol, polyacrylamide, polyacrylamide-acrylic acid copolymer
Fillers	28		kaolin clay, calcined clay, calcium carbonate, titanium dioxide, talc, plastic pigments, alumina trihydrate, calcium sulphoaluminates, amorphous silica, silicate
Pitch control agents	6		alum, talc
Others			detergents, emulsifiers, defoamers, deposit control agents, microbiological slime control

Sources: European Commission, 1999, p.324; Hagemeyer et al., 1992, p.43 ; Thorp et al., 1991, p.141

17. Use levels and loss rates of papermaking chemicals are provided in Table 5 (European Commission, 1996, p.701). The data provided indicates that the loss to wastewater varies with type of chemicals used, ranging from 10% for retention aids to 100% for anti-foaming agents.

Table 5 – Use Levels and Loss Rates of Papermaking Chemicals

Chemicals	**Use Level**				**Loss to Wastewater**
	Newsprint	Board	Printing and Writing Paper	Tissue	
Anti-foaming	0.2 mg/L	0.03%	0.003%	0.003%	100%
Charge control	0.02-0.1%	no data	no data	no data	10-30%
Retention aid	0.1-0.5%	0.1-0.5%	no data	no data	10-30%
Retention aid and wet strength resin	no data	2-3%	no data	0.2-1.25%	10-30%
Biocide	5-40 mg/L	5-40 mg/L	5-40 mg/L	5-40 mg/L	no data
Softening agents	no data	no data	no data	0.2-0.3%	25-40%
Size (e.g., alum/rosin)	0.4-1.0%	0.4-1.0%	no data	no data	70-90% alum alone, 30% with rosin
AKD	no data	no data	0.05-0.3%	no data	spillages & intermittent washout
Binding agents, e.g., starch, CMC	0.5-1.5%	0.5-1.5%	no data	no data	no data
Surface coating, e.g., wax	0.1-0.8%	8-15 g/side	no data	no data	spillages & intermittent washout

Source: European Commission, 1996, p.701

18. The loss of dyes to wastewater is determined by their fixation rates which are further dependent upon the substrate applied to and the use of fixatives. As given in Table 6, the fixation rate of anionic direct dyes used for making printing and writing grades can be improved from a low of 79% to a high of up to 98% with fixatives (European commission, 1996, p.699). Similar improvement is also found for other types of dyes.

Table 6 – Fixation Rates of Different Dyes

Type of Dyes	**Substrate**	**Fixation without Fixatives**	**Fixation with Fixatives**
Anionic direct	Bleached & unbleached pulp	79-90%	up to 98%
Cationic direct	All types	90-99%	no data
Basic	Bleached pulp	50-70%	no data
	Mechanical pulp	60-80%	up to 95%
Acid	Sized packaging paper	40-60%	80-90%

Source: European Commission, 1996, p.700.

4 – RELEASE ESTIMATION

4.1 – Wastewater

19. Wastewater from non-integrated paper mills is generated from several water use areas. These areas are listed below along with typical consumption data (European Commission, 1999, p.326):

- As cleaning water, commonly known as shower water, for paper machines. It lubricates and cleans forming fabrics and wet press felts to maintain satisfactory dewatering performance. The consumption rate is 5-20 m^3 per tonne of pulp.
- As sealing water in stuff boxes, suction boxes, vacuum systems and cleaners. The consumption rate is 1-6 m^3 per tonne of pulp.
- As a solvent and dispersant for fillers and additives. The consumption rate is 1.5-3 m^3 per tonne of pulp.
- As make-up water in stock preparation for certain paper grades.
- As cooling water for process equipment. It is often recirculated and not included in water consumption. The use level is 3-10 m^3 per tonne of pulp.
- As process water for power plants. It is normally not included in water consumption. The use level is 2-3 m^3 per tonne of pulp.

20. Summarized in Table 7 is water consumption data for the pulp and paper industry in Canada, the U.S. and the European Union. In Canada, the water consumption was reduced from 73 m^3/tonne in 1995 to 69 m^3/tonne in 1999 for the industry as a whole (Forest Products Association of Canada, www.fpac.ca, 2004). The data for the province of Quebec in Canada was in the range of 57-62 m^3/tonne in 1999 which was lower than the national average (Quebec Forest Product Council, www.cifg.qc.ca, 2004). The sector of non-integrated paper mills in Canada consumed much less water at 23 m^3/tonne (personal communications with Environment Canada, 2004).

Table 7– Water Consumption by Pulp and Paper Industry

Region	Sector	Water Consumption (m^3/tonne)	Reference
Canada	Pulp and paper industry as a whole	69-73	Forest Products Association of Canada, www.fpac.ca, 2004
Quebec, Canada	Pulp and paper industry as a whole	57-62	Quebec Forest Product Council, www.cifq.qc.ca, 2004
Canada	Bleached Kraft mills	97.4	Personal communications with Environment Canada, 2004
Canada	Non-integrated mills	23.2	Personal communications with Environment Canada, 2004
Canada	Deinking mills	21.4	Personal communications with Environment Canada, 2004
USA	Pulp and paper industry as a whole	17-50	USEPA, 2002, p.36
USA	Bleached kraft mills	15-45	Personal communications with U.S. Environmental Protection Agency, 2004
European Union	Pulp and paper industry as a whole	15-100	European Commission, 1999, p.32

21. Given in Table 8 are estimates of water consumption from non-integrated paper mills in the European Union (European Commission, 1996, p.700). These estimates varied with paper grades, ranging

from 2-20 m^3/tonne for packaging and board to 40-75 m^3/tonne for printing and writing grades. In Finland, the wastewater from paper mills was generated at an average of 15.9 m^3/tonne (Braunschweiler, 2001; Sirkka, 2001). Hagemeyer et al. (1992, p.173) also reported similar figures in the range of 10-25 m^3 of water per tonne of paper.

Table 8 – Estimates of Water Consumption for Paper Production

Type of Paper	Water Consumption (m^3/tonne)	Degree of Closure
Printing and writing	40-75	40-70%
Tissue	57	40-70%
Newsprint	24-35	65-85%
Packaging and board	2-20	>95%

Source: European Commission, 1996, p.700

22. If the wastewater generation rate is unknown, it can be assumed to be approximately equal to the water consumption rate and vice versa.

4.2 – Solid Waste

23. Sludge is the major type of solid waste from non-integrated paper mills. It is generated from water and wastewater treatment (European Commission, 1999, p.340).

4.3 – Air Emissions

24. Paper machines are a source of emissions of volatile organic hazardous air pollutants (HAP's) and volatile organic compounds (VOC's). A field test study of 13 full-scale paper machines located at 11 mills in the U.S. found HAP and VOC emissions at 0.15 lb and 0.44 per ton of pulp, respectively (NCPI, 1997, No.740). Methanol was the major component of the HAP emissions at 0.071 lb per ton of pulp, followed by acetaldehyde, biphenyl, phenol, and chloroform.

5 – EMISSION SCENARIOS

5.1 – Fate of Chemical Agents

25. Described in Figure 2 is the fate of a chemical agent used at a facility. The agent is shipped to the facility using one or more types of containers. It is then unloaded or unpackaged and transferred to the production process. The agent leaves the facility via the following routes:

- Container residue that remains in containers after unloading or unpackaging and ends up in wastewater or is disposed of by other means.

- Process residue that remains in process vessels and transfer pipelines and also ends up in wastewater or is disposed of by other means.

- Liquid loss that enters wastewater streams during normal applications.
- Air emission that occurs if the agent contains volatile components.
- Reaction loss that occurs if the agent undergoes chemical reactions during its use.
- Product retention that accounts for a portion of the agent fixed onto finished products.

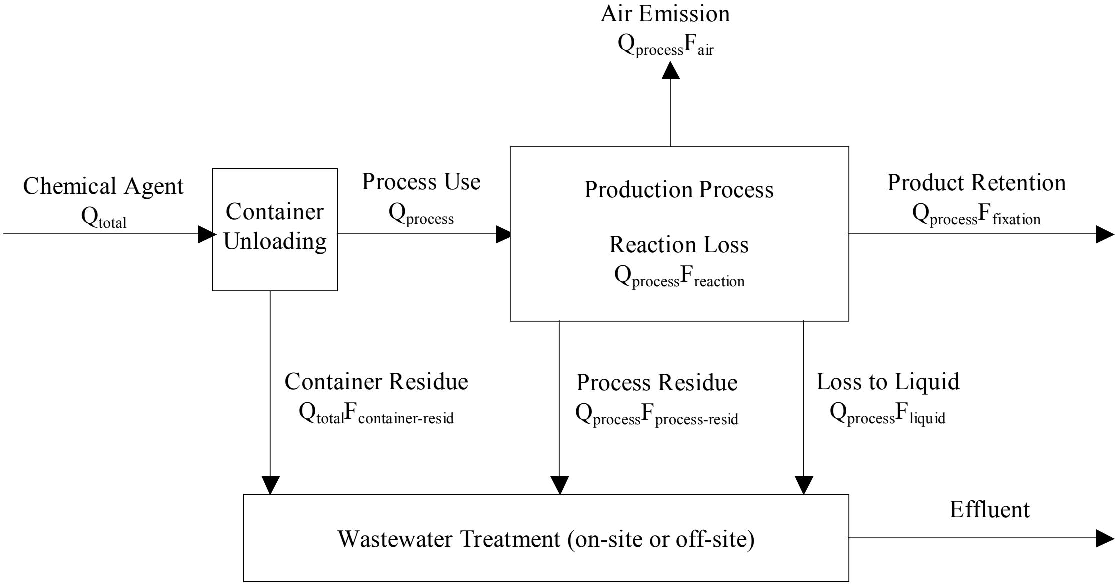

Figure 2 – Fate of a Chemical Agent Used at a Facility

5.2 – General Approach to Aqueous Emission Estimation

26. A general approach to aqueous emission estimation was recommended by the Organization for Economic Cooperation and Development in 2000 in a publication entitled "Guidance Document on Emission Scenario Documents" (OECD, 2000). The approach is based on the fixation of chemical agents onto finished products and can be described by the following equation assuming no air emission and reaction loss:

$$E_{water} = \frac{Q_{product} Q_{agent} C_{substance} (1 - F_{fixation})}{T_{operation}}$$

27. The equation includes a set of input variables on the right and one output variable on the left. The definitions and value types of these variables are provided in Table 9.

Table 9 – Input and Output Variables of Aqueous Emission Estimation Equation

Variable		Symbol	Units	Value Type
Output	Aqueous emission of a substance in chemical agent	E_{water}	kg/d	Calculated
Input	Annual production	$Q_{product}$	tonne/yr	User input without default available
	Chemical agent use rate	Q_{agent}	kg/tonne	Provided with default which can be modified by users
	Substance concentration in chemical agent	$C_{substance}$	%	
	Fixation rate (fraction of chemical agent retained by product)	$F_{fixation}$	%	
	Annual operation days	$T_{operation}$	d/yr	

Source: OECD, 2000.

5.3 – Emission Estimation Calculations

5.3.1 – Emission to Wastewater

28. The emission to wastewater from a non-integrated paper mill can be estimated according to a scheme described in Figure 2. The scheme is based on a spreadsheet formula used by the USEPA for exposure estimation. The emission consists of three portions: 1) liquid loss; 2) container residue; and 3) process residue. Liquid loss is incurred when a fraction of a chemical agent is not retained by finished products and enters wastewater, while container and process residues are common losses resulting from chemical handling and transferring. The following equation can be used for the aqueous emission estimation:

$$E_{water} = liquid\ loss + container\ residue + process\ residue$$

$$= \frac{Q_{total} C_{substance}}{T_{operation}} (1 - F_{container-resid} - F_{process-resid})(1 - F_{air} - F_{reaction} - F_{fixation}) +$$

$$\frac{Q_{total} C_{substance}}{T_{operation}} F_{container-resid} + \frac{Q_{total} C_{substance}}{T_{operation}} F_{process-resid}$$

where

E_{water}: daily aqueous emission of a substance in chemical agent, kg/d
Q_{total}: total chemical agent received by or shipped to a facility, kg/yr
$C_{substance}$: substance concentration in chemical agent, %
$F_{container-resid}$: container residue as percentage of total chemical agent received by or shipped to a facility, %
$F_{process-resid}$: process residue as percentage of total chemical agent received by or shipped to a facility, %
F_{air}: air emission as percentage of chemical agent used in production process, %
$F_{reaction}$: reaction loss as percentage of chemical agent used in production process, %
$F_{fixation}$: fixation rate, i.e., fraction of chemical agent retained by finished products, %
$T_{operation}$: annual operation days, d/yr

5.3.2 – Total Chemical Agent

29. The total amount of a chemical agent received by or shipped to a facility can be estimated from the use rate of the agent if it is not provided directly. The use rate may be expressed on mass of finished products or volume of water or wastewater, depending upon the application of the agent. As a result, one of the equations given below may be used to determine the total amount of a chemical agent.

30. For use rate based on product mass:

$$Q_{total} = \frac{Q_{product} Q_{agent}}{(1 - F_{container-resid} - F_{process-resid})}$$

For use rate based on water volume (usually water treatment chemicals):

$$Q_{total} = \frac{Q_{product} Q_{water} X_{agent} \times 10^{-3}}{(1 - F_{container-resid} - F_{process-resid})}$$

For use rate based on wastewater volume (usually wastewater treatment chemicals):

$$Q_{total} = \frac{Q_{product} Q_{wwater} X_{agent} \times 10^{-3}}{(1 - F_{container-resid} - F_{process-resid})}$$

where

Q_{total}: total chemical agent received by or shipped to a facility, kg/yr
$F_{container\text{-}resid}$: container residue as percentage of total chemical agent received by or shipped to a facility, %
$F_{process\text{-}resid}$: process residue as percentage of total chemical agent received by or shipped to a facility, %
$Q_{product}$: annual paper production, tonne/yr
Q_{agent}: chemical agent use rate based on product mass, kg/tonne
Q_{water}: water consumption rate based on product mass, m^3/tonne
Q_{wwater}: wastewater generation rate based on product mass, m^3/tonne
X_{agent}: chemical agent use rate based on volume of water or wastewater, g/m^3 or ppm.

5.3.3 – Air Emission

31. The fraction of a substance in a chemical agent emitted to the atmosphere refers to the release after a pollution control device and is defined as

$$F_{air} = \frac{E_{air}}{Q_{use}} \times 100\%$$

where

F_{air}: fraction of a substance in a chemical agent released to air, %

E_{air}: quantity of a substance in a chemical agent released to air, kg/d
Q_{use}: quantity of a substance in a chemical agent used in production process, kg/d

32. The air emission of a target substance can be estimated from a reference substance based on vapour pressure if the two substances are involved in the same operations (USEPA, 2000).

$$F_{air} = F_{air-ref} \frac{P_{air}}{P_{air-ref}}$$

where

F_{air}: fraction of a target substance released to air, %
$F_{air-ref}$: fraction of a reference substance released to air, %
P_{air}: vapour pressure of a target substance, Pa
$P_{air-ref}$: vapour pressure of a reference substance, Pa

33. A reference substance should be volatile so that its air release reaches a sufficient quantity, while at the same time, it should be found in aqueous discharge to ensure reasonable partition between water and air. To simplify calculations it is necessary to assume that the reference substance is not retained by finished products and is released to air and water only. Under these conditions, the air emission of the reference substance can be estimated by the equation.

$$F_{air-ref} = \frac{E_{air-ref}}{E_{air-ref} + E_{water-ref}}$$

where

$E_{air-ref}$: quantity of reference substance released to air, kg/d
$E_{water-ref}$: quantity of reference substance released to water, kg/d

34. Errors may occur in applying the above equation when the volatilities of the target and reference substances are influenced to different extents by operating conditions such as pH (Stellan Fischer, 2005). Care should, therefore, be taken to select a reference substance that behaves as closely as possible to the target substance with respect to water solubility, partition, stability and ionization.

5.3.4 – Reaction Loss

35. The loss due to chemical reactions is substance specific. In general, it is assumed at zero, i.e., the substance in question does not undergo chemical transformation. Many substances, however, change chemically and need to be evaluated from the data available. For example, certain active ingredients in biocides have been found to hydrolyze and biodegrade within the water recycle loops of paper mills and these reactions need to be taken into account in the estimation of emissions to wastewater (European Commission, 2003).

5.4 – Parameter Defaults

5.4.1 – Container Residue

36. Container residue results from chemical unloading and its quantity depends primarily upon the type of containers used. Listed in Table 10 are container residue defaults used by the USEPA for exposure

estimation. Semi-bulk and bulk are common container types used by the pulp and paper industry. It is recommended that a value of 3.0% instead of 4.0% be used to estimate liquid drum residue for Canadian facilities. Recent USEPA OPPT models further suggest 3% as a default for liquid drum residues and 1% for dry solids residues in transport containers.

Table 10 – Container Residue Defaults

Container Type	**Residue as % of Total Quantity Received**	
	Dry	Liquid
Bag	0.1	0.2
Keg	0.3	0.6
Drum	1.0	4.0
Semi-bulk	0.1	0.5
Bulk	0.1	0.2

Source: USEPA spreadsheet exposure estimation, 2004

5.4.2 – Process Residue

37. Process residue results from the use of process vessels and transfer pipelines. Listed in Table 11 are process residue defaults used by the USEPA for exposure estimation.

Table 11 – Process Residue Defaults

Process Hardware	**Residue as % of Total Quantity Received**	
	Dry	Liquid
General	0.1	1.0
Batch vessel	0.2	1.0
Transfer pipeline	0.1	1.0

Source: USEPA Spreadsheet Exposure Estimation, 2004

5.4.3 – Air Emission

38. The fraction of a substance in a chemical agent released to air depends upon its volatility. Its default is zero assuming the substance is a non-volatile compound. This default should be only used when releases to water, land or incineration are estimated. The value for a volatile substance may be estimated using emission factors or engineering calculations.

5.4.4 – Reaction Loss

39. The default for reaction loss is zero assuming no chemical reaction takes place as a chemical agent is used in production processes.

5.4.5 – Water Consumption Rate

40. It was estimated that Canadian non-integrated paper mills consumed 17-30 m^3 of water per tonne of production with an average of 23 m^3/tonne in 2002 (personal communications with Environment Canada, 2004).

5.4.6 – Wastewater Generation Rate

41. It was estimated that Canadian non-integrated paper mills generated 16-26 m^3 of wastewater per tonne of production with an average of 21 m^3/tonne in 2002 (personal communications with Environment Canada, 2004).

5.4.7 – Annual Paper Production

42. The annual paper production ($Q_{product}$) for Canadian non-integrated paper mills is in the range of 13,000-105,000 tonne/yr per mill with a typical figure at 83,000 tonne/yr. This figure was arrived at by totaling the rated capacity of each non-integrated paper mill (tonnes/yr) as listed in Pulp and Paper Canada (2004) and dividing by the total number of those mills to obtain the arithmetical average.

5.4.8 – Annual Operation Days

43. The default for annual operation days ($T_{operation}$) is 350 d/yr. It is based on the assumption that a two-week shutdown period is required for annual maintenance. The actual value may, however, vary from mill to mill.

5.4.9 – Use Rate, Active Substance Concentration and Fixation Rate

44. The use rate, active substance concentration, and fixation rate for chemicals used in various operations were evaluated in a previous study (Crechem Technologies, 2003). Their defaults are reviewed with some revisions in this study and presented in Tables 12-17.

45. It has been found that the aqueous releases of some chemicals are too high when estimated from the use rates given in Tables 12-17. The reason for the overestimation is due to the fact that these chemicals are only used on an intermittent basis or with variable dosages to treat intermittent problems or continuous problems of varying intensity, while the release calculations are based on continuous operations with conservative assumptions for chemical use. Coagulant polymers, felt wash agents, and chelants are examples of these chemicals.

46. With respect to chemicals that are considered to be totally water soluble in the tables below, a positive fixation rate was still indicated as a range. It is possible that although considered water soluble, a given substance may still be adsorbed onto fibre, and in the absence of specific data to the contrary, a range of 1-20% is used as the fixation rate.

Table 12 – Use Rate, Active Substance Concentration and Fixation Rate for Chemicals Used in Stock Preparation at Non-integrated Paper Mills

Chemical Agent	**Use Rate (Q_{agent}, kg/tonne)**		**Concentration ($C_{substance}$, %)**		**Fixation Rate ($F_{fixation}$, %)**	
	Default	Range	Default	Range	Default	Range
Sizes	5.0	0.5-10	50	5-100	20	10-30
Wet strength agents	5.0	2.5-20	100	no data	80	70-90
Dry strength agents	4.0	0.5-7.5	100	no data	50[2]	50[2]
Basic dyes	5.0	0.1-10	100	no data	73[1]	50-95[1]
Acid dyes	5.0	0.1-10	100	no data	65[1]	40-90[1]
Anionic direct dyes	5.0	0.1-10	100	no data	89[1]	79-98[1]
Cationic direct dyes	5.0	0.1-10	100	no data	95[1]	90-99[1]
Dye fixatives	5.0	0.1-10	100	no data	45	45-50
Fluorescent whites	5.0	0.1-10	100	no data	45	45-50
Pitch/stickies control	2.5	1-5	50	10-100	~~0~~10	~~0~~1-20
Boilouts/cleaners	no data	no data	35	20-50	~~0~~10	~~0~~1-20
Retention/drainage aids (coagulants)	5.0	1-20	100	no data	80	70-90
Retention/drainage aids (flocculants)	0.5	0.02-1	100	20-100	80	70-90
Charge control	2.5	1-20	100	no data	80	70-90
Fillers	210	210-210	100	no data	95	95
Chelants	0.12	0.08-0.16	100	no data	10	1-20
Microbiological control	no data	no data	25	10-40	10	1-20
Emulsifiers	1.0	0.5-2	100	no data	10	1-20
Foam control	0.25	0.13-0.5	50	10-100	10	1-20
Scale control	no data	no data	100	no data	10	1-20

Sources: Crechem Technologies Inc., 2003

[1] Data provided by European Commission (1996, p.700)

[2] Estimates

Table 13 – Use Rate, Active Substance Concentration and Fixation Rate for Chemicals Used in Paper Machines at Non-integrated Paper Mills

Chemical Agent	Use Rate (Q_{agent}, kg/tonne)		Concentration ($C_{substance}$, %)		Fixation Rate ($F_{fixation}$, %)	
	Default	Range	Default	Range	Default	Range
Pitch/stickies control (liquid)	1.0	0.25-2.5	50	10-100	10	1-20
Pitch/stickies control (talc)	5.0	1.3-13	100	10-100	25	25-50
Boilouts	no data	no data	35	20-50	10	1-20
Corrosion inhibitors	0.5	0.5-5	100	no data	10	1-20
Antiskid agents	0.6	0.38-0.75	100	no data	50[4]	50[4]
Cleaners	no data	no data	100	no data	10	1-20
Felt cleaning	1.0[1]	1.0[1]	25	25-100	10	1-20
Microbiological control	no data	no data	25	10-40	10	1-20
Saveal polymers (coagulants)	4.0	0.79-15.8[2]	35	no data	10	1-20
Saveall polymers (flocculants)	1.0	0.016-0.79	100	20-100	10	1-20
Foam control	1.0	0.25-2	50	10-80	10	1-20
Surface size	5.0	0.5-10	100	no data	10	1-20
Retention aids (coagulants)	1.0	0.25-1	100	20-100	80	70-90
Retention/drainage aids (micro-particles)	0.3[3]	0.099-0.396[3]	80[3]	70-90[3]	10	1-20
Formation aids	2	2-3	100	no data	50[4]	50[4]

Source: Crechem Technologies Inc., 2003

[1] The use rate for felt cleaning rarely exceeds 1 kg/tonne for continuous applications.

[2] The estimate for the high end of the range for saveall polymers (coagulants) is higher than the industry norm by a factor of 10 and a reasonable rate can be assumed at 4.0 kg/tonne.

[3] The use level and concentration of retention/drainage aids (micro-particles) for non-integrated paper mills are assumed to be the same as those for recovered paper mills.

[4] Estimates

Table 14 – Use Rate, Active Substance Concentration and Fixation Rate for Chemicals Used in Coating at Non-integrated Paper Mills

Chemical Agent	Use Rate (Q_{agent}, kg/tonne)		Concentration ($C_{substance}$, %)		Fixation Rate ($F_{fixation}$, %)	
	Default	Range	Default	Range	Default	Range
Latex	20	20-20	100	no data	50[1]	50[1]
Fillers	210	210-210	100	no data	95	95
Microbiological control	no data	no data	25	10-40	10	1-20
Starch/size	5.0	0.5-10	30	10-50	20	10-30
foam control	0.5	0.13-0.5	50	10-100	10	1-20
Boilouts	no data	no data	35	20-50	10	1-20

Source: Crechem Technologies Inc., 2003

[1] Estimates

Table 15 – Use Rate, Active Substance Concentration and Fixation Rate for Chemicals Used in Recovery and Power Boilers at Non-integrated Paper Mills

Chemical Agent	Use Rate (Q_{agent}, kg/tonne)		Concentration ($C_{substance}$, %)		Fixation Rate ($F_{fixation}$, %)	
	Default	Range	Default	Range	Default	Range
Air pollution control	0.0027	0.0014-0.0027	100	no data	5	1-10
Condensate treatment	0.0062	0.0031-0.0062	100	no data	5	1-10
Boiler water treatment	0.015	0.0077-0.015	100	no data	5	1-10
Scale control	0.038	0.0077-0.077	100	no data	5	1-10
Corrosion inhibitors	0.0077	0.0015-0.0077	100	no data	5	1-10

Source: Crechem Technologies Inc., 2003

Table 16 – Use Rate and Active Substance Concentration for Chemicals Used in Water Treatment at Non-integrated Paper Mills

Chemical Agent	Use Rate (X_{agent}, ppm)		Concentration ($C_{substance}$, %)	
	Default	Range	Default	Range
Corrosion inhibitors	5.0	0.1-5	100	no data
Microbiological control	no data	no data	25	10-40
Scale control	5.0	5-50	100	no data
Settling aids (coagulants)	5.0	5-100	100	no data
Settling aids (flocculants)	2.5	0.1-5	100	20-100

Source: Crechem Technologies Inc., 2003

Table 17 – Use Rate and Active Substance Concentration for Chemicals Used in Wastewater Treatment at Non-integrated Paper Mills

Chemical Agent	Use Rate (X_{agent}, ppm)		Concentration ($C_{substance}$, %)	
	Default	Range	Default	Range
Settling aids (coagulants)	50	5-100	35	no data
Settling aids (flocculants)	2.5	0.1-5	100	20-100
Foam control	25	2-25	50	10-100
Nutrients	5	1-5	100	no data
Sludge conditioners (flocculants)	5	0.1-10	100	no data
Odour control	15	5-150	100	no data
Colour control (coagulants)	100	200	100	no data

Source: Crechem Technologies Inc., 2003

6 – EMISSION ESTIMATION EXAMPLE

6.1 – Scenario Description

47. An acid dye is supplied as a solution for use in paper dyeing at a non-integrated paper mill. The concentration of the dye is 70 wt% with the balance being water, organic solvents, and salts. The pure form of the dye is a solid substance under normal conditions that is highly soluble in water and has a very low

vapour pressure at ambient temperature. The dry substance has a density of about 1.5 kg/m^3 and its 70 wt% solution is about 1.2 kg/m^3.

48. The dye solution is used to produce a coloured paper product. It is shipped to the mill in 1,000 L totes and the total annual shipment is 16,000 kg. The solution is then transferred to mixing chests where it is incorporated into a pulp slurry. The slurry is subsequently fed to a paper machine and converted into a continuous sheet of paper upon dewatering and drying. The water collected from the paper machine, known as white water, is reused in the papermaking process after being clarified. Any excess water from the clarification operation is discharged to an on-site wastewater treatment facility before being released to a receiving river.

49. The mill operates 350 days per year, but the dye solution is only used for 40 consecutive days. The production of the coloured paper product is 15,000 tonnes on an annual basis and the use rate of the dye solution is in the range of 1-1.5 kg/tonne. The overall exhaustion of the dye substance to the paper product is 90% and the remaining 10% is released to the on-site wastewater treatment facility.

50. Estimate the quantity of the acid dye substance released daily, during the period when it is used, to the on-site wastewater treatment plant.

6.2 – Solution

51. The calculation for this example will be limited to the estimation of the aqueous release of the acid dye substance to the on-site wastewater treatment plant to illustrate the use of the emission estimation methods described. The daily release to be determined will pertain to the 40 day period when the dye solution is used and the release of the dye substance outside of this period can be assumed to be zero.

6.2.1 – Known Parameters

52. The known parameters given in the example are:

- Total dye solution supplied annually Q_{total} = 16,000 kg/yr
- Annual operation days relating to use of dye solution $T_{operation}$ = 40 d/yr
- Dye solution use rate Q_{agent} = 1-1.5 kg/tonne
- Dye substance concentration in dye solution $C_{substance}$ = 70 wt%
- Exhaustion rate or fixation rate of dye substance $F_{fixation}$ = 90%

53. The parameters that can be readily estimated are as follows:

- It is assumed that the dye substance does not undergo chemical changes during the papermaking process, as far as the unfixed fraction is concerned. The loss due to chemical reactions, therefore, equals $F_{reaction} = 0$.

- No site-specific data is available for container residue. Considering the dye solution is a liquid and is shipped in 1,000 L totes (semi-bulk), on-site cleaning is assumed and the default for the fractional loss is $F_{container\text{-}resid}$ = 0.5%, as recommended by USEPA (2004).

- Concerning process residue, only transfer pipelines are anticipated to convey continuously the dye solution from totes at the colour kitchen to the paper machine mixing chests and regular cleaning is not expected for this type of operation~~s~~ except at the end of the 40 day use period. As a result, process residue can be reasonably assumed to be negligible, i.e., $F_{process\text{-}resid} = 0$.

- Since the substance has a very low vapour pressure, the fraction released to air is negligible, i.e., $F_{air} = 0$.

6.2.2 – Use Rate

54. The use rate of the dye solution is defined as a ratio of the dye solution added to the mixing chests to the paper production. The dye solution added equals the total supplied to the mill minus container and process residues. The use rate is, therefore, determined as

$$Use\ rate\ of\ dye\ solution = \frac{Q_{total}(1 - F_{container-resid} - F_{process-resid})}{Q_{product}}$$

$$= \frac{16{,}000\ kg/yr \times (1 - 0.5\% - 0\%)}{15{,}000\ tonne/yr}$$

= 1.06 kg/tonne

Use rate of dye solution = 1.06 kg/tonne

55. The use rate agrees with the range (1-1.5 kg/tonne) given for the papermaking process.

6.2.3 – Container Residue

56. The daily loss of the dye substance from container residue to wastewater prior to on-site wastewater treatment is estimated as

$$Container\ residue = \frac{Q_{total} C_{substance}}{T_{operation}} F_{container-resid}$$

$$= \frac{16{,}000\ kg/yr \times 70\%}{40\ d/yr} \times 0.5\%$$

= 1.40 kg/d

Container residue = 1.40 kg/d

6.2.4 – Process Residue

57. The daily loss of the dye substance from process residue to wastewater prior to on-site wastewater treatment is estimated as

$$Process\ residue = \frac{Q_{total} C_{substance}}{T_{operation}} F_{process-resid}$$

$$= \frac{16{,}000\ kg/yr \times 70\%}{40\ d/yr} \times 0\%$$

= 0 kg/d

Process residue = 0 kg/d

6.2.5 – Liquid Loss

58. The liquid loss refers to the loss from the excess water removed from the white water recycle loop prior to on-site wastewater treatment and is estimated as

$$Liquid\ loss = \frac{Q_{total} C_{substance}}{T_{operation}} (1 - F_{container-resid} - F_{process-resid})(1 - F_{air} - F_{reaction} - F_{fixation})$$

$$= \frac{16{,}000\ kg/yr \times 70\%}{40\ d/yr} (1 - 0.5\% - 0\%)(1 - 0\% - 0\% - 90\%)$$

$$= \frac{16{,}000\ kg/yr \times 70\%}{40\ d/yr} \times 99.5\% \times 10\%$$

= 27.84 kg/d

Liquid loss = 27.84 kg/d

6.2.6 – Total Release

59. The total release of the dye substance to wastewater prior to on-site wastewater treatment is the sum of the aqueous releases from container residue, process residue and liquid loss.

Total release to wastewater = Container residue + Process residue + Liquid loss

= 1.40 kg/d + 0 kg/d + 27.84 kg/d

= 29.24 kg/d

Total loss to wastewater = 29.24 kg/d

7 – DATA GAPS AND UNCERTAINTIES

60. Chemical use rate is considered the major area for data gaps and uncertainties. Although a range is provided for each class of chemicals, it is approximate and has not been reviewed by industry. Such a range needs to be confirmed or refined by industry (users and/or suppliers) in order to reflect typical mill operations.

61. The concentration of a substance in a chemical is generally lacking, but is not considered an issue. This is because in assessing the exposure of a given substance in a given scenario, the concentration is provided by the company that is involved with the use of the substance.

62. Data on air emissions originating from each class of chemicals is not readily available. The data depends upon not only the volatility of the ingredients in the chemicals, but also the operating conditions under which the chemicals are applied. Emission factors may be established to provide a realistic approach to the estimation of air emissions.

63. Reaction loss is important to the determination of environmental releases, but little information is available. Hydrolysis, neutralization and ionization are expected to be common to many chemicals such as biocides and the change in their chemical forms needs to be quantified.

64. It is expected that broke recycle and white water recycle have significant impact on water releases. No site-specific data is available to substantiate the impact yet, but data in this nature should be sought to confirm that the releases are determined not only by chemical use rate, but also by operating conditions, i.e., recycle rates for broke, or white water, or both.

GLOSSARY

Broke – Fibre from both the wet end or dry end (as paper) which is recycled internally as part of the furnish to the paper machine after reprocessing.

Couch pit – Part of the broke system, a pulper to handle broke after the wire and presses of a paper machine.

Stuff box – A constant head tank to ensure a uniform dispersion of stock to a paper machine headbox.

Use Rate – An amount of a chemical agent used in pulp making operations per unit pulp production, usually expressed as kg/tonne of pulp.

Active Substance Concentration – Concentration of an active ingredient, usually a substance of concern, in a chemical agent, usually expressed as wt%.

Fixation Rate – Fraction of an active ingredient in a chemical agent, or a chemical agent, retained by pulp product, usually expressed as wt%.

Boil-out – Recirculation at high temperature over a period of time, usually several hours, of a caustic or acid based dispersant/surfactant solution in a specific part of a pulp or paper mill in order to dissolve or dislodge accumulations or deposits of fibre, fillers, pitch, scale, microbiological slime, or combinations thereof, which are causing throughput or quality problems in the finished product. Chelant boilouts can be performed if the deposition is mainly inorganic scale.

Digester Boil-out – Usually, a recirculation of dispersants and sequestrants to help remove calcium carbonate scale in a specific section of a digester, particularly in the upper cooking zone heat exchanger section of Kamyr digesters.

ABBREVIATIONS

CIFQ – Conseil Industriel Forestier du Québec

ESD – Emission scenario document

HAP – Hazardous air pollutants

NCPI – National Council of the Paper Industry

USEPA – United States Environmental Protection Agency

OPPT – USEPA's Office of Pollution Prevention and Toxics

VOC – Volatile organic compounds

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