EUROPEAN COMMISSION

Integrated Pollution Prevention and Control (IPPC)

Reference Document on Best Available Techniques in the Pulp and Paper Industry

December 2001

Executive Summary

EXECUTIVE SUMMARY

This Reference Document on best available techniques in the pulp and paper industry reflects the information exchange carried out according to Article 16(2) of Council Directive 96/61/EC. The document has to be seen in the light of the preface, which describes the objectives of the document and its use.

Paper is essentially a sheet of fibres with a number of added chemicals that affect the properties and quality of the sheet. Besides fibres and chemicals, manufacturing of pulp and paper requires a large amount of process water and energy in the form of steam and electric power. Consequently, the main environmental issues associated with pulp and paper production are emissions to water**,** emissions to air, and energy consumption. Waste is expected to become a gradually increasing environmental issue of concern.

Pulp for papermaking may be produced from virgin fibre by chemical or mechanical means or may be produced by the re-pulping of recovered paper. A paper mill may simply reconstitute pulp made elsewhere or may be integrated with the pulping operations on the same site.

This document covers the relevant environmental aspects of pulp and papermaking from various fibrous materials in integrated and non-integrated pulp and paper mills. Non-integrated pulp mills (market pulp) are only manufacturing pulp that is then sold on the open market. Non-integrated paper mills are using purchased pulp for their paper production. In integrated pulp and paper mills the activities of pulp and papermaking are undertaken on the same site. Kraft pulp mills are operating in both non-integrated and integrated manner whereas sulphite pulp mills are normally integrated with paper production. Mechanical pulping and recycled fibre processing is usually an integrated part of papermaking but has become a stand-alone activity in a few single cases.

Neither environmentally relevant upstream processes like forestry management, production of process chemicals off-site and transport of raw materials to the mill nor downstream activities like paper converting or printing are included in this document. Environmental aspects which do not specifically relate to pulp and paper production such as storage and handling of chemicals, occupational safety and hazard risk, heat and power plants, cooling and vacuum systems and raw water treatment are not or only briefly treated.

This BREF consists of an introductory section (general information, Chapter 1) and five major parts:

- the kraft pulping process (Chapter 2),
- the sulphite pulping process (Chapter 3),
- mechanical pulping and chemi-mechanical pulping (Chapter 4),
- recycled fibre processing (Chapter 5), and
- papermaking and related processes (Chapter 6).

Each of these chapters has five main sections according to the general outline of IPPC BAT Reference Documents. For most readers it will not be necessary to read the whole document but only those chapters or sections that are of interest for the mill in question. For example, market kraft pulp mills are only concerned by Chapter 2; integrated kraft pulp and paper mills are concerned by Chapter 2 and 6, relevant information on integrated recycled paper processing mills can be found in Chapter 5 and 6.

At the end of the document there is a list of references and a glossary of terms and abbreviations that facilitates understanding.

The general information (Chapter 1) include statistical data about paper consumption in Europe, the geographical distribution for pulp and paper production across Europe, some economic aspects, a rough overview about pulp and paper production and major environmental issues, and a classification of pulp and paper mills in Europe. The chapter on general information closes with some general remarks on the determination of BAT for the sector that is characterised by a high diversity of products and (combinations of) processes involved and a high degree of process-integrated technical solutions.

For each of the major 5 chapters information on the following aspects are presented: applied processes and techniques; major environmental concerns such as resource and energy demand, emissions and waste; description of relevant techniques for emission abatement, waste minimisation and energy savings; identification of best available techniques; and emerging techniques.

As for the reported emission and consumption figures, it should be borne in mind that, due to the use of some different measurement methods in the various Member States, data are not always strictly comparable from country to country. (See Annex III for more information on this issue but the different methods used do not alter the conclusions drawn in this document).

The discussion of the techniques to consider in determination of BAT all follow the same structure and cover a short description of the technique, main achieved environmental performance, applicability, cross-media-effects, operational experiences, economics, driving forces for implementing this technique, example plants and reference literature. The section on Best Available Techniques includes ranges of emission and consumption levels that are associated with the use of BAT. The conclusions on BAT are based on experiences from real world examples and the expert judgement of the TWG.

Pulp and papermaking is a complex area that consists of quite many process stages and different products. However, the wide range of raw materials used, processes involved in pulp and papermaking can be broken down into a number of unit operations for the sake of discussion. In this document, environmental concerns and relevant techniques for prevention and reduction of emissions/waste and reducing consumption of energy and raw materials are described separately for five major classes (Chapter 2 to 6). Where appropriate and considered as necessary, these main classes are further sub-divided in sub-classes.

The document reflects at sector level the variety in terms of raw materials, energy sources, products and processes in the European paper industry. However, in specific cases within each main product category there is a certain range of raw materials and product specification that differ from production of standard qualities and may have an impact on operational conditions and the potential for improvement. This is especially true for special paper mills producing a high number of different qualities in sequential manner on their machines or for paper mills producing „special qualities“ of paper.

The exchange of information has allowed conclusions on BAT. The sections in each of the Chapters that describe BAT should be referred to for a complete understanding of BAT and the associated emissions. The key findings are summarized below.

General BAT for all processes

During the information exchange it emerged that the most effective measure for the reduction of emissions/consumption and the improvement of economic performance is the implementation of the best available process and abatement technologies in combination with the following: -

- Training, education and motivation of staff and operators;
- Process control optimisation;

- Sufficient maintenance of the technical units and the associated abatement techniques;
- Environmental management system which optimises management, increases awareness and includes goals and measures, process and job instructions etc.

BAT for Kraft pulp processing (Chapter 2)

The sulphate or kraft process is the dominating pulping process worldwide due to the superior pulp strength properties and its application to all wood species. In kraft pulping the wastewater effluents**,** the emissions to air including malodorous gases and the energy consumption are the centres of interest. In some countries also waste is expected to become an environmental issue of concern. The main raw materials are renewable resources (wood and water) and chemicals for cooking and bleaching. Emissions to water are dominated by organic substances. Effluent from bleach plant, where chlorine-containing bleaching chemicals are used, contains organically bound chlorine compounds, measured as AOX. Some compounds discharged from mills show toxic effects on aquatic organisms. Emissions of coloured substances may effect the living species in the recipient negatively. Emissions of nutrients (nitrogen and phosphorus) can contribute to eutrophication in the recipient. Metals extracted from the wood are discharged in low concentrations but due to high flows the load can be of significance. A significant reduction of both chlorinated and non-chlorinated organic substances in the effluent of pulp mills have been achieved to a large extent by in-process measures.

Best available techniques for kraft pulp mills are considered to be

- Dry debarking of wood;
- Increased delignification before the bleach plant by extended or modified cooking and additional oxygen stages;
- Highly efficient brown stock washing and closed cycle brown stock screening;
- Elemental chlorine free (ECF) bleaching with low AOX or Totally chlorine free (TCF) bleaching;
- Recycling of some, mainly alkaline process water from the bleach plant;
- Effective spill monitoring, containment and recovery system;
- Stripping and reuse of the condensates from the evaporation plant;
- Sufficient capacity of the black liquor evaporation plant and the recovery boiler to cope with the additional liquor and dry solids load;
- Collection and reuse of clean cooling waters;
- Provision of sufficiently large buffer tanks for storage of spilled cooking and recovery liquors and dirty condensates to prevent sudden peaks of loading and occasional upsets in the external effluent treatment plant;
- In addition to process-integrated measures, primary treatment and biological treatment is considered BAT for kraft pulp mills.

For bleached and unbleached kraft pulp mills the BAT emission levels to water that are associated with the use of a suitable combination of these techniques are the following:

	Flow m^3/Adt	**COD kg/Adt**	**BOD kg/Adt**	**TSS kg/Adt**	**AOX kg/Adt**	**Total N kg/Adt**	**Total P kg/Adt**
Bleached pulp	30 - 50	8-23	0.3-1.5	0.6-1.5	< 0.25	0.1-0.25	0.01-0.03
Unbleached pulp	15 - 25	5-10	0.2-0.7	0.3-1.0	-	0.1-0.2	0.01-0.02

These emission levels refer to yearly averages. The water flow is based on the assumption that cooling water and other clean water are discharged separately. The values refer to the contribution of pulping only. In integrated mills emissions from papermaking (see Chapter 6) have to be added according to product mix manufactured.

Off-gas emissions from different sources are considered as the other relevant environmental issue. Emissions to the atmosphere originate from recovery boiler, lime kiln, bark furnace, chip storage, cooking digester, pulp washing, bleaching plant, bleaching chemical preparation, evaporation, screening, washing, white liquor preparation, and various tanks. A part of this is the diffuse emissions that escape from various points of the process. The main point sources are the recovery boiler, the lime kiln and auxiliary boilers. Emissions consist mainly of nitrogen oxides, sulphur-containing compounds such as sulphur dioxide, and malodorous reduced sulphur compounds. In addition there are emissions of particulates.

Best available techniques for reducing emissions to air are

- Collection and incineration of concentrated malodorous gases and control the resulting SO_2 emissions. The strong gases can be burnt in the recovery boiler, in the lime kiln or a separate, low NO_x furnace. The flue gases of the latter have a high concentration of SO_2 that is recovered in a scrubber.
- Diluted malodorous gases from various sources are also collected and incinerated and the resulting SO_2 controlled.
- TRS emissions of the recovery boiler are mitigated by efficient combustion control and CO measurement;
- TRS emissions of the lime kiln are mitigated by controlling the excess oxygen, by using low-S fuel, and by controlling the residual soluble sodium in the lime mud fed to the kiln.
- The SO_2 emissions from the recovery boilers are controlled by firing high dry solids concentration black liquor in the recovery boiler and/or by using a flue gas scrubber;
- BAT is further the control of NO_x emissions from the recovery boiler (i.e. ensuring proper mixing and division of air in the boiler), lime kiln and from auxiliary boilers by controlling the firing conditions, and for new or altered installations also by appropriate design;
- SO_2 emissions from auxiliary boilers are reduced by using bark, gas, low sulphur oil and coal or controlling S emissions with a scrubber.
- Flue gases from recovery boilers, auxiliary boilers (in which other biofuels and/or fossil fuels are incinerated) and lime kiln are cleaned with efficient electrostatic precipitators to mitigate dust emissions.

For bleached and unbleached kraft pulp mills the BAT emission levels to air from the process that are associated with a combination of these techniques are shown in the following table. The emission levels refer to yearly averages and standard conditions. Emissions from auxiliary boilers e.g. due to production of steam used for drying of pulp and/or paper are not included. For emission levels from auxiliary boilers it is referred to the section BAT for auxiliary boilers further below.

	Dust kg/Adt	**SO_2 (as S) kg/Adt**	**NOx (NO+NO_2 as NO_2) in kg/Adt**	**TRS (as S) kg/Adt**
Bleached and unbleached kraft pulp	0.2-0.5	0.2-0.4	1.0-1.5	0.1-0.2

The values refer to the contribution of the pulp production only. That means that in integrated mills the figures for the process emissions are related to the kraft pulp production only and do not include air emissions from steam boilers or power plants that might be operated to provide the energy needed for paper production.

Best available techniques for reducing waste is to minimise the generation of solid waste and recover, recycle and re-use these materials, wherever practicable. Separate collection and intermediate storage of waste fractions at source can be beneficial to meet this aim. When the collected waste is not re-usable in the process external utilisation of residuals/waste as substitutes or incineration of organic materials in suitably designed boilers with energy recovery is considered as BAT.

In order to reduce the consumption of fresh steam and electric power, and to increase the generation of steam and power internally, a number of measures are available. In energy efficient non-integrated pulp mills the heat generated from black liquor and incineration of bark exceeds the energy required for the entire production process. However, fuel oil will be needed at certain occasions like start-up and also at many mills in the lime kiln.

Energy efficient kraft pulp and paper mills consume heat and power as follows:

- Non-integrated bleached kraft pulp mills: 10-14 GJ/Adt process heat and 0.6-0.8 MWh/Adt of power;
- Integrated bleached kraft pulp and paper mills (e.g. uncoated fine paper): 14-20 GJ/Adt process heat and 1.2-1.5 MWh/Adt ofpower;
- Integrated unbleached kraft pulp and paper mills (e.g. kraftliner): 14-17.5 GJ/Adt process heat and 1-1.3 MWh/Adt power.

BAT for Sulphite pulp processing (Chapter 3)

The production of sulphite pulp is much smaller than the production of kraft pulp. The pulping process can be carried out with different cooking chemicals. The document focuses on magnesium sulphite pulping because of its importance in terms of capacity and numbers of mills running in Europe.

In many respects the kraft and sulphite processes have similarities not least regarding the possibilities of applying different internal and external measures to reduce emissions to environment. The major differences between the two chemical pulping processes from an environmental point-of-view are to be found in the chemistry of the cooking process, the chemical preparation and recovery system and the reduced bleaching required because of better initial brightness of sulphite pulp.

As in kraft pulping also in sulphite pulping the wastewater effluents and the emissions to air are the centres of interest. The main raw materials are renewable resources (wood and water) and chemicals for cooking and bleaching. Emissions to water are dominated by organic substances. Some compounds discharged from mills show toxic effects on aquatic organisms. Emissions of coloured substances may effect the living species in the recipient negatively. Emissions of nutrients (nitrogen and phosphorus) can contribute to eutrophication in the recipient. Metals extracted from the wood are discharged in low concentrations but due to high flows the load can be of significance. For bleaching of sulphite pulp the use of chlorine containing bleaching chemicals is normally avoided, i.e. TCF-bleaching is applied. Therefore, the effluents from the bleach plant do not contain relevant amounts of organically bound chlorine compounds.

Information on techniques to consider in the determination of BAT is generally much weaker for sulphite mills than for kraft pulp mills. Therefore, from the limited information supplied by the members of the TWG in the course of the information exchange on BAT only a few techniques could be described to the same extent as for kraft pulping. The available data set is relatively small. This could be partly compensated because of the inherent similarities between sulphite and kraft pulping. A number of techniques for pollution prevention and control for kraft pulping are also valid in most respects for sulphite pulping. Where there are particular differences between kraft and sulphite technologies attempts have been made to collect the necessary information. However, only information from Austria, Germany and Sweden could be used for the description of the techniques and the conclusion on BAT. A significant reduction of emissions to water has been achieved by in-process measures.

Best available techniques for sulphite pulp mills are considered to be:

- Dry debarking of wood;
- Increased delignification before the bleach plant by extended or modified cooking;
- Highly efficient brown stock washing and closed cycle brown stock screening;
- Effective spill monitoring containment and recovery system;
- Closure of the bleach plant when sodium based cooking processes is being used;
- TCF bleaching;
- Neutralising of weak liquor before evaporation followed by re-use of most condensate in the process or anaerobic treatment;
- For prevention of unnecessary loading and occasionally upsets in the external effluent treatment due to process cooking and recovery liquors and dirty condensates sufficiently large buffer tanks for storage are considered as necessary;
- In addition to process-integrated measures, primary and biological treatment is considered BAT for sulphite pulp mills.

For bleached sulphite pulp mills the BAT emission levels to water that are associated with the use of a suitable combination of these techniques are the following:

	Flow m^3**/Adt**	**COD kg/Adt**	**BOD kg/Adt**	**TSS kg/Adt**	**AOX kg/Adt**	**Total N kg/Adt**	**Total P kg/Adt**
Bleached pulp	40 - 55	20-30	1-2	1.0-2.0	-	0.15-0.5	0.02-0.05

These emission levels refer to yearly averages. The waste water flow is based on the assumption that cooling water and other clean water are discharged separately. The values refer to the contribution of pulping only. In integrated mills emissions from papermaking (see Chapter 6) have to be added according to product mix manufactured.

Off-gas emissions from different sources are considered as the other relevant environmental issue. Emissions to the atmosphere originate from different sources the most relevant being the recovery boiler and the bark furnace. Less concentrated SO_2 containing releases originate from washing and screening operations and from vents of the evaporators and from various tanks. A part of these emissions escapes diffuse from various points of the process. Emissions consist mainly of sulphur dioxide, nitrogen oxides and dust.

Best available techniques for reducing emissions to air are:

- Collection of concentrated SO_2 releases and recovery in tanks with different pressure levels;
- Collection of diffuse SO_2 releases from various sources and introducing them in the recovery boiler as combustion air;
- Control of SO_2 emissions from the recovery boiler(s) by use of electrostatic precipitators and multi-stage flue gas scrubbers and collection and scrubbing of various vents;
- Reduction of SO_2 emissions from auxiliary boilers by using bark, gas, low sulphur oil and coal or controlling S emissions;
- Reduction of odorous gases by efficient collection systems;
- Reduction of NO_x emissions from the recovery boiler and from auxiliary boilers by controlling the firing conditions;
- Cleaning of the auxiliary boilers flue gases with efficient electrostatic precipitators to mitigate dust emissions;
- Emission optimised incineration of residues with energy recovery.

The BAT emission levels from the process associated with a combination of these techniques are depicted in the following table. Emissions from auxiliary boilers e.g. due to production of steam used for drying of pulp and/or paper are not included. For these installations emission levels that are associated with BAT are presented in the section BAT for auxiliary boilers further below.

	Dust kg/Adt	SO_2 (as S) kg/Adt	NOx (as NO_2) kg/Adt
Bleached pulp	0.02 - 0.15	0.5 - 1.0	1.0 – 2.0

These emission levels refer to yearly averages and standard conditions. The values refer to the contribution of the pulp production only. That means that in integrated mills the figures for the process emissions are related to the pulp production only and do not include air emissions from auxiliary boilers or power plants that might be operated to provide the energy needed for paper production.

Best available techniques for reducing waste is to minimise the generation of solid waste and recover, recycle and re-use these materials, wherever practicable. Separate collection and intermediate storage of waste fractions at source can be beneficial to meet this aim. When the collected waste is not re-usable in the process, external utilisation of residuals/waste as substitutes or incineration of organic materials in suitably designed boilers with energy recovery is considered as BAT.

In order to reduce the consumption of fresh steam and electric power, and to increase the generation of steam and power internally, a number of measures are available. Sulphite pulp mills are heat and power self-sufficient by using the heat value of the thick liquor, bark and wood waste. In integrated mills there is a need for additional steam and electricity that is generated in on- or off-site power plants. Integrated sulphite pulp and paper mills consume 18 - 24 GJ/Adt process heat and 1.2 - 1.5 MWh/Adt electricity.

BAT for Mechanical pulping and chemi-mechanical pulping (Chapter 4)

In mechanical pulping the wood fibres are separated from each other by mechanical energy applied to the wood matrix. The objective is to maintain the main part of the lignin in order to achieve high yield with acceptable strength properties and brightness. There are two main processes to be distinguished:

- The groundwood process where logs are pressed against a rotating grinder stone with simultaneous action of water and:
- refiner mechanical pulp that is produced by defiberizing wood chips between disc refiners.

The characteristics of the pulp can be affected by increasing the process temperature and, in the case of refining, by the chemical pre-treatment of the wood chips. The pulping process in which the wood is pre-softened with chemicals and refined under pressure is called chemo-thermo-mechanical pulping and is also covered by this document.

Most mechanical pulping is integrated with paper manufacture. Therefore, the emission levels associated with the use of BAT are given for integrated pulp and paper mills (except for CTMP).

In mechanical pulping and chemi-mechanical pulping the wastewater effluents and consumption of electricity for the drives of grinders or refiners are the centres of interest. The main raw materials are renewable resources (wood and water) and some chemicals for bleaching (for CTMP also for chemical pre-treatment of the chips). As processing aids and to improve the product properties (paper auxiliaries) various additives are applied during paper manufacturing. Emissions to water are dominated organic substances that are lost in the water phase in the form of dissolved or dispersed substances. If mechanical pulp is bleached in one or two alkaline peroxide steps the releases of organic pollutants increase significantly. Peroxide bleaching result in additional COD-loads before treatment of about 30 kg O_2/Adt. Some compounds discharged from mills show toxic effects on aquatic organisms. Emissions of nutrients (nitrogen and phosphorus) can contribute to eutrophication in the recipient. Metals extracted from the wood are discharged in low concentrations but due to high flows the load can be of significance.

A big part of techniques to consider in the determination of BAT refer to the reduction of emissions to water. In mechanical pulping processes the water systems are usually quite close. Surplus clarified waters from the paper machine are usually used to compensate for the water leaving the circuit with the pulp and the rejects.

Best available techniques for mechanical pulp mills are considered to be:

- Dry debarking of wood
- Minimisation of reject losses by using efficient reject handling stages
- Water recirculation in the mechanical pulping department
- Effective separation of the water systems of the pulp and paper miill by use of thickeners
- Counter-current white water system from paper mill to pulp mill depending on the degree of integration
- Use of sufficiently large buffer tanks for storage of concentrated wastewater streams from the process (mainly for CTMP)
- Primary and biological treatment of the effluents, and in some cases also flocculation or chemical precipitation.

For CTMP mills a combination of an anaerobic and aerobic treatment of the wastewater is also regarded as an efficient treatment system. Finally, evaporation of the most contaminated wastewater and burning of the concentrate plus activated sludge treatment of the rest might be especially an interesting solution for upgrading mills.

The emission levels that are associated with a suitable combination of these techniques are presented separately for non-integrated CTMP mills and integrated mechanical pulp and paper mills. These emission levels refer to yearly average values.

	Flow m^3/t	**COD kg/t**	**BOD kg/t**	**TSS kg/t**	**AOX kg/t**	**Total N kg/t**	**Total P kg/t**
Non-integrated CTMP mills (contribution of pulping only)	15-20	10-20	0.5-1.0	0.5-1.0	-	0.1-0.2	0.005-0.01
Integrated mechanical pulp & paper mills (such as newsprint, LWC and SC paper mills)	12-20	2.0-5.0	0.2-0.5	0.2-0.5	< 0.01	0.04-0.1	0.004-0.01

In case of integrated CTMP mills, emissions from papermaking (see Chapter 6) have to be added according to product mix manufactured.

For integrated mechanical pulp and paper mills the emission levels refer to both pulping and papermaking and are related to kg pollutant per tonne of paper produced.

In mechanical pulping, the ranges for COD depend especially on the share of the fibre furnish that is bleached with peroxide because peroxide bleaching results in higher initial loads of organic substances before treatment. Therefore, the upper end of the emission range associated with BAT is valid for paper mills with a high proportion of peroxide bleached TMP.

Emissions to the atmosphere are mainly emissions from heat and electricity generation in auxiliary boilers and volatile organic carbons (VOC). Sources of VOC emissions are chip heaps and evacuation of air from chests from wood-chip washing and from other chests and condensates from the steam recovery from refiners that are contaminated with volatile wood components. A part of these emissions escapes diffuse from various points of the process.

Best available techniques for reducing emissions to air is efficient heat recovery from refiners and abatement of VOC emissions from contaminated steam. Apart from VOC emissions, mechanical pulping generate releases to the atmosphere that are not process-related but caused by energy generation on-site. Heat and power is produced by combustion of different types of fossil fuels or renewable wood residuals like bark. BAT for auxiliary boilers is discussed further below.

Best available techniques for reducing waste is to minimise the generation of solid waste and recover, recycle and re-use these materials, wherever practicable. Separate collection and intermediate storage of waste fractions at source can be beneficial to meet this aim. When the collected waste is not re-usable in the process external utilisation of residuals/waste as substitutes or incineration of organic materials in suitably designed boilers with energy recovery is considered as BAT, thus minimising the disposal of rejects to landfill.

In order to reduce the consumption of fresh steam and electric power a number of measures are available. Energy efficient mechanical pulp and paper mills consume heat and power as follows:

- Non-integrated CTMP: For pulp drying recovered process heat can be used i.e. no primary steam is needed. The power consumption is 2 - 3 MWh/ADt.
- Integrated newsprint mills consume 0 - 3 GJ/t process heat and 2 - 3 MWh/t of electricity. The steam demand depends on the fibre furnish and the degree of steam recovery from the refiners.
- Integrated LWC paper mills consume 3 - 12 GJ/t process heat and 1.7 - 2.6 MWh/t of electricity. It has to be noted that the fibre furnish of LWC consists usually only of about one third of PGW or TMP the rest being bleached kraft pulp and fillers and coating colours. If the production of bleached kraft pulp is carried out at the same site (integrated) the contribution of the energy demand of kraft pulping have to be added according to fibre furnish mix manufactured.
- Integrated SC paper mills consume 1 - 6 GJ/t process heat and 1.9 - 2.6 MWh/t of electricity.

BAT for Recycled fibre processing (Chapter 5)

Recovered fibre has become an indispensable raw material for the paper manufacturing industry because of the favourable price of recovered fibres in comparison with the corresponding grades of virgin pulp and because of the promotion of recovered paper recycling by many European countries. The recovered paper processing systems vary according to the paper grade to be produced e.g. packaging paper, newsprint, testliner, or tissue paper and the type of furnish used. Generally, recycled fibre (RCF) processes can be divided in two main categories:

- processes with exclusively mechanical cleaning i.e. without deinking. They comprise products like testliner, corrugating medium, board and cartonboard
- processes with mechanical and chemical unit processes i.e. with deinking. They comprise products like newsprint, tissue, printing and copy paper, magazine papers (SC/LWC), some grades of cartonboard or market DIP.

The raw materials for RCF based paper production consist mainly of recovered paper, water, chemical additives, and energy in the form of steam and power. Large quantities of water are used as process water and cooling water. As processing aids and to improve the product properties (paper auxiliaries) various additives are applied during paper manufacturing. The environmental impact of recovered paper processing comprises basically emissions to water, solid waste (especially if wash de-inking is applied as e.g. in tissue mills) and atmospheric emissions. Emissions to the atmosphere are mainly related to energy generation by combustion of fossil fuels in power plants.

Most recovered paper processing mills are integrated with paper manufacture. Therefore, the emission levels associated with the use of BAT are given for integrated mills.

A big part of techniques to consider in the determination of BAT refer to the reduction of emissions to water.

Best available techniques for recovered paper processing mills are considered to be**:**

- Separation of less contaminated water from contaminated one and recycling of process water;
- Optimal water management (water loop arangement), water clarification by sedimentation, flotation or filtration techniques and recycling of process water for different purposes;
- Strict separation of water loops and counter-currents flow of process water;
- Generation of clarified water for de-inking plants (flotation);
- Installation of an equalisation basin and primary treatment;
- Biological effluent treatment. An effective option for de-inked grades and depending on the conditions also for non-de-inked grades is aerobic biological treatment and in some cases also flocculation and chemical precipitation. Mechanical treatment with subsequent anaerobic-aerobic biological treatment is the preferable option for non-deinked grades. These mills usually have to treat more concentrated wastewater because of higher degree of water circuit closure;
- Partial recycling of treated water after biological treatment. The possible degree of water recycling is depending on the specific paper grades produced. For non-deinked paper grades this technique is BAT. However, the advantages and drawbacks need to be carefully investigated and will usually require additional polishing (tertiary treatment).
- Treating internal water circuits

For integrated recovered paper mills, the emission levels associated with the use of a suitable combination of best available techniques are the following:

	Flow m^3/t	**COD kg/t**	**BOD kg/t**	**TSS kg/t**	**Total N kg/t**	**Total P kg/t**	**AOX kg/t**
Integrated RCF paper mills without de-inking (e.g. wellen-stoff, testliner, white topliner, cartonboard etc.)	< 7	0.5-1.5	<0.05-0.15	0.05-0.15	0.02-0.05	0.002-0.005	<0.005
RCF paper mills with de-inking (e.g. newsprint, printing & writing paper etc.)	8 - 15	2-4	<0.05-0.2	0.1-0.3	0.05-0.1	0.005-0.01	<0.005
RCF based tissue mills	8-25	2.0-4.0	<0.05-0.5	0.1-0.4	0.05-0.25	0.005-0.015	<0.005

The BAT emission levels refer to yearly averages and are presented separately for processes with and without de-inking. The waste water flow is based on the assumption that cooling water and other clean water are discharged separately. The values refer to integrated mills i.e. recovered paper processing and papermaking is carried out at the same site.

Common treatment of wastewater from a RCF paper mill or a consortium of RCF paper mills in the municipal wastewater treatment plant is also considered as BAT when the common treatment system is appropriate for dealing with paper mill effluents. The removal efficiencies of the common waste water treatment system should be calculated and the comparable removal efficiencies or concentrations of releases established before considering this option as BAT.

Air emissions in RCF based paper mills are mainly related to plants installed for the production of heat and in some cases for co-generation of electricity. Saving of energy corresponds therefore with reduction of air emissions. The power plants are usually standard boilers and can be treated like any other power plants. To decrease energy consumption and air emission the following measures are considered as BAT: Co-generation of heat and power, improving existing boilers and when equipment is replaced use of less energy consuming equipment. For emission levels associated with the use of BAT it is referred to the section BAT for auxiliary boilers further below.

Best available techniques for reducing waste are to minimise the generation of solid waste and recover, recycle and re-use these materials, wherever practicable. Separate collection and intermediate storage of waste fractions at source can be beneficial to meet this aim. When the collected waste is not re-usable in the process external utilisation of residuals/waste as substitutes or incineration of organic materials in suitably designed boilers with energy recovery is considered as BAT. Reduction of solid waste can be achieved by optimising the fibre recovery by upgrading of stock preparation plants, optimisation of the amount of cleaning stages in the stock preparation, application of dissolved air flotation (DAF) as in-line treatment of water-loops to recover fibres and fillers and to clarify process water. A balance between cleanliness of stock, fibre losses and energy requirements and costs has to found and are usually depending on the paper grades. The reduction of the amount of solid waste to be landfilled is BAT. This can be achieved by efficient reject and sludge handling on-site (de-watering) to enhance dry solids content and subsequent incineration of sludge and/rejects with energy recovery. Produced ash can be used as raw material in the building materials industry. Different options for incineration of rejects and sludge are available. The applicability is limited by the size of the mill and to a certain extent by the fuel used for generation of steam and power respectively.

Energy efficient recovered paper mills consume process heat and power as follows:

- Integrated non-deinked RCF paper mills (e.g. testliner, fluting): 6 - 6.5 GJ/t process heat and 0.7 - 0.8 MWh/t of power;
- Integrated tissue mills with DIP plant: 7 - 12 GJ/t process heat and 1.2 - 1.4 MWh/t of power;
- Integrated newsprint or printing and writing paper mills with DIP plant: 4 - 6.5 GJ/t process heat and 1 - 1.5 MWh/t of power.

BAT for Papermaking and related processes (Chapter 6)

The manufacturing of fibres used for papermaking has been described in the Chapters 2 to 5. In Chapter 6 paper and board manufacturing is described independently from pulp manufacturing. This approach has been chosen because the same unit processes around the paper and board machine are required in every paper mill whether it is integrated with pulp production or not. The description of papermaking as part of integrated pulp mills would increase the complexity of the technical description. Finally, in numbers, most paper mills in Europe are non-integrated mills.
For integrated paper mills this chapter is relevant as far as the papermaking is concerned.

Paper is made from fibres, water and chemical additives. Furthermore, a lot of energy is needed to drive the whole process. Electric power is mainly consumed for the operation of various motor drives and for refining in stock preparation. Process heat is mainly used for heating of water, other liquors, and air, evaporating water in the dryer section of the paper machine, and conversion of steam into electric power (in case of co-generation). Large quantities of water are used as process water and cooling water. As processing aids and to improve the product properties (paper auxiliaries) various additives may be applied during paper manufacturing.

The environmental issues of paper mills are dominated by emissions to water and by the consumption of energy and chemicals. Solid waste is also generated. Atmospheric emissions are mainly related to energy generation by combustion of fossil fuels in power plants.

Best available techniques for reducing emissions to water are

- Minimising water usage for different paper grades by increased recycling of process waters and water management;
- Control of potential disadvantages of closing up the water systems;
- Construction of a balanced white water, (clear) filtrate and broke storage system and use of constructions, design and machinery with reduced water consumption when practicable. This is normally when machinery or components are replaced or at rebuilds;
- Application of measures to reduce frequency and effects of accidental discharge;
- Collection and reuse of clean cooling and sealing waters or separate discharge;
- Separate pre-treatment of coating wastewaters;
- Substitution of potentially harmful substances by use of less harmful alternatives;
- Effluent treatment of wastewater by installation of an equalisation basin;
- Primary treatment, secondary biological, and/or in some cases, secondary chemical precipitation or flocculation of wastewater. When only chemical treatment is applied the discharges of COD will be somewhat higher but mainly made up of easily degradable matter.

For non-integrated paper mills the emissions levels that are associated with the use of BAT are presented for uncoated and coated fine paper and tissue separately in the table below. However, the differences between the paper grades are not very distinct.

Parameters	**Units**	**Uncoated fine paper**	**Coated fine paper**	**Tissue**
BOD_5	kg/t of paper	0.15-0.25	0.15-0.25	0.15-0.4
COD	kg/t of paper	0.5-2	0.5-1.5	0.4-1.5
TSS	kg/t of paper	0.2-0.4	0.2-0.4	0.2-0.4
AOX	kg/t of paper	< 0.005	< 0.005	< 0.01
Total P	kg/t of paper	0.003-0.01	0.003-0.01	0.003-0.015
Total N	kg/t of paper	0.05-0.2	0.05-0.2	0.05-0.25
Flow	m^3/t of paper	10-15	10-15	10-25

The BAT emission levels refer to yearly averages and exclude the contribution of pulp manufacturing. Although these values refer to non-integrated mills they can also be used to approximate emissions caused by papermaking units in integrated mills. The waste water flow is based on the assumption that cooling water and other clean water are discharged separately.

Common treatment of wastewater from a paper mill or a consortium of paper mills in the municipal wastewater treatment plant is also considered as BAT when the common treatment system is appropriate for dealing with paper mill effluents. The removal efficiencies of the common wastewater treatment system should be calculated and the comparable removal efficiencies or concentrations of releases established before considering this option as BAT.

Air emissions from non-integrated paper mills are mainly related to steam boilers and power plants. These plants are generally standard boilers and do not differ from any other combustion plants. It is assumed that they are regulated like any other auxiliary boiler of the same capacity (see below).

BAT concerning solid waste is the minimisation the generation of solid waste and recovery, re-use and re-cycle of re-usable materials as far as possible. Separate collection of waste fractions at source and intermediate storage of residuals/waste can be beneficial to allow for a greater proportion to be reused or recycled rather than landfilled. Reduction of fibre and filler losses, the application of ultra-filtration for coating wastewater recovery (only for coated grades), efficient de-watering of the residues and sludge to high dry solids are further available techniques. BAT is the reduction of the amount of waste to be landfilled by identification of possibilities for recovery operations and - if feasible - utilisation of waste for material recycling or incineration with energy recovery.

In general in this sector BAT is considered to be the use of energy efficient technologies. A lot of options for energy saving in many stages within the manufacturing process are available. Usually these measures are linked with investments to replace, rebuild or upgrade process equipment. It should be noticed that energy saving measures are mostly not applied only for energy saving. Production efficiency, improvement of product quality and reduction of overall costs is the most important basis for investments. Energy savings can be achieved by implementation of a system for monitoring energy usage and performance, more effective dewatering of the paper web in the press section of the paper machine by using wide nip (shoe) pressing technologies and use of other energy efficient technologies as e.g. high consistency slushing, energy efficient refining, twin wire forming, optimised vacuum systems, speed adjustable drives for fans and pumps, high efficiency electric motors, well sized electric motors, steam condensate recovery, increasing size press solids or exhaust air heat recovery systems. A reduction of direct use of steam can be achieved by careful process integration by using pinch analysis.

Energy efficient non-integrated paper mills consume heat and power as follows:
- Non-integrated uncoated fine paper mills have a process heat demand of 7 - 7.5 GJ/t and a power demand of 0.6 - 0.7 MWh/t;
- Non-integrated coated fine paper mills have a process heat demand of 7 - 8 GJ/t and a power demand of 0.7 - 0.9 MWh/t;
- Non-integrated tissue mills based on virgin fibre have a process heat demand of 5.5 - 7.5 GJ/t and a power demand of 0.6 - 1.1 MWh/t.

BAT for auxiliary boilers

Depending on the actual energy balance of the given pulp or paper mill, the type of external fuels used and the fate of possible biofuels as bark and wood-waste there are atmospheric emissions from auxiliary boilers to consider. Pulp and paper mills manufacturing pulp from virgin fibres are normally operating bark boilers. For non-integrated paper mills and RCF paper mills air emissions are mainly related to steam boilers and/or power plants. These plants are generally standard boilers and do not differ from any other combustion plant. It is assumed that they are regulated like any other installation of the same capacity. Therefore, generally acknowledged BAT for auxiliary boilers are only briefly mentioned in this document. Those techniques are:
- application of cogeneration of heat and power if the heat/power-ratio allows it
- use of renewable sources as fuel such as wood or wood waste, if generated, to reduce the emissions of fossil CO_2
- control of NO_x emissions from auxiliary boilers by controlling the firing conditions, and installation of low-NOx burners
- reducing SO_2 emissions by using bark, gas or low sulphur fuels or controlling S emissions
- In auxiliary boilers burning solid fuels efficient ESPs (or bag filters) are used for the removal of dust.

BAT associated emission levels from auxiliary boilers in pulp and paper industry that incinerate different kind of fuels are summarized in the table below. The values refer to yearly average values and standard conditions. However, the total product specific releases to air are very site specific (e.g. type of fuel, size and type of installation, integrated or non-integrated mill, production of electricity).

Released substances	Coal	Heavy fuel oil	Gas oil	Gas	Biofuel (e.g. bark)
mg S/MJ fuel input	100 - 200 [1] (50 - 100)[5]	100 –200 [1] (50-100)[5]	25-50	<5	< 15
mg NO_x/MJ fuel input	80 - 110 [2] (50-80 SNCR)[3]	80 – 110 [2] (50–80 SNCR)[3]	45-60 [2]	30 -60 [2]	60 –100 [2] (40–70 SNCR)[3]
mg dust/Nm^3	10 - 30 [4] at 6% O_2	10 – 40 [4] at 3 % O_2	10-30 3% O_2	< 5 3% O_2	10 - 30 [4] at 6% O_2

Notes:
1) Sulphur emissions of oil or coal fired boilers depend on the availability of low-S oil and coal. Certain reduction of sulphur could be achieved with injection of calcium carbonate.
2) Only combustion technology is applied
3) Secondary measures as SNCR are also applied; normally only larger installations
4) Associated values when efficient electrostatic precipitators are used
5) When a scrubber is used; only applied to larger installations

It has to be noted that auxiliary boilers within the pulp and paper industry are of a very variable size (from 10 to above 200 MW). For the smaller only the use of low-S fuel and combustion techniques can be applied at reasonable costs while for the larger also control measures. This difference is reflected in the table above. The higher range is considered BAT for smaller installations and is achieved when only quality of fuel and internal measures are applied; the lower levels (in brackets) are associated with additional control measures like SNCR and scrubbers and are regarded as BAT for larger installations.

Use of chemicals and additives

In the pulp and paper industry a large number of chemicals are used depending on the paper grade produced, the process design and operation and the product qualities to be achieved. On the one hand process chemicals for the production of pulp are required, on the other hand chemical additives and auxiliaries are applied in paper production. Chemical additives are used to give paper various characteristics while chemical auxiliaries are used to increase efficiency and reduce disruption of the production process.
For chemical usage the availability of a database for all used chemicals and additives and the application of the principle of substitution is considered as BAT. That means that less hazardous products are used when available. Measures to avoid accidental discharges to soil and water from handling and storage of chemicals are applied.

Degree of consensus

This BREF has met support from most members of the TWG and participants at the 7th meeting of the Information Exchange Forum. However, CEPI – representing the pulp and paper industry – and a few Member States did not express their full support for this final draft and contested some of the conclusions presented in the document. Mention is made below of some of the key areas of contention and Chapter 7 provides further detail.

CEPI and one Member State took the view that the economic difference between new/existing and large/small mills had not been sufficiently considered and that clear differences should have been established in the BREF. Furthermore, CEPI and three Member States believe that a typical mill will not be able to, at the same time, reach all the presented emission and consumption levels associated with the use of a suitable combination of the various techniques that are considered as BAT. In their view, no sufficiently integrated assessment of all parameters has been carried out. Contrary to this view, however, mills have been identified who do achieve all the presented levels at the same time and this minority view above was not shared by most members of the TWG.

Apart from these general issues, there are also a few specific issues where the final conclusions did not receive unanimous support in the TWG. CEPI and two Member States consider that for TSS for bleached kraft pulping, the upper end of the range associated with the use of BAT should be 2.0 kg/Adt instead of 1.5 kg/Adt. CEPI and one Member State also consider that some of the ranges associated with the use of BAT for the various paper grades are too stringent. Conversely, there are TWG members who consider that certain concluded BAT associated levels are excessively lenient bearing in mind the more recent achievements of some pulp and paper mills.

The European Environmental Bureau – representing environmental organisations – expressed some further dissenting views, including that ECF-bleaching in kraft pulp mills does not meet the BAT criteria regarding the precautionary and the prevention principles and that, in general, tertiary treatment of effluents should include treatment with ozone, peroxide or UV radiation followed by a biofiltration step.