Technical Manual on Industrial Pollution Control

(Pulp and Paper Industry)

Based on project cases and investigation research reports of
Japan Environment Corporation (JEC)

MARCH 1998

JAPAN ENVIRONMENT CORPORATION

FOREWORD

During Japan's rapid economic growth phase from the latter half of the 1950s there was grave industrial pollution and deterioration of the citizens' living environments, but a national effort to address these problems delivered the country from this crisis situation. No doubt information on this experience and the pollution control technologies is proving highly useful now to countries that need to cope with pollution, and providing environmental information to other countries is also one of Japan's obligations as an international initiative to solve environmental problems.

Environmental conservation technologies have advanced in tandem with technological innovation in production equipment. Under tough competition, private enterprises have worked on raising productivity while at the same time endeavoring to change to production processes with lighter environmental burdens. These days companies can conserve the environment even better by adopting cleaner production.

Much of this technological innovation for production and environmental conservation has been achieved by private enterprise, but the national and local governments also play major roles in achieving pollution control by taking many actions such as establishing emission standards, formulating pollution control plans, and providing guidance and financial assistance to companies. It is safe to say that pollution control in Japan was achieved through concerted effort by government and the private sector.

Over the 30 years since its founding in 1965, the Japan Environment Corporation (JEC) has worked on controlling industrial pollution by carrying out construction and transfer projects and giving loans in its capacity as a national organization that specializes in providing financial assistance for pollution control. JEC has played an especially big role in the achievement of pollution abatement by small- and medium-sized enterprises (SMEs), which were faced with the necessity to control pollution, but found it difficult to do anything because they lacked both money and technology.

We compile the "Technical Manual on Industrial Pollution Control " series on the basis of JEC project cases and with a focus on the SME industry types that have an especially urgent need for improvement as regards pollution abatement in developing countries. This manual compiles information concerning pollution abatement technology in the pulp and paper industry while incorporating the perspective of cleaner production and noting also conditions in paper and pulp mills.

JEC commissioned the Overseas Environmental Cooperation Center, Japan (OECC) to perform the "Study on Building a Database for Transferring Environmental Technology

Abroad," and prepared the "Japan Environment Corporation Overview and Case File," which is a compilation of JEC's functions and experiences, examples from the Construction and Transfer Programme case file, and examples from the Loan Programme. This Technical Manual on Industrial Pollution Control supplements the Japan Environment Corporation Overview and Case File.

We would be pleased if Japan's experiences in pollution abatement are of use to other countries working to control pollution, and make even a slight contribution to conserving the global environment.

Japan Environment Corporation

Osamu Watanabe
President

Technical Manual on Industrial Pollution Control (Pulp and Paper Industry)

Contents

Summary Report of Technical Manual on Industrial Pollution Control
(Pulp and Paper Industry)
March 1998

1. General Background

Japan achieved rapid economic growth from the latter half of 1950s through the 1960s. Drastic expansion of industrial production simultaneously caused environmental pollution, and the concentration of population in urban areas worsened the living environment there, so it was time to tackle these problems and look for urgent countermeasures.

To cope the serious industrial pollution problem, the government began to consolidate various kinds of legal systems in the former half of the 1960s, enforcing emission regulations on pollutants and promoting the construction of pollution control facilities.

At the time, corporations regarded as pollution sources urgently needed to improve their production facilities and install new pollution control facilities. However, the investment to be made in these facilities was not only a heavy burden for the industrial field, but also technically difficult especially for the small- and medium-sized enterprises which were unable to develop and introduce pollution control techniques by themselves, since Japan at that time had relatively little experience with pollution control measures.

As form a part of the break through such difficulties, the government organized a new system for loaning the official funds for pollution control expenses, at lower interest than that charged by commercial financial corporations, with the objective of promoting industrial pollution control and furthering the development of infrastructures. Thus, for this reason, Japan Environment Corporation (abbreviated as "JEC", hereafter) was established in October 1965 using governmental funds, as a nonprofit corporation to undertake the task of pollution control, in compliance with the "Environmental Pollution Control Service Corporation Law" promulgated in June 1965.

For developing countries that are going to address their environmental problems, Japanese experience is undoubtedly helpful, though the Japanese methods have used to surmount pollution and environmental problems might not immediately apply to their similar problems. In particular, the data accumulated by JEC are doubly significant, i.e. (1) Technical information on pollution control measures enforced in business, and (2) Management and business know-how as a financial organization specialized in pollution control. As a part of its new mandate of "Providing environmental information to overseas areas", JEC has started a new program of providing information on projects carried out and project operation know-how. As a part of this project which prepares a document summarizing technical guidelines by extracting technical information about pollution control measures involved in the past financing and construction / transfer projects by industrial category, this report covers subjects concerning the Pulp and Paper Industry.

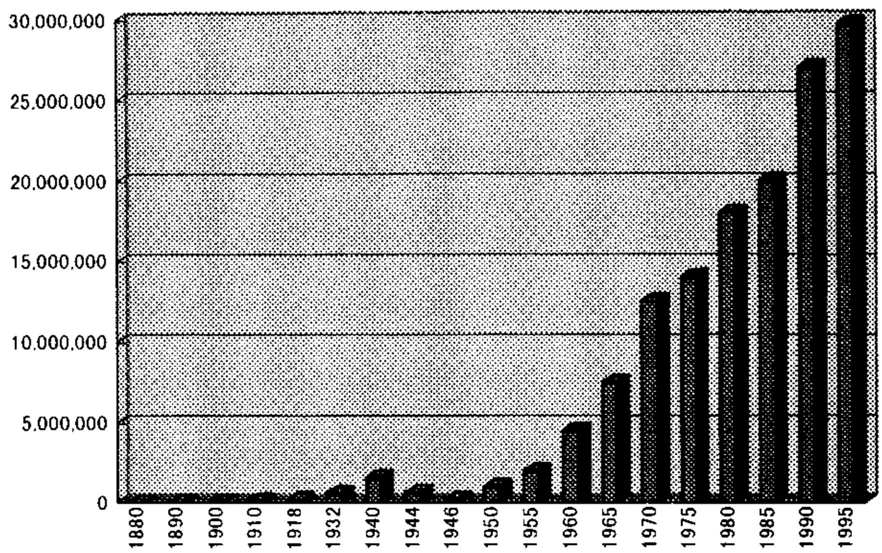
In Japan, various facilities, known as "end-of-pipe technologies" for the treatment or disposal of discharged pollutants within certain standard values were developed and improved in the pollution-ridden 1970s. Such facilities were installed as a policy of so-called "emergency evacuation" to meet standard values in the short term. Yet, these technologies also included the negative aspect of always entailing additional capital investments in production facilities as well as ordinary administrative and maintenance expenses, moreover the problems were postponed because of the migration of pollutants among media.

Compared with "end-of-pipe technologies", methods of preventing pollution by reviewing raw materials and processing technologies, improving and reforming production processes themselves, simultaneously achieves resource-saving, energy-saving and production cost reduction. One such method is known as "cleaner production", and it is proved to be highly effective. Although the superiority of such techniques was not necessarily evident from the outset, they have gradually been empirically fostered in the history of pollution control policies in Japan and other countries, and now those techniques are receiving international recognition.

Needless to say, in Japan as well, such techniques have been adopted so far in various fields. The oil crises of the 1970s forced industry to adopt comprehensive resource-saving and energy-saving policies in which production processes were reviewed, so not a few countermeasures which nowadays can be called "cleaner production" were in fact adopted. However, in spite of Japan's use of such invaluable techniques and experience, it has hardly disclosed them so far to after countries beyond the barrier of trade secrets.

2. History of Environmental Problems in the Pulp and Paper Industry

The pulp and paper industry is a water-bound industry, like the chemical and steel industries, and is liable to cause universal environmental problems, such as air pollution, water pollution, offensive odors, noises, vibration, and waste. Among these, water pollution can be said to be the most serious. This industry exists on the massive use of water, as it is said to have once consumed 500 tons of water to manufacture one ton of paper. (Today, 150 to 200 tons of water are still required.)



Source: This figure was prepared from numerical data in the "Pulp and Paper Handbook (Japan Paper Association)" and "Practical Knowledge of Pulp and Paper."

Figure 1 Historical change of paper and board product (unit: ton)

As shown in Figure 1, the Japanese pulp and paper industry has rapidly grown since the 1950s, and since that time environmental problems have become more and more serious.

Effluent discharge from the pulp and paper industry contains massive suspended solids and organic components. In 1970, about a half of the BOD component discharge into rivers that was of industrial origin is said to be caused by the pulp and paper industry in Japan.

Industrial origin (300)		Household origin
Pulp and paper industry (150)	Other industries (150)	(75)

Source: "Aquatic Environment Strategy"

Figure 2 Annual BOD discharge in 1970 (Unit: 10,000 tons)

In the 1990s, problems with pollution due to dioxin in effluent arose and thus countermeasures against dioxin were called for.

As to air pollution, problems arose with soot & dust, sulfur oxides, and nitrogen oxides due to exhaust emissions from boilers which were used to produce a large amount of steam, black liquor recovery boilers, lime kilns, waste incinerators, etc. Offensive odors due to blow gas and waste water from the manufacturing processes of the industry and hydrogen sulfide gas from effluent sludge also created serious environmental problems. Although water pollution and air pollution control measures have been taking root year by year, new problems with the treatment of ever-increasing waste are now arising from the scarcity of waste disposal sites.

3. Pulp and Paper Industrial Environment Control Measures and Cleaner Production

Manufacturing Technologies in the pulp and paper industry is largely divided into five processes: wood preparation, pulp manufacture, stock preparation, paper making, and coating/finishing. Of these processes, the pulp manufacturing process is largely subdivided into three groups by materials and treatment measures: chemical, mechanical, and waste paper pulp manufacturing processes. Inherent environmental problems arise at each phase of these processes.

(1) Water pollution control measures

The pulp manufacturing process causes the most environment problems. Chemical pulp manufacture accounts for nearly 80% of the methods at present. This method digests chips with chemicals, so its effluent contains high-level water pollutants.

On the other hand, because the conventional method of manufacturing pulp only from conifer trees had already reached its capacity, there was a growing need for some other manufacturing technology adaptable to almost all kinds of trees, such as conifer, broad-leaved trees, and tropical (South-Seas) trees to meet the rapidly increasing demand. It was Kraft pulp (a kind of chemical pulp) that met this need. Manufacturing Kraft pulp entails using cooking chemicals in large quantities. Fortunately enough, it is economical to recover chemicals by concentrating and burning black liquor as a by-product of solution of lignin from lumber into cooking liquor. This method also allows thermal energy generated from the burning process to be recovered as vapor. For this reason, the Kraft pulp manufacturing process is basically equipped with a black liquor combustion and chemical recovery process. The sharp increase in pulp and paper production achieved through the introduction of a Kraft pulp-based manufacturing method in turn reduced the impact of black liquor with the highest COD content being discharged from the pulp and paper industry, and also served as energy-saving measures. This changeover in manufacturing process can be seen as cleaner production.

The COD_{Mn} amount discharged from the pulp and paper industry was 2.2 million tons in 1970. On the other hand, given that the discharge of COD_{Mn} would increase simply in proportion to the annual growth paper and board product in 1989, the amount is presumed to have increased to about 450 tons. In fact however, the actual discharge was no more than 200 thousand tons. This sharp decrease is ascribed to a 58% decrease due to modifications to the manufacturing process and a 26% decrease due to the black liquor recovery process, which amounted to a 84% decrease in practical terms because of the adopted countermeasures which may be called "cleaner production". The resulting content purified in effluent treatment facilities known as "end-of-pipe technologies" was no more than 16%.

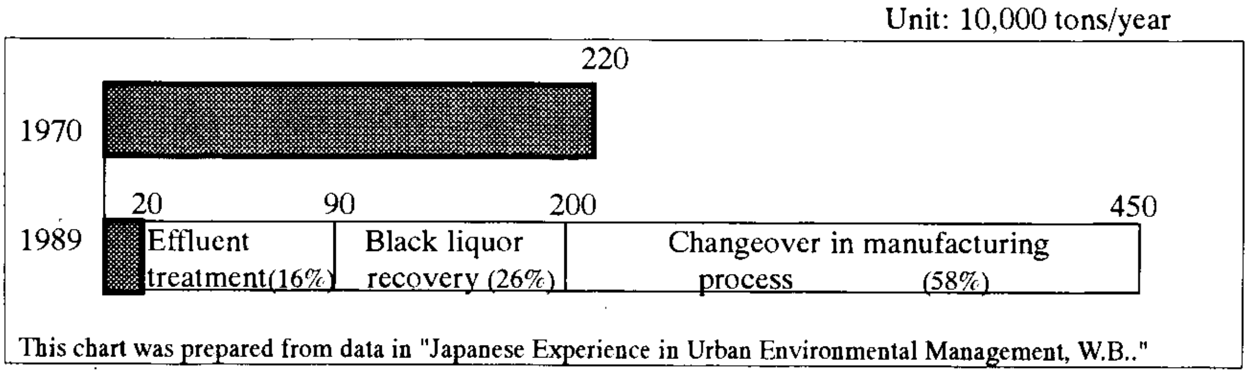


Figure 3 Transition of COD_{Mn} load in pulp and paper industry effluents in Japan

In the manufacturing processes of pulp and paper, water is used in large quantities as dilution water and wash water. Reducing water consumption also lessens the environmental impact and achieves resources-savings, so it can be regarded as a very important factor. For pulp washing, the conventional and widely employed method was dehydrating materials after diluting them in wash water and this entailed the use of large quantities of water. A new method, known as "substitution washing," extrudes impurities in a wash liquid without diluting materials and has proved very effective for reducing water consumption. As to the utility of recycled water, a large quantities of white water which is discharged from paper making process is widely used as dilution water in manufacturing pulp and blending materials. Effluent from the manufacturing processes is finally discharged after reducing the polluting level to standard values.

Chlorine had been widely used as a bleaching agent used in the bleaching process, because of its inexpensiveness and its ability to decompose lignin selectively. However, with the recent trend viewing chlorine bleaching as a problematic source of organic chlorine compounds such as dioxin, the "oxygen bleaching method" using oxygen or ozone instead of chlorine has come into use and is becoming the mainstream. Technological progress since the 1980s enabled a substantial reduction in chlorine consumption with the installation of an oxygen bleacher at the initial bleaching stage. Oxygen bleaching also allows lignin to be removed and enabled COD levels to be lessened as well as serving as a countermeasure against dioxin. Hence, the oxygen bleaching method is now used in about 98% of Japan's Kraft pulp production mills.

(2) Air pollution control measures

In pulp and paper mills, various boilers and incinerators emit soot & dust, sulfur oxides (SOx), and nitrogen oxides (NOx). Most of these boilers are fueled by inexpensive C heavy oil with a high sulfur content, but others use coal, petroleum coke, bark, or wood chips. There are also black liquor recovery boilers peculiar to the pulp and paper industry. The burning facilities in a pulp and paper mill normally include sludge incinerators that burn sludge from the effluent treatment facilities and lime kilns that calcinate sludge (calcium carbonate) from the effluent treatment facilities into quicklime (calcium oxide).

As for air pollution control measures, dust collector equipment is reinforced for soot & dust control, low-sulfur fuels are widely used, and flue gas desulfurization units are installed for SOx control. The sulfur thus caught by flue gas desulfurization is utilized as a component chemical for cooking liquor. Changeover to low-nitrogen fuels and improvements to combustion conditions and methods are being made for NOx control. Moreover, in some mills, denitrification units using the dry ammonia contact reduction method have been installed.

(3) Offensive odor control measures

Offensive odors often account for residents' most serious complaints with pulp and paper mills. Offensive odors are emitted most often from chemical pulp mills. Especially in Kraft pulp mills, the chip digester for cooking chips, the evaporator for concentrating waste cooking liquor, and the recovery boiler for burning concentrated black liquor may well become the major sources of offensive odors. Burning collected odorous gases is usually employed as the main countermeasure against offensive odors. As to drain treatment, stripping towers are widely installed to purge odorous components in the liquor by vaporization so that various condenser drains with a high odorous gas content are not mixed in the effluent. The odorous gases emitted there are fed into combustion equipment for dissolution treatment.

(4) Dioxin control measures

To investigate the discharge of dioxin and the like from pulp and paper mills in recent years, the Environment Agency conducted in 1990 a comprehensive survey of effluents from 60 pulp and paper mills. The survey encompassed process waste water, effluent sludge, ash and soot & dust from sludge incinerators, waste water from final waste disposal site, exhaust gases from black liquor recovery boilers, the atmosphere of the surrounding environment, the public water areas into which effluents from mills are discharged, and fishery products from fishery grounds near the mills.

As a consequence, the Environment Agency assessed that although Japan's environmental pollution near pulp and paper mills at present is not considered dangerous to human health, the production of dioxin and the like and their concentration in the environment should be reduced as much as possible and measures for this purpose should be taken as quickly as possible. The agency requested pulp and paper manufacturers and related administrative organizations to take the necessary action. The Japan Paper Association thus set voluntary target values and guidelines for organochlorine compounds in effluent and is successfully attaining the values at present.

(5) Effective utilization of energy

Although the pulp and paper industry is said to be a massive energy consumer like the steel industry, it achieved a 34% improvement in the 1991 energy consumption unit load over the 1973 figures through energy-saving, such as energy reclamation and recycling of exhaust heat, effluent, solid waste, etc. In particular, enough energy to cover about one-third of the overall energy consumed by the manufacturing processes of the pulp and paper industry is reclaimed by burning organic substances such as lignin in permanently installed black liquor recovery boilers for Kraft pulp manufacture. For chemicals as well, most (98% reclamation rate) are recycled as cooking chemical liquids through a recovery boiler and causticizing system, and only a few chemicals are replenished.

(6) Active utilization of waste paper

As waste paper can be effectively used to lessen the environmental impact and save resources and energy, it is being actively recycled in Japan. Japan's waste paper utilization rate was at the world's highest level, 53.4% in 1995. Consumers' efforts and paper manufacturers' technological developments are in the background of this high rate of waste paper utilization. Environment-conscious state-of-the-art technologies, such as foreign substance removal, deinking, and bleaching, are widely applied. Legal frameworks have also been consolidated in recent years.

4. Mill Case Surveys

We conducted case surveys of actual production status, environmental control measures, and cleaner production at three representative mills (two waste paper recycling mills and one Kraft pulp mill) selected from factories being financed by JEC for environment control measures.

(1) Case A

Mill *A* is recycling used milk cartons and high-quality waste paper to produce toilet

paper. Milk cartons are usually waterproofed with polyethylene coating on both sides, which created problems treating the waste polyethylene generated when waste paper was digested and so they were once regarded as unusable.
However, significant energy-savings have been achieved by restraining industrial waste generation when burning waste polyethylene as fuel and supplying exhaust heat to the paper production processes.

Milk cartons as a material for toilet paper are too hard to be dissolved into water, so some old high-quality waste paper, such as copier paper or newspaper advertisement paper, is usually mixed 60 ~ 65 % of the total volume in with milk cartons to produce toilet paper. When the mill's polyethylene burning boilers were renewed, JEC financed about 80% of the necessary expenses. In addition, effluent treatment systems have been installed with loans from JEC to keep to the tightened effluent regulations of the Water Pollution Control Law. Furthermore, paper sludge that used to be discarded as waste is nowadays recycled into foaming agents for iron manufacture using rotary kilns. The rotary kiln was also installed with loans from JEC.

(2) Case B

Mill *B* is recycling old waste paper that matches Japanese preferences for higher grades of whiteness by adding various wrinkles. They are applying floatator-based advanced deinking techniques, introducing dispersing machines to reduce COD by mechanical deinking, reducing chemical additives in the bleaching process by prolonged soaking, and raising the concentrations of chemicals in liquids with smaller doses by adding a bleaching agent after lowering the water content of the pulp. Loans from JEC were spent on the installation of effluent treatment facilities and flue gas desulfurization units, and the expansion of sludge incineration facilities.

(3) Case C

Mill *C* is manufacturing pulp from lumber chips. For water pollution control measures, this mill has been making an effort not only to install effluent treatment facilities and review the processes but also to reduce the load on treatment facilities by seeking to convert to closed systems as much as possible. Oxygen bleaching has been introduced into the pulp bleaching process instead of the widely used chlorine to prevent dioxin problems. This method also reduced COD and lightened the colors of effluents. Moreover, steam generated by the combustion of black liquor is used to generate enough electric power to cover about 85% of the total power and 70% of the total steam consumed by this mill. Various pollution control measures have been taken in this mill. Nine of them were financed by JEC, such as installation of the soot & dust treatment facilities, effluent treatment facilities, offensive odor prevention system, and industrial waste treatment (disposal) facilities.

5. Examples of JEC Financing

Over the 31 years from 1966 to 1996 JEC has provided 5,712 loans amounting to about 984 billion yen. Of all 27 industry categories, the pulp and paper industry received 729 loans amounting to about 95.8 billion yen, on 10% of the total. From these figures, we may consider pulp and paper industry to occupy an important position and funds must have been invested in many pollution-related improvements. Those loans are concentrated in the first half of the 1970s, as evident from the 78 loans in 1972 at the peak, when active pollution problems surfaced and various effluent regulations were tightened. A breakdown of the types of pollution prevention facilities in the pulp and paper industry financed by JEC shows that effluent and soot & smoke treatment facilities account for 52.9% (maximum) and 22.6% respectively, which are together to about three-fourths of the total. Likewise, a breakdown of actual funds raised to introduce pollution prevention facilities used loans of JEC shows that JEC finances account for about are half (52.0%) of the total; banks loans account for 30.7%; and self-financed investments account for 17.3%. This indicates that JEC financing has contributed greatly to the introduction of pollution prevention facilities.

1. Pollution Control Measures in Japan, and JEC

Japan achieved rapid economic growth from the latter half of 1950s through the 1960s. Rapid expansion of industrial production simultaneously caused environmental pollution, and the concentration of population in urban areas worsened the living environment there, so it was time to tackle these problems and look for urgent countermeasures.

To cope with the serious industrial pollution problem, the government began to consolidate various kinds of legal systems in the former half of the 1960s, enforcing emission regulations on pollutants and promoting the construction of pollution control facilities.

The government also tried to systematically rearrange the urban areas and develop infrastructures in accordance with the clearly established industrial location policy. However, since these measures did not work efficiently, air pollution, water pollution, etc. brought serious physical hazards to residents in some regions, resulting in serious social problems.

Being exposed to severe criticism by society, corporations regarded as pollution sources urgently needed to improve their production facilities and install new pollution control facilities. However, the investment to be made in these facilities was not only a heavy burden for the industrial field, but also technically difficult especially for the small and medium scale corporations which were unable to develop and introduce pollution control techniques by themselves, since Japan at that time had relatively little experience with pollution control measures.

In order to break through such difficulties, the government, which provided exemption from taxes for pollution control investments and which was doing research and development work on pollution control techniques, organized a new system for loaning the official funds for pollution control expenses, at lower interest than that charged by commercial financial corporations, with the objective of promoting industrial pollution control and furthering the development of infrastructures. Thus, for this reason, JEC was established in October 1965 using governmental funds, as a nonprofit corporation to undertake the task of pollution control, in compliance with the "Environmental Pollution Control Service Corporation Law" promulgated in June 1956.

Such government policy and the support of people throughout the country enabled Japan to break free from its critical stalemate concerning the pollution problems at that time. The successful outcome is entirely due to the appropriate combination of "regulation" with "assistance" done by the government. As a specific organization to enforce government policy in the assistance aspect, JEC has played the following roles:

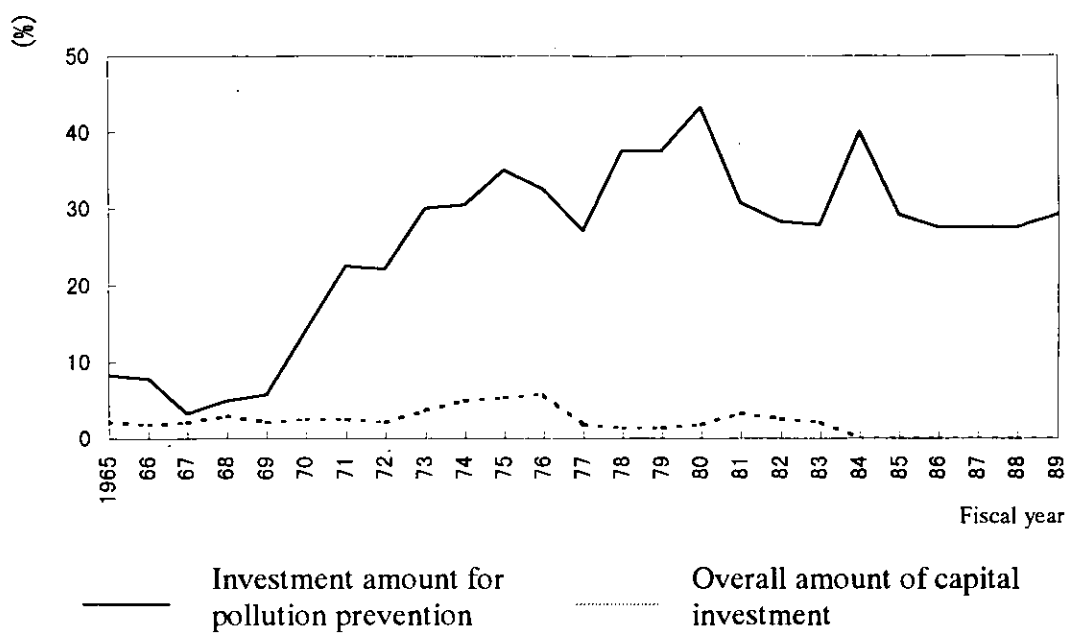
Firstly, using a methodology in which JEC directly constructs facilities and transfers them to each applicant, JEC has corrected inappropriate land utilization, contributing greatly to conservation and improvement of the urban environment. The urban environment was improved by transferring factories and business offices, which had been randomly scattered in urban areas, to other areas suitable for their location or by constructing buffer green belts and park facilities to separate the factory area from the residential area.

It should not be forgotten that such transfer projects of JEC not only contributed to improving of the on-site environment but at played a leading role in the pollution control measures taken by private corporations. Involving repeated trial and error, these pioneering project cases implemented by JEC provide excellent examples of techniques and methods when pollution control measure work is being done by a private corporation.

Secondly, JEC has played a leading role in supplying pollution control funds for industry. These funds supplied to date are said to correspond to about 10% of the total amount invested by Japanese industry for industrial pollution control.

When JEC started, private financial corporations were reluctant to loan installation funds for pollution control equipment, because the equipment did not directly contribute to promoting the productivity of manufactures and was still immature. Consequently, JEC's financing system played a pioneering role in this field. Thereafter, accompanying the recognized importance of pollution control measures, these private financial corporations gradually expanded their loan frames toward this field, making reference to JEC's actual results.

The solid line in Fig. 1-1 shows the proportion of total investment by businesses in pollution abatement that was made with loans by government-affiliated financial institutions (JEC and the Japan Development Bank). It climbed rapidly after 1970 and attained the 30-40% range. The sharp rise in loan amounts by JEC during these years (19 billion yen in 1970, 55 billion yen in 1973, and 126 billion yen in 1975) hints at a similar increase in loan amounts by private financial institutions. The dotted line indicates the proportion of loans by government-affiliated financial institutions in total capital outlays, which is far lower than that for pollution-control investments.



Source: White Paper of the Environment in Japan 1992

Fig 1-1 Ratio of Financing by Governmental Affiliated Financial Organs

JEC's mandate has been revised and its organization has been reshuffled so as to cope with problems newly arisen corresponding to environmental situation in Japan, for example by the addition of new business and elimination of existing business of reduced significance. At present, JEC is engaged in new tasks such as appropriate treatment and disposal of industrial waste substances, protection of the natural environment and conservation of the global environment.

Shown in the table below are the conditions for implementing construction transfer program and financing program which JEC is now undertaking.

Table 1-1 Table of conditions for programs by JEC (Construction & transfer program)

(as of January 9, 1998)

Name of facility for construction		Target	Down payment rate	Repayment period (incl. deferment period)	Deferment period	Interest rate (Annual interest %)
Group installation building		Small- and medium-sized enterprises or local government	5% or more	Within 20 years	Within 2 years	2.20
		Body other than above	10% or more	Within 20 years	Within 2 years	2.40
Common welfare facility		Small- and medium-sized enterprises	5% or more	Within 20 years	Within 2 years	2.20
		Local government	10% or more	Within 20 years	Within 2 years	2.20
		Body other than above	15% or more	Within 20 years	Within 2 years	2.40
Greenery area as air pollution measures		Local government	10% or more	Within 20 years	Within 2 years	2.20
Industrial waste treatment facility provided with greenery area	Facility for treating waste from specific industry	Local government, Local public entities, or Public-private entities	10% or more	Machinery: within 15 years Others: within 20 years	Within 2 years	2.20
	Final disposal site provided with greenery area	Local government	10% or more	Within 20 years	Within 2 years	2.20
Composite facility in National Park and Quasi-National Park		Local government, or Public-private entities	10% or more	Within 20 years	Within 2 years	2.20

Table 1-2 Table of conditions for programs by JEC (Lone program)

(as of January 9, 1998)

Facility or enterprise for loan	Target	Portion of loan	Repayment period (incl. deferment period)		Deferment period		Interest rate (Annual interest %)	
			Machinery	Others	Machinery	Others	3 years after loaning	4 years and onwards
Industrial pollution control facility (relating to common-use facility)	Small- and medium-sized enterprises or local government (incl. Air conditioning & heating in the community)	Within 80%	Within 15 years	Within 20 years	Within 2 years	Within 3 years	2.20	
	Body other than above	Within 70%					2.30	2.40
Industrial pollution control facility (relating to individual's facility)	Small- and medium-sized enterprises or local government	Within 80%	Within 15 years		Within 2 years		2.20	
	Body other than above	Within 50%					2.40	
Industrial pollution control facility (industrial waste treatment facility)	Local government	Within 80%	Within 15 years	Within 20 years	Within 2 years	Within 3 years	2.20	
	Center or local public entities	Within 80%	Within 15 years		Within 2 years		2.20	
	Public-private entities						2.20	
	Small- and medium-sized enterprises						2.20	
	Body other than above	Within 50%	Within 15 years		Within 2 years		2.40	2.50
Business for soil pollution control in urban district	Small- and medium-sized enterprises	Within 80%	Within 20 years		Within 3 years		2.20	
	Body other than above	Within 70%	Within 20 years		Within 3 years		2.40	
Loaning business for installation of combined-type private sewage treatment tank		Within 100%	Within 5 years		Within 6 months		3.00	

2. Environmental Problem in Developing Countries, and JEC

Among developing countries, some countries and districts in the rapid economic growth are confronted with industrial pollution and urban environmental problems accompanying unprecedentedly violent changes of the existing structure of society.

Developing countries are simultaneously experiencing the problems that developed countries once had, plus those that they now have. Although developing countries cannot directly apply the experiences of Japan in overcoming pollution and other environmental problems to their own situations, actively communicating Japan's experiences certainly serves a useful purpose. In particular, the data accumulated by JEC are doubly significant, i.e. (1) Technical information on pollution control measures enforced in business, and (2) Management and business know-how as a financial organization specialized in pollution control. As a part of its new mandate of "providing environmental information to overseas area", JEC has started a new program of providing information on projects carried out to date and project operation know-how.

This program started in the 1992 fiscal year with investigation and research work to examine basic strategies for information transfer. Based upon the approved strategies, a report "Overview of Japan Environment Cooperation (JEC) and Case studies" (Japanese and English) concerning JEC's functions and experiences, and cases of construction and transfer projects (case files), was edited and sent to international organizations and governments of developing countries in the 1993 fiscal year. Financing project cases were summarized in data sheets and compiled in the electronic form in the data base. These existing data sheets (514 cases) were also distributed in the printed form in the 1994 fiscal year.

Since the 1995 fiscal year, as a part of this project, by extracting technical information about pollution control measures involved in the past financing and construction/transfer projects by industrial category, JEC has started to prepare a document summarizing technical guidelines. This document, translated into English, is expected to be widely used as a training text book, oriented toward administrative officials and environmental pollution managing engineers in developing countries. Some important industries have been selected for the target sector of this program, the metal prating industry and the fishery processing industry in 1995, the textile dyeing/finishing industry and meat processing industry in 1996 and the pulp and paper industry in this year 1997. The current document entitled "Technical Manual on Industrial Pollution Control – Based on project cases and investigation and research reports of Japan Environment Corporation (JEC) – " is the product.

In May 1993, a "global environmental fund" was established by contributions from the government and private bodies, and management of the fund was entrusted to JEC. Since then, using the management profits of the fund, JEC has been providing fund assistance and other support for environmental protection activities in developing countries conducted by domestic and overseas non-governmental organization (NGO). Projects eligible for aid cover a broad spectrum that of course includes pollution control, as well as nature protection and environmental education training. Examples in which this Pollution Control Manual was offered were utilization at training meetings for Asian leaders held by the Overseas Environmental Cooperation Center (Japan) and TechnoNet Asia (NGO in Singapore) in Bangkok, Thailand in November 1996 under the theme "Treatment of Small- and Medium-sized Enterprises Plating Waste in Asia" and in October 1997 under the theme "Mitigating Pollution in the Marine Products Processing Industry". Moreover, some cases of small-and medium-size enterprises devoting themselves to a high level environmental management were also introduced and it was reported that Japan needs to introduce to those people not only its experiences on pollution control but also the way as to how to tackle and solve the upcoming problems.

In order for Japan to further contribute to promoting the environment conservation in developing countries, it is considered necessary to render the technical support more positively in the form of proposition. However, the technical support should be reviewed by exchanging opinions with the readers so as to reflect their requests and suggestions. Then, technical support may not be regarded only as transmission of information from Japan. In implementing Japan's role in promoting the environmental conservation in developing countries, JEC would like to fulfill its function as an interface for the technical cooperation on the pollution control.

For further detailed information regarding the general JEC activities or publications, please do not hesitate to contact the following JEC Division.

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3. A Unified Approach to Controlling Industrial Pollution

3.1 Background

People in several regions of Japan suffered grave health damage from industrial pollution during the rapid economic growth phase, and the nation was faced with the need to immediately legislate regulations and to quickly enact controls on pollution sources pursuant to those regulations. Facing a huge groundswell of anti-pollution public sentiment, polluting factories found that complying with legal standards was an essential element for survival in their local communities. Installing equipment to bring emitted pollutants within standards, a practice now called "End-of-Pipe Technologys" was highly useful as a way of satisfying standards to get around the problem quickly. However, this technique always entails capital outlays in addition to those for production facilities, which necessitate ordinary running expenses, and because pollutants just move among various media (for example, scrubbing flue gas to control air pollution moves the pollutants to water systems, and cleaning effluent moves the pollutants into the waste stream), it puts off solving the problem. Moreover, it becomes necessary to procure funds for developing new treatment technologies and installing treatment facilities, in which, as noted above, JEC has played an important role. Meanwhile, the OECD Council adopted the "Polluter Pays Principle" (PPP) as its basic philosophy, which holds that polluters themselves should shoulder the costs of pollution abatement, and that governments should not do it for them. JEC's assistance program was in agreement with this, for it provided economic incentives to businesses, local governments, and other entities that wanted to implement measures for pollution mitigation and environmental conservation, by this means getting them to actively institute the needed measures themselves and without delay. In this way JEC's assistance was conceived as a program that achieved both maintenance and improvement of the citizens' living environment, and the sound advancement of industry.

3.2 Cleaner Production

Compared with "End–of-Pipe-Technologies", methods of preventing pollution by reviewing raw materials and processing technologies, improving and reforming production processes themselves, simultaneously achieves resource-saving, energy-saving and production cost reduction. The fact that such an approach called "Cleaner Production (CP)" is far more effective has already been proved in the experiences of industrial pollution control in most developed countries. In Japan it has been possible from the beginning to incorporate such technologies into a variety of fields, and especially the twice oil crises that occurred from the latter half of the 1970s forced industry to carry out tough measures for conserving resources and energy. Companies reassessed their production processes and implemented many responses that would now be called "cleaner production." It is regrettable that these valuable technologies and experiences are protected as industrial secrets, and even now have hardly been made available to others.

In the financing project of JEC, "effectiveness from management viewpoint" and "recovery of valuables" have been considered as important criteria in screening the funding target since its early days. Not only removal of hazardous substances, but also general rationalization of management and effective utilization of resources by improving the process, are considered to be essential factors for pollution control measures. It is conceivable that the coexistence of pollution control measures with economic development in Japan has been realized by consistently maintaining such a philosophy.

Although the superiority of such methods has not always been apparent from the outset, they have, throughout the history of pollution control, gradually been developed in both Japan and other countries, and are now recognized internationally. Further, in recent years the concept of environmental management has become an international standard (ISO), and is leading to more active efforts at granting recognition for environmentally friendly manufacturing plants under international standards. In Japan too, efforts to gain authorization under these standards are becoming widespread.

The fundamental thinking that underpins cleaner production and environmental management, which is behind such production process reassessments and other efforts, is spelled out in Agenda 21, a document adopted at the 1992 UN Conference on Environment and Development in Rio de Janeiro, Brazil.

> Business and industry, including transnational corporations, should recognize environmental management as among the highest corporate priorities and as a key determination to sustainable development. Some enlightened leaders of enterprises are already implementing " responsible care" and product stewardship policies and programs fostering openness and dialogue with employees and the public and carrying out environmental audits and assessments of compliance. These leaders in business and industry, including transnational corporations, are increasingly taking voluntary initiatives, promoting and implementing self- regulations and greater responsibilities in ensuring their activities have minimal impacts on human health and the environment. (The potions of the original omitted.) The improvement of production systems through technologies and processes that utilize resources more effectively and at the same time produce less wastes achieving more with less is an important pathway towards sustainability for business and industry. (Remainder omitted)
> -----Except from Agenda 21, Chapter 30, "STRENGTHENING THE ROLE OF BUSINESS AND INDUSTRY" , adopted at the United Nations Conference on Environment & Development (UNCED) (June 1992, Rio de Janeiro)

3.3. Organization and Education for Pollution Control

Pollution control is an indispensable task for corporate management, and it is evident from the "Polluter-Pays-Principle" (PPP) that the pollution problem should be primarily solved as the responsibility of the corporation itself. Furthermore, pollution control should be handled as part of the overall facility arrangement and operation plan in the factory including modification of the production process, not just as the matter of treatment facility. If pollution control is entirely entrusted to the personnel in charge of the job site, it is not effectively performed. It is important that the top manager of the corporation bears the highest responsibility for pollution control organization, which is to promote systematic pollution control through the corporation.

Of course, the top manager must plan not only adjustment of the production amount and product items with variations of the market, but also pollution control at source level; as well as planning the arrangement and the performance in maintenance of the treatment facility according to the production amount and product items. Moreover, taking into account the various available options, including the expansion of existing equipment and the installation of additional facilities as well as development of low pollution products and cleaner production processes and the renovation of facilities involving factory relocation to an industrial park of the site (possibly, in group), the top manager must make rational judgments about pollution control in the future.

Also, education of organization members, or all employees, is needed to enlighten them about pollution control awareness. Of course, personnel in the pollution control division must be convinced of the importance of their operation. On the other hand, personnel in the production division must also be educated, considering the fact that proper management in the production process is indispensable for product quality control and good operation of the pollution control facilities. It may be particularly effective to let all personnel know the environmental implication of their operation, such as properties of chemicals used, appropriate use and storage of raw materials, contents of air emission and wastewater, and their influence on treatment facility and external environment, etc.

3.4 Need for Investigation at the Project Design Phase

It is desirable to conduct environmental impact assessment when new siting, relocating or expanding a factory, as well as renovating a factory, is planned and designed. By doing so, the present situation surrounding the factory can be understood, and sources and amounts of contaminants to be generated by the planned production processes can be estimated, and the technique for measures to be taken against these and the environmental influence can be evaluated, and optimal measures can be selected to minimize adverse environmental influence under given conditions.

In this process, it is important not only to evaluate the external influence for the proposed plan but also to examine most suitable industrial locations and environmental control programs by combining various optional factors including comparison of multiple programs and change of the program itself.

Precisely conducted investigation at the design phase makes a remarkable contribution to successful environment control as well as to future business management. Accurate design can be achieved by correctly understanding the necessary information, such as up-to-date availability of technical options, estimated amounts of contaminants and allowable emission levels (including regulation trends in future). A facility designed by such a process will be able to exhibit its full functions in good condition, and even if a malfunction dose occur, the cause will be so easily identified and analyzed that measures can be taken immediately. On the other hand, in a case where the necessary information is inaccurate and the installed facility is unsuitable, these deficiencies can occasionally cause critical condition in functions in the facility. In principle, such investigation should be done by the industry itself, but it can be done by entrusting to specialists such as consultant firms. Even though some expenses are unavoidable, they are generally a very small portion of the overall expenditures of the factory development and may be beneficial from the long-term point of view, taking into account the reduced expense for emission measures and the smooth proceeding of production in the future.

In the evaluation of production process and emission control techniques, it is also efficient to look for available data from the study of similar precedent cases. However, direct transfer of experiences in other regions is sometimes problematic due to the difference of geographical properties (district, climate), national conditions (infrastructure, labor market), and legal regulations and data analysis methods. Fact-finding investigation is indispensable for accurately understanding whether or not the target area to which the technique is transferred satisfies the basic design requirement for correct function of each technique.

3.5 Monitoring and Management

The discharge of pollutants from a factory must be regularly measured and recorded and then reported to an authority. Such procedures are legal requirements in many countries. Inspection of fulfillment of regal requirement such as emission standards is a minimum task, but the most important is to examine the present state of the ongoing environmental control program and the outcome thereof in the light of the objectives initially set up. Such a procedure has further significance: it reveals whether or not the environmental impact assessment in the preliminary investigation was correctly carried out. If the objectives are inadequately attained, revision of environmental control program and procedures is required.

Even if legal requirements are not involved, voluntarily conducted monitoring and recordings are very useful for the factory itself. Namely, if discharge data is abnormal, abnormality of the treatment facility as well as abnormality of production process operated in the factory can be readily detected. By doing so, not only unfavorable influence on the external environment can be immediately avoided, but stable product quality can be maintained. Moreover, basic data can be collected so that uneconomical segments of the factory operation and resources can be identified and the facilities would be modified in the future for improving product quality and saving on production cost. An environmental audit is composed of systematized procedures described above.

3.6 Technical Options for Industrial Pollution Control

3.6.1 Group Location and Transfer

It is often difficult to install additional treatment facilities for the existing process in the restricted space and available solutions may be limited for enforcement of pollution control on corporations randomly scattered in a residential-commercial region. In some cases, it may be more efficient to transfer these corporations as a group, to move into an industrial park where individual treatment facility sites are secured or a joint treatment facility is prepared. Characteristically, this simultaneously solves problems of flue gas and wastewater as well as noise and vibration.

In many cases, these transferred corporations can improve their production efficiency by introducing new processes, rationalizing facility lay-out and expanding work space, so that this transfer project contributes greatly not only to pollution control but to the modernization and rationalization of these corporations. Moreover, improvements of the urban environment are expected to be much more effective when the acquisition of transfer sites and the utilization of sites remaining after transfer are implemented in relation to city planning programs.

On the other hand, the projects for grouping and joint installation of factories have the following problems.

1) Increase in project-fund scale
2) Land acquisition difficulties
3) Raw materials and products must be transported for long distance
4) Commuting of employees

JEC's industrial park construction and transfer projects are as follows: A cooperative association is organized by small-scale factories which are having difficulty in taking pollution control measures immediately. After JEC secures a new site for the industrial park and constructs factory buildings and pollution control facilities at site, these are transferred to the cooperative association. Each corporation constituting the cooperative association repays the expenses of constructing these facilities in long terms and is under an obligation to use the site remaining after the factory transfer for housing and offices which cause no pollution problems. At the new site, not only is the environmental protection promoted by securing a site for the pollution control facility or by installing a joint pollution control facility there, as described in the next paragraph, but also the creation of new production circumstances such as the ensuring of greenery and amenities in the factory park, is planned. The local government plays important roles in such areas as selection /acquisition of the new business site and guidance/coordination for utilizing the former sites.

3.6.2 Individual Treatment System versus Joint Treatment System

As measures for treating discharges such as air emission containing smoke/soot and flue gas, wastewater, and solid waste associated with the operation at factories and work sites, installation of a pollution control facility jointly by a group of corporations may be more advantageous than installing individual facilities by each corporation. The following advantages are possible merits of joint facilities.

1) Joint facility saves space.
2) Construction of a large facility is economical due to the advantage of scale. Joint-enterprise enhances reliability so that its fund raising ability is improved.
3) Joint work saves on operation costs. Expert operators and technicians are easily secured.
4) The treatment techniques and facility are easily upgraded.
5) By mixture and interaction of discharge from different sources (cf. Improving quantitative and qualitative steadiness, dilution, neutralization, complementation of nutrients, etc.), characteristic of the treaty is improved.

On the other hand, disadvantages are observed, as follows:

1) Since the discharge is concentrated at a specific site, its environmental influence is intensely localized. Sometimes, an advanced treatment facility is needed, and

consequently its construction cost is rather mire than expected.

2) Since the cost of laying the wastewater collector conduits is rather high, this offsets the advantage of saving construction cost.
3) It is not easy to formulate a fee system that satisfies every participant corporation as well as providing incentive for motivating corporate efforts to reduce the pollution load. Consequently, a joint treatment facility dose not always results in saving of running cost.
4) Mishandling by one corporation among participants can interrupt operation of the joint treatment facility. During the recovery time, operation of all participant corporations may have to be at standstill. Sometimes, it is difficult to identify the source of trouble and to take measures for preventing recurrence.
5) Freedom of production operation is restricted. (Changes of operation time and product inventory/processes in an individual corporation may be restricted by the operation time and performance of the joint treatment facility.)
6) The individual corporation's awareness of responsibility for pollution control may be decreased.

The joint pollution control facility construction and transfer projects by JEC focused on the advantages of joint treatment. Including the pioneering project first implemented, remarkable achievements have been made since 1965. However, as pollution control activities have spread, the technical ability of private corporations has been improved and a number of consultants and manufactures with relevant experts have been established. Accordingly, as far as conventional pollution control measures are concerned, this trend has enabled even small- and medium-sized enterprises to independently implement pollution control measures either by themselves or by hiring special contractors. The disadvantages of the joint treatment system are being emphasized later and the system has not often been applied since 1985.

4. An Overview of the Pulp and Paper Industry

4.1 History of the Pulp and Paper Industry

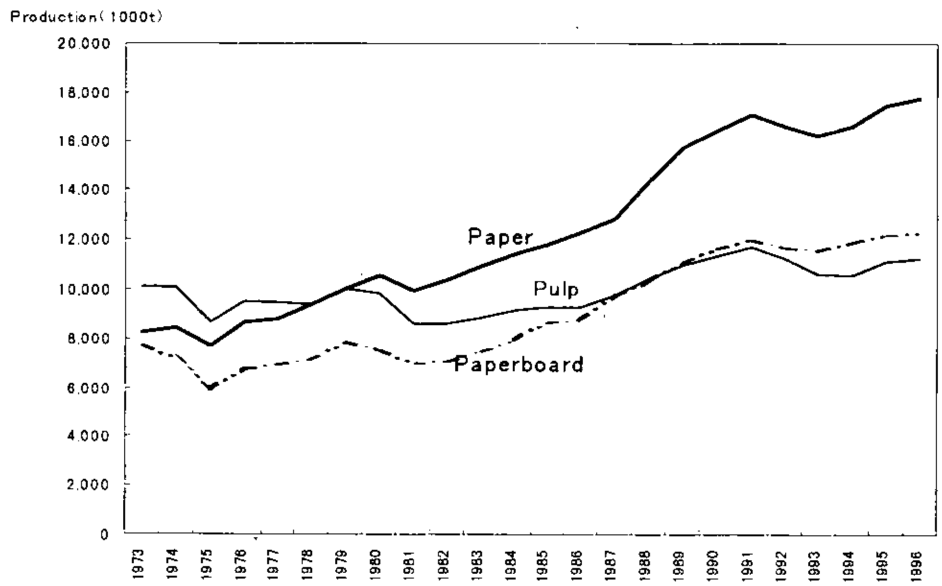
The oldest Japanese reference to paper is in the *Nihon Shoki (published in A.D.720)*, stating that the art of papermaking came from the Korean kingdom of Kokuryo during the reign of Empress Suiko in A.D. 605. Subsequently papermaking (then done by hand) increasingly flourished, so that in the Heian period (A.D. 794~1192) there were production centers throughout almost the whole of Japan.

Western papermaking, which is the primary method now, came to Japan after the Meiji Restoration of 1868, and Japan actively worked to bring in this technique by sending knowledgeable persons to advanced countries from about 1872 to 1876. Later the demand for paper grew in conjunction with the development of the journalism industry, such as newspapers, magazines, and other publications, and in about 1890, in an effort to achieve higher-quality paper, Japan made the switch from papermaking that used rags and straw as stock to a chemical industry that uses wood. After that the industry developed rapidly through the Sino-Japanese, Russo-Japanese, and First World wars, and mainly the three companies Oji, Fuji, and Kabakoh grew into large-scale wood pulp manufacturing and paper production firms. Owing to the world depression, the bottom fell out of the paper market, and these three companies merged into Oji Paper Co., Ltd. in 1933, for a time accounting for over 80% of Western-style paper manufacturing and 95% of pulp production volume in Japan. This monopoly continued until about 1940, when paper mills were built and equipped according to uniform standards due to establishment of the Joint Paper Sales Company by the 10 companies in the Japan Paper Association and 56 outsider firms, and to issuance of the Papermaking Industry Enhancement Provisions during the Second World War. Oji's operation gradually shrank owing to these. Further, monopolistic companies were dismantled one after another under postwar US occupation policy, which brought an end to Oji's monopoly and moved Japan's papermaking industry toward intercompany competition.

The paper industry developed in conjunction with rapid post-World War II economic growth. Although the industry was affected somewhat by the twice oil shocks after 1965, by a jump in wood chip prices, and by other factors, paper demand continually expanded, and Japan became the world's second-ranking producer of paper and paperboard, and the fourth-ranking producer of pulp (1992 figures). But in recent years there was a temporary dip in paper demand because of the bubble economy's collapse in the latter half of 1991. During the postwar high economic growth phase, pollution caused by pulp and paper manufacturing processes became apparent, as represented by the sludge problem in Tagonoura Harbor. A variety of environmental conservation measures taken by administrative agencies and the paper industry resulted in solving the pollution problem to some degree after 1975, but even now the paper industry faces a major task in perfecting closed-loop manufacturing techniques that impose little environmental burden.

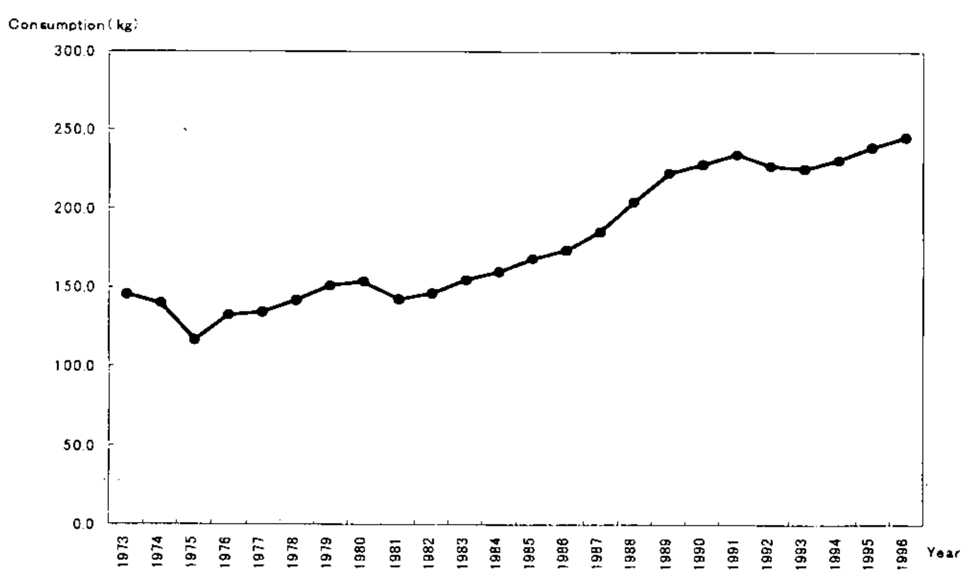
4.2 Current State of the Pulp Industry

Japan's 1996 production of paper and paperboard (30,013 thousand tons) was the world's second-highest (about 10.6% of total world production), and its pulp production (11,199 thousand tons) was fourth (about 6.4% of total world production), making Japan one of the world's major pulp and paper producers.



source: Japan Paper Association "Statistic annual report"

Figure 4-1 Change of paper, paperboard and pulp production



source: Japan Paper Association "Statistic annual report"

Figure 4-2 Change of Japan's annual per capita consumption about paper and paperboard

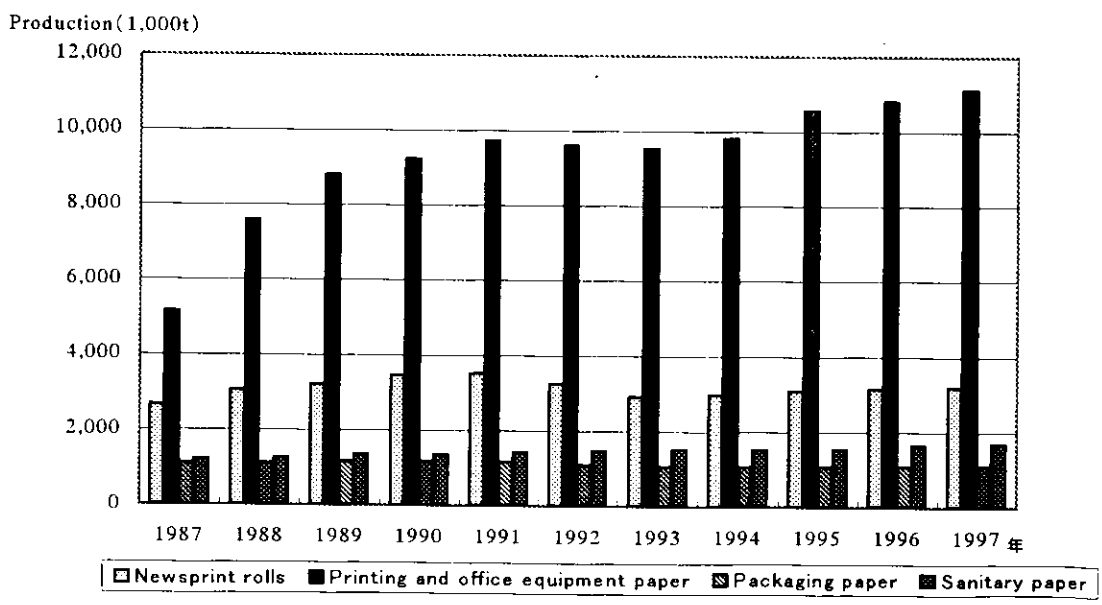
Fig. 4-1 shows paper, paperboard, and pulp production from 1973 to 1996. Despite the temporary effects of the 1973 and 1978 oil shocks, demand continued to rise year by year, and production rose sharply during the bubble years. There was a short production decline in 1991 and thereafter when the bubble collapsed, but it increased again beginning in 1994.

Consumption of paper and paperboard exhibited the same trend (Fig. 4-2) with Japan's annual per capita consumption of 146.0 kg in 1982 (ninth-ranked worldwide) rising swiftly to 245.2 kg in 1996 (fourth-ranked).

4.2.1 Paper

Annual paper production in 1997 was about 18 million tons. The proportion for printing and office equipment paper is highest at 60.8%, followed by newsprint rolls at 17.5%, packaging at 6.1%, sanitary paper at 9.4%, and miscellaneous types at 6.2%.

Fig. 4-3 shows production for various types of paper. In 1991 newsprint and office equipment paper went into a temporary decline, but increased again beginning in 1994. There was also a temporary decline in packaging paper owing to the promotion of simple packaging in order to reduce waste, but in recent years it is again increasing. By contrast, as sanitary paper is a daily necessity it is hardly affected by business downturns, and its production increases year by year.

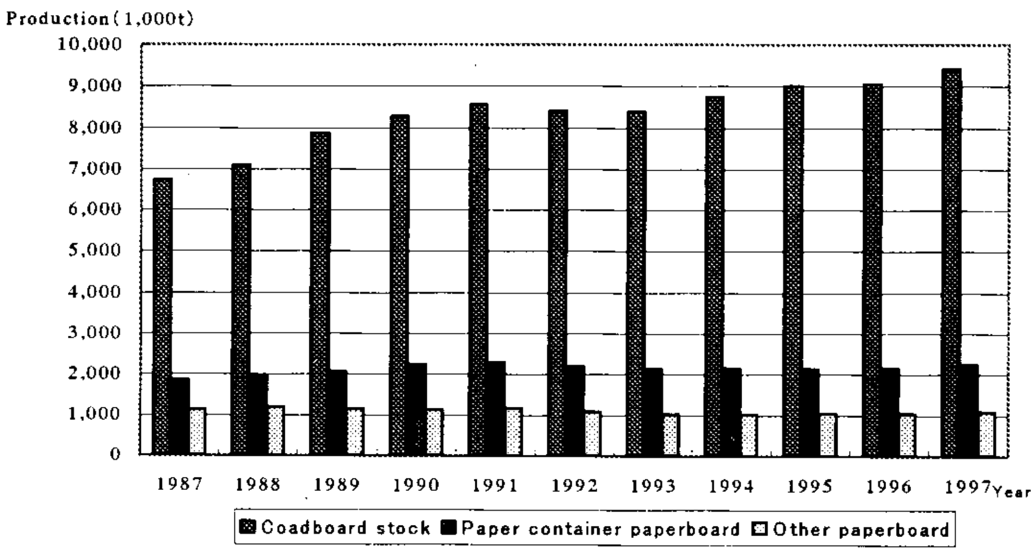


Source: Ministry of International Trade and Industry " Statistic annual report of pulp and paper ", Japan Paper Association "Statistic annual report"

Figure 4-3 Change of paper production by type

4.2.2 Paperboard

Paperboard production in 1997 was 12,747 thousand tons, of which the largest proportion at over 70% is for cardboard stock, followed by under 20% for paper containers. As paperboard production by type indicates (Fig. 4-4), cardboard stock, paper container paperboard, and other paperboard all declined after 1991 just as paper production did. Conceivable reasons for this include the following: Paperboard is easily affected by the business cycle because it is used mainly for industrial packaging material; and it is also affected by the promotion of simple packaging meant to reduce waste. However, production of cardboard stock has continued to increase since 1994, while that of paper container paperboard and other paperboard has been either level or increasing slightly.



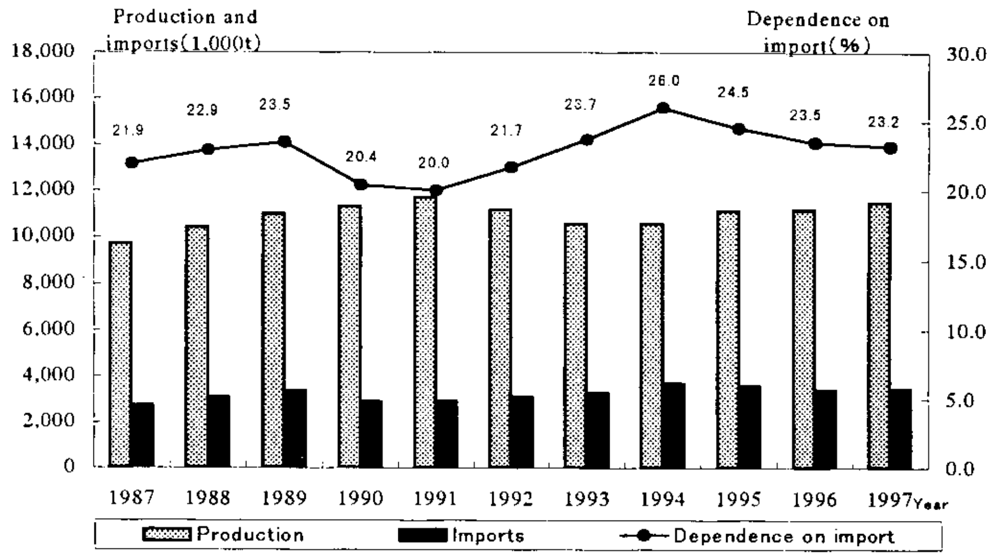
Source: Ministry of International Trade and Industry " Statistic annual report of pulp and paper ", Japan Paper Association "Statistic annual report"

Figure 4-4 Change of paperboard production by type

4.2.3 Pulp

Pulp production is influenced by the recovery and use of waste paper, and pulp imports. During the business boom of 1987-1991 the industry aggressively built and added to pulp production facilities to increase pulp production, but after the 1991 bubble economy collapse, consumption of cheaper imported pulp took precedence, and the utilization of waste paper increased, which resulted in a pulp production drop (Fig. 4-5). But in 1995 when production of paper and paperboard recovered, pulp production likewise increased again. Behind these increases is the international jump in pulp prices, which induced through-process paper manufacturers to embark on augmenting their own production. For that reason pulp imports have remained unchanged since 1996, when the international pulp market fell into a slump.

Pulp for paper is roughly divided into chemical and mechanical pulp types depending on the method used to separate the wood fibers. Chemical pulping works by chemically dissolving the lignin that bonds the fibers, while mechanical pulping tears the fibers apart with machines. Other ways of manufacturing pulp are a semichemical process in which mechanical treatment follows chemical treatment, and making non-wood pulp from materials other than wood. Below are descriptions of each pulp type's characteristics. Table 4-1 presents the pulp categories and manufacturing methods.



Source: Ministry of International Trade and Industry " Statistic annual report of pulp and paper ", Japan Paper Association "Statistic annual report"

Figure 4-5 Change of Pulp production and imports

(1) Chemical Pulp

Chemical pulp is manufactured by using chemicals to break down the lignin that acts as glue for the plant fibers, then extracting only the fibers. This process has a pulp conversion rate of only 45-55%, but because it eliminates the lignin, which is a coloring substance, it is possible to make paper with high strength and whiteness, and another advantage is that it can be used with both softwood and hardwood trees.

(2) Semichemical Pulp

Semichemical pulp is manufactured with chemical treatment followed by grinding in a refiner. It was developed for the purpose of making high-conversion-rate pulp from hardwood trees, and has a rate of 65-90%, which falls between the chemical and mechanical processes. Semichemical pulp has been used mainly to make core stock and newsprint rolls, but recently reclaimed paper increasingly goes into core stock and newsprint roll raw material, and semichemical pulp production has declined.

(3) Mechanical Pulp

The pulp conversion rate of this process is very high at about 95% because the wood is ground, which necessitates the use of softwood because of its comparatively long fibers and a great deal of electric power. Despite this and other disadvantages, this method allows the manufacture of paper that is thin but highly opaque.

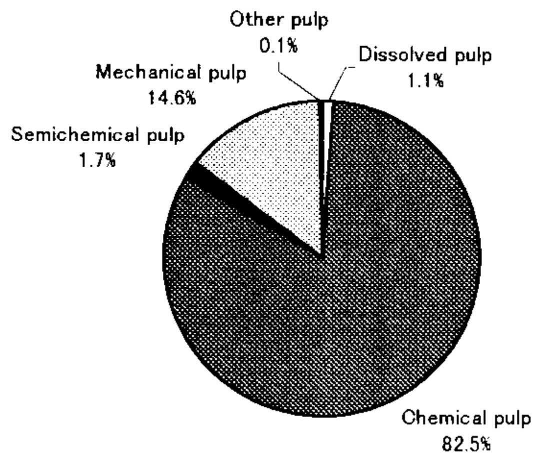
Table 4-1 Pulp categories and manufacturing methods

1. Dissolved pulp (DP) Processing method is basically as same as sulfite pulp, but it is specially made of refined materials. The hardwood trees are mainly used for raw materials.
2. Papermaking pulp (1) Chemical pulp a. Sulfite pulp (SP) This pulp is made by sulfurous acid method under the condition of acidity. Digestive chemicals, sulfurous acid gas made of sulfur and lime hydrogensulfite liquid made by chemical reaction of limestone, are used. Recently, sodium or magnesium is commonly used instead of lime. b. Kraft pulp (KP) a) Unbleached Kraft pulp (UKP) This pulp is made by sulfate method. Sodium sulfide, which is made from mirabilite and caustic soda, is used as the digestive chemicals. Continuous digester is used for this method in general. Digesting waste liquid, black liquor is condensed so that recovery boiler burns its liquid, then chemicals are recovered and reused. Furthermore, generated steam is also supplied to the digesting and papermaking process. b) Bleached Kraft pulp (BKP) Bleaching of UKP makes BKP. Chlorine, caustic soda and chlorine dioxide are used as bleaching chemicals. For the environmental countermeasure, oxygen-bleaching method that replaces chlorine with oxygen becomes popular recently. (2) Semi-chemical pulp a. Semi-chemical pulp (SCP) After treated logs and chips by chemicals such as caustic soda and sodium sulfite, fiber is loosened by mechanical treatment like refiner. The degree of chemical treatment is larger than mechanical treatment. b. Chemi-ground pulp (CGP) The degree of mechanical treatment is larger than chemical treatment. (3) Mechanical pulp a. Grind pulp (GP) Grinder refines logs of softwood mechanically. b. Refiner ground pulp (RGP) Chip is refined by refiner c. Thermo-mechanical pulp (TMP) Chip is softened by pre-heat and refined by refiner. (4) Others Pulp is made of materials except wood such as straw, hemp and cotton linter.

Source: Japan Paper Association "Pulp and paper handbook 1998"

Fig. 4-6 shows the makeup of 1997 pulp production by type. Chemical pulp is highest at over 80%, followed by mechanical pulp at 10-odd percent. Chemical pulp is mostly Kraft pulp, of which bleached Kraft pulp is under 70% and unbleached is over 10%.

Kraft pulp production has been on the rise since the 1950s when advances were achieved in bleaching methods. The reason is that until then there was a high dependence on softwood species for wood, but the Kraft process can be used for almost any tree species whether softwood or hardwood, and because it is possible to recover chemicals and energy from the cooking chemicals (black liquor).



Source: Ministry of International Trade and Industry " Statistic annual report of pulp and paper "

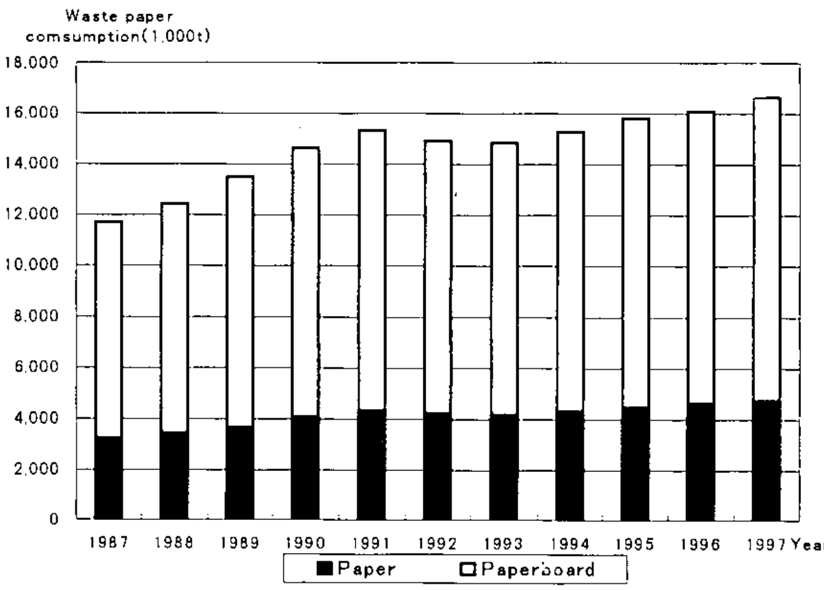
Figure 4-6 Makeup of pulp production by type indicates

4.2.4 Waste paper

Fig. 4-7 shows the consumption of paper and paperboard made with waste paper. Consumption of waste paper is directly proportional to the production of paper and paperboard, and they tended to increase until 1991, but then slipped into decline. Since 1994 when production of paper and paperboard again increased, the consumption of waste paper likewise heightened.

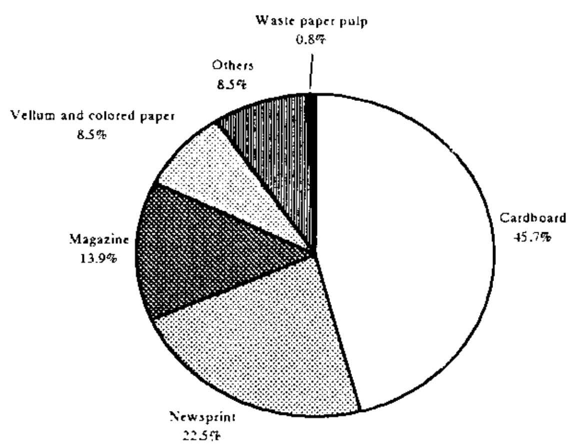
A look at the makeup of waste paper according to paper and paperboard shows that paper is about 30% and paperboard about 70%, with no appreciable change in that ratio over the last decade.

From the percentages of waste paper consumed in various uses (Fig. 4-8) one can see that cardboard is the largest at just under half of the total, followed by newsprint (about 23%), magazines (about 14%) and vellum and colored paper (about 9%).



Source: Paper Recycling Promotion Center "Wastepaper handbook"

Figure 4-7 Consumption of paper and paperboard



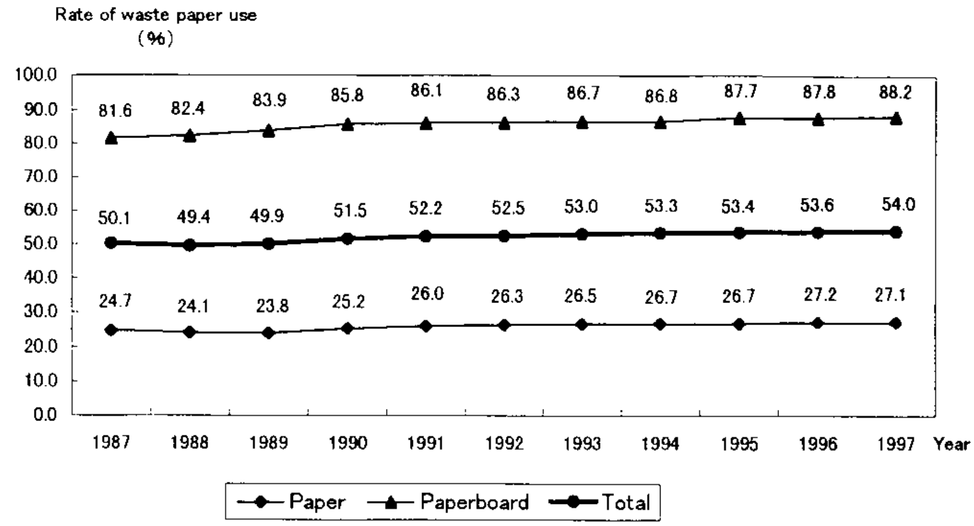
Source: Paper Recycling Promotion Center "Wastepaper handbook"

Figure 4-8 Percentages of waste paper consumed in various uses

Fig. 4-9 shows the rate[1] of waste paper use as raw material in papermaking. Waste paper has long been used in cardboard stock, paperboard for paper containers, sanitary paper, and other items, but in recent years it has become a primary papermaking stock used more than pulp.

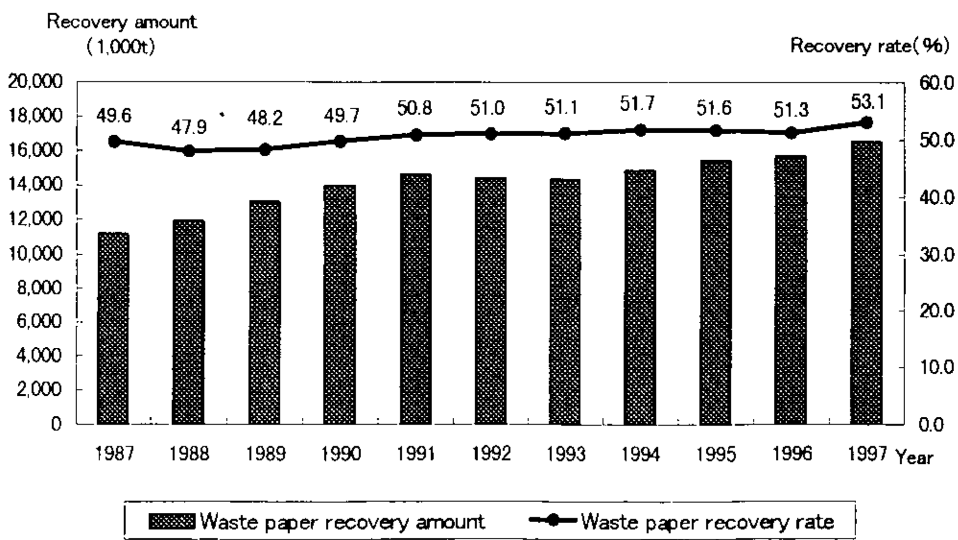
[1] Rate of waste paper use = amount of waste paper consumed / amount of papermaking stock consumed x 100

The usage rates of waste paper in paper and paperboard shows that in paperboard the pulp content increased year by year until in 1997 it attained just under 90%. On the other hand, the recycled content of paper has hovered between 20 and 30% with little change. The reason for this difference is that high-recycled content in printing and office equipment paper, which account for the biggest share of paper, is difficult at this time due to economic factors, and to quality and other technical constraints.



Source: Paper Recycling Promotion Center "Wastepaper handbook"

Figure 4-9 Rate of waste paper use as raw material in papermaking



Source: Paper Recycling Promotion Center " Statistics Report of wastepaper Demand "

Figure 4-10 Waste paper recovery amount and rate

The waste paper recovery amount[2] and rate[3] appear in Figs. 4-10. Until 1991 the former climbed rapidly, but as paper and paperboard production similarly increased, the recovery rate has held steady at about 50% for the past decade. Because there are many things that cannot be recovered, such as book collections and toilet tissue paper, the ceiling on the recovery rate is said to be about 65%, which means that the current recovery rate is quite high. Three to five percent of the waste paper obtained in Japan is imported, with the amount of imported waste paper determined by the import price and the amount of waste paper recovered domestically.

In about 1987 the waste paper recovery and use rates were both under 50%, but in 1997 were over 50%, suggesting that paper recycling is proceeding smoothly while maintaining the supply/demand balance. But in the autumn of 1996 the recovery amount exceeded demand despite increased waste paper use, which brought about a temporary halt to waste paper recovery. To solve this serious problem of excess waste paper it is important to amend the social climate that seeks higher quality than needed in printing and office equipment paper, for which demand is particularly high, and increase the recycled content of those paper types.

[2] Amount of waste paper recovered = amounts of waste paper and waste paper pulp obtained - amount of waste paper imported + amount of waste paper exported

[3] Waste paper recovery rate = amount of waste paper recovered / domestic demand for paper and paperboard x 100

5. Environmental Measures by the Pulp and Paper Industry

5.1 Pulp and Paper Manufacturing Processes and Pollutants

The primary manufacturing processes for pulp and paper (Fig. 5-1) can be roughly divided into the five stages of wood preparation, pulping, stock preparation, papermaking, and coating and finishing. Of these, the pulping process is roughly divided into three manufacturing processes depending on raw materials and treatment methods: chemical pulping, mechanical pulping, and waste paper pulping. Each stage in each of these processes has its own environmental problems.

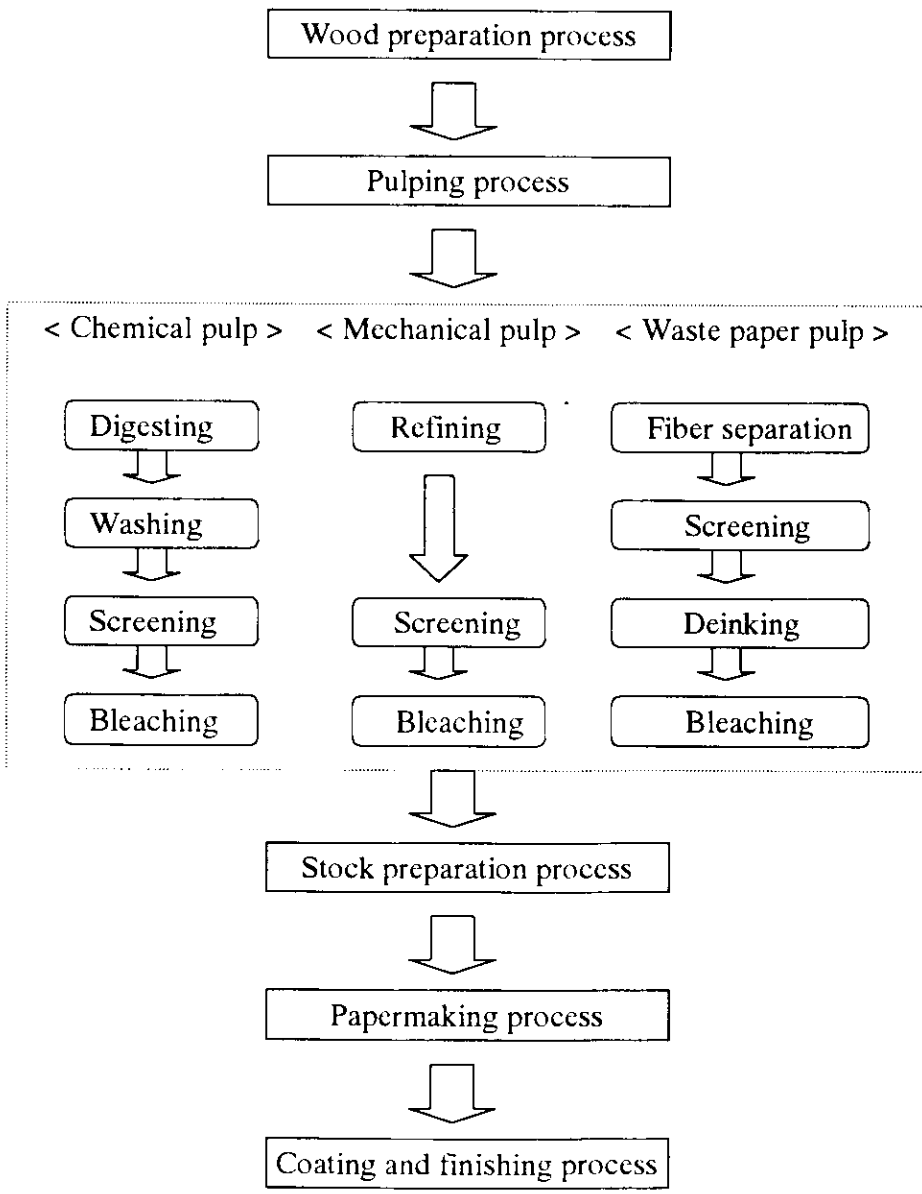


Figure 5-1 Pulp and paper manufacturing processes

5.1.1 Wood Preparation

Wood preparation involves cutting and debarking the wood in a manner suited to the pulping method. For mechanical pulping, the wood is cut into sizes suited to grinders and refiners, debarked, and made into small chunks or chips. For chemical pulping, the wood is broken down into small pieces and chipped so that the digester chemicals can easily penetrate into the wood.

<Associated Environmental Problems>

The main environmental problems arising in the preparation process are water pollution and wastes. Although the amounts of bark and sawdust coming from cutting and debarking are small in comparison with the total industrial wastes generated by pulp and paper manufacturing, the wastewater from chip washing and wet debarkers causes problems with suspended solids and coloring. As the bark particles in wastewater are suspended solids, they precipitate if released without treatment and cause sludge pollution.

5.1.2 Pulping

Pulping uses different processes depending on raw materials and the pulping process, and there are diverse environmental problems depending on those differences.

(1) Chemical Pulping

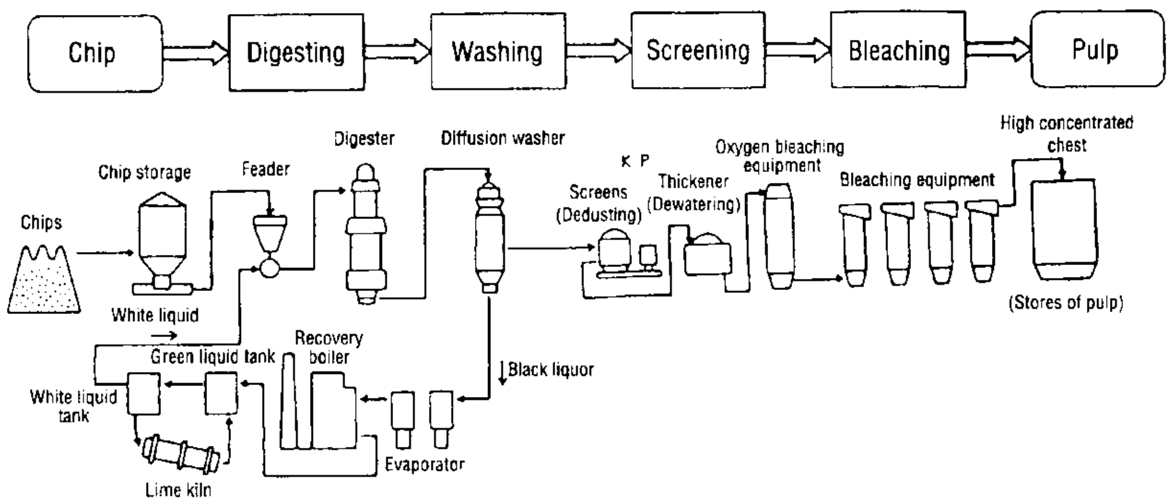
Chemical pulping consists mainly of digesting, washing, screening and bleaching. First, chemical digesting dissolves the lignin, and then the mixture is washed to remove impurities in the pulp, such as lignin, pitch, organic acids, and residual digesting chemicals. Washed pulp is passed through screens or other fixtures to remove contaminants, and when even greater whiteness is desired, it is bleached. Fig. 5-2 shows the process for making chemical pulp (Kraft pulp).

a) Digesting and Washing

Digesting involves putting chips and chemicals (caustic soda and sodium sulfide) into a digester and cooking them in order to dissolve the lignin that acts as a glue to hold the plant fibers together. The digesting chemicals containing dissolved lignin are run through washing equipment where the black liquor is separated out as the pulp is washed.

<Associated Environmental Problems>

The main environmental problems arising in the digesting and washing process for chemical pulp are water pollution, air pollution, and offensive odors. The digesting wastewater, which contains the cooking chemicals and dissolved organic substances such as lignin, are the biggest sources of water pollution in the manufacture of pulp and paper, causing a high BOD and water coloring. The post-washing black liquor from Kraft pulp, which accounts for over 80% of all chemical pulp produced in Japan, is normally concentrated and burned. As equipment to recover heat and chemicals are part of the plant, only 2 or 3% of the digesting wastewater is emitted. Air pollution is caused by the exhaust gas from the black liquor recovery boilers and lime kilns (part of the caustification equipment for recovered chemicals) that are connected with the digesting and washing process. These facilities emit particulate, SOx, and NOx. In Kraft pulp plants the sulfur compounds (methyl mercaptan, hydrogen sulfide, methyl sulfide, methyl disulfide, etc.) in condenser drains and blow gas cause offensive odors.



Source: Japan Paper Association "Pulp and paper handbook 1998"

Figure 5-2 Chemical pulp (Kraft pulp) manufacturing process

b) Screening

Screening is a process that removes foreign matter from pulp separated out in washing, and its main components are cleaners and screens.

Cleaners use centrifugal force and differences in specific gravity to separate pulp from foreign matter, and are suited to separating out things heavier than pulp, such as sand, metal scraps, undigested tree knots, and the like.

Screens separate pulp and foreign matter using size and shape, so pulp passes through the holes or slits in screen plates, while foreign matter remains on top of the plates.

<Associated Environmental Problems>

The main environmental problem arising out of screening is the generation of wastes. Grit, dregs, and other foreign matter removed from pulp account for about 6% of all industrial wastes generated in pulp and paper manufacturing. Depending on the type of pulp manufacturing, polluted water is emitted from the filters that come after the cleaners.

c) Bleaching

Pulp used for printing paper and other types that demand high whiteness require bleaching after digesting, washing, and screening. The bleaching effect in chemical pulp is heightened by alkaline extraction of lignin that could not be removed by in the digestion and washing processes, and then bleach is added. Because quick bleaching damages fibers, bleaching is often done slowly by repeating alkaline extraction followed each time by bleaching. Between each round, washing removes chemicals and eluted lignin.

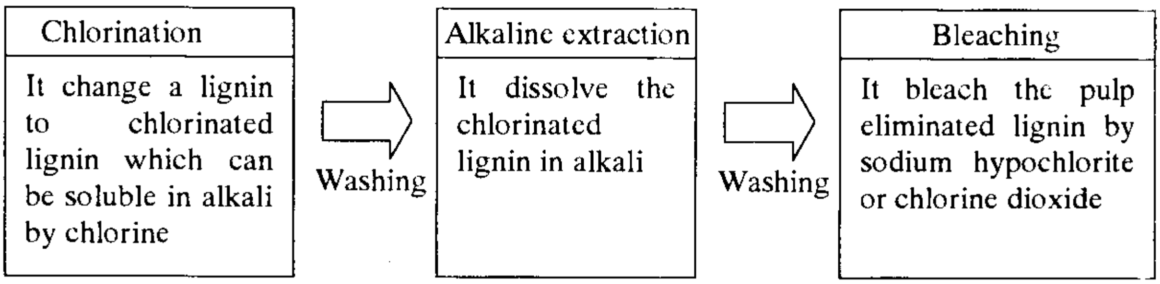


Figure 5-3 Bleaching process of chemical pulp

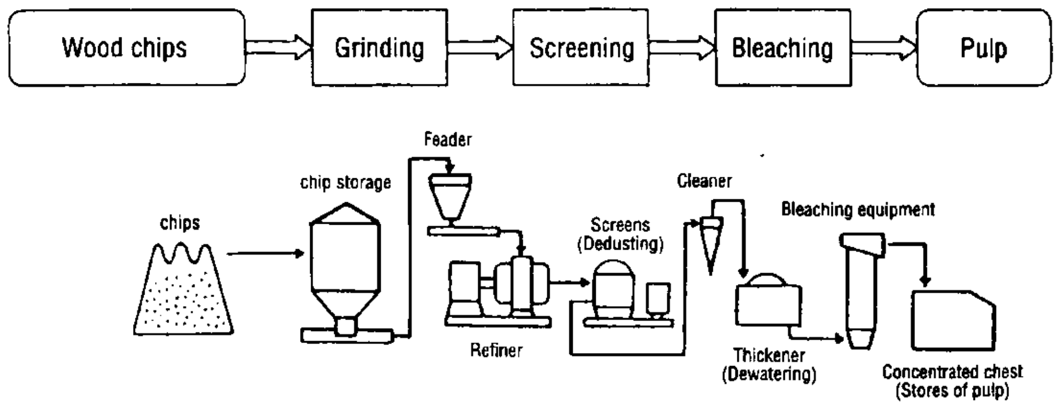
In general, chlorine was used widely for bleaching agent because of cheapness. However, oxygen bleaching method using oxygen or ozone instead of chlorine as much as possible becomes the main current recently, because chlorine bleaching is thought the cause of organic chlorine compounds such as dioxins.

<Associated Environmental Problems>

Water pollution is the main environmental problem caused by chemical pulp bleaching. Because, as noted above, lignin and other coloring substances are eluted before bleaching, wastewater from the bleaching process contains lignin and other dissolved organic compounds (chlorinated lignin, reduced sugars, organic acids), and bleaching chemicals. And as bleaching uses chlorine gas and chlorine-based chemicals, wastewater contains chlorinated organic compounds, including small amounts of dioxins.

(2) Mechanical Pulp

Mechanical pulp is made chiefly by the processes of grinding or refining logs or chips, screening, and bleaching. First, grinders or refiners grind logs or chips to break apart the fibers. The ground pulp then passes through screens, cleaners, or other cleaning equipment to screen it, and then it is bleached when whiteness is required. Fig. 5-4 shows the manufacturing process for mechanical pulp (refiner-ground pulp).



Source: Japan Paper Association "Pulp and paper handbook 1998"

Figure 5-4 Manufacturing Process for mechanical pulp (refiner-ground pulp)

a) Grinding

Grinding is the process that tears apart the fibers in logs and chips with mechanical processing such as grinders and refiners. Raw materials include not only logs, but also items like sawmill scraps, which were formerly discarded or burned. Pulp is classified into three types depending on the raw material and grinding method. Producing ground wood pulp involves mechanically grinding softwood logs by pushing them into a grinder. Refiner-ground pulp and thermo-mechanical pulp both grind chips in refiners, but while the former process grinds at atmospheric pressure, the latter grinds them at heating of 110-125°C under pressurization.

<Associated Environmental Problems>

The main environmental problems arising from mechanical pulp grinding are noise, vibration, and wastes. Grinding by mechanical means requires much energy, and the process generates noise and vibration. Grinding logs and chips also produces sawdust and other substances, but in volume they are a very small part of the total industrial wastes generated in pulp and paper manufacturing. When chips are washed before grinding in refiners, wastewater with a high organic content is emitted.

b) Screening

Just as with chemical pulp, mechanical pulp passes through screens, cleaners, or other cleaning equipment to clean it.

<Associated Environmental Problems>

The only environmental problem is the generation of wastes.

c) Bleaching

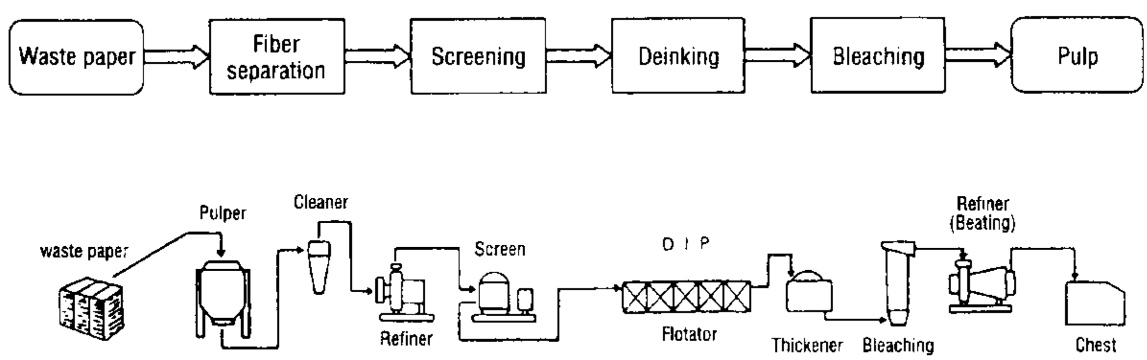
Since mechanical pulp still contains lignin from the wood, it is not removed in the bleaching process. Rather, bleaching agents like hydrogen peroxide and sodium hydrosulfite are used to decolor the lignin, but the bleaching effect is limited.

<Associated Environmental Problems>

The main environmental problem arising from mechanical pulp bleaching is water pollution by bleaching chemicals. However, mechanical pulp pollutes less than chemical pulp because it does not elute lignin or use chlorine chemicals.

(3) Waste Paper Pulp

The main manufacturing processes for waste paper pulp are fiber separation, screening, deinking, and bleaching, but the stages differ depending on the waste paper types and product use. To begin with, waste paper and water are put into a pulper, which separates the fibers with mechanical agitation, and then the pulp is screened with cleaners, screens, or other cleaning equipment. Ink particles are then separated from the fibers in a flotator or other deinking equipment, followed by bleaching if greater whiteness is required. Fig. 5-5 shows the manufacturing process for waste paper pulp.



Source: Japan Paper Association "Pulp and paper handbook 1998"

Figure 5-5 Manufacturing process for waste paper pulp

a) Fiber Separation and Screening

Fiber separation is the process of putting waste paper and water in a pulper and pulling the fibers apart with mechanical agitation. This process also removes large foreign objects. Pulper types differ according to the type of waste paper: Low-concentration pulpers are used to stir paperboard waste at concentration of 4-6%, while high-concentration pulpers stir high-quality waste at concentrations of 10-20%. Waste newsprint is processed in drum pulpers that have a high-concentration (12-20%) fiber separation zone and a low-concentration (3-4%) cleaning zone. There is also a cooking method that can deink and decolor as it separates fibers. While smaller in scale, it is relieved of the trouble of selecting waste paper types because it can be used with a wide variety of waste papers, and provides excellent pulp. A generally used type of pulper is the horizontally rotating spherical cooker using caustic soda for cooking.

Basically waste paper screening is done with cleaners, screens, or other cleaning equipment just as for chemical and mechanical pulp, but because waste paper contains many kinds of foreign matter, screening equipment is chosen according to waste paper type and product use.

<Associated Environmental Problems>

The main environmental problem in the fiber separation and screening for waste paper pulp is the generation of wastes. Waste paper eliminated in stock selection and waste paper residue account for about 4% of total industrial wastes generated in pulp and paper manufacturing. Another problem is water pollution by pulper water left after cooking. Especially when digestion is used, the lignin that remains in the waste paper is dissolved and becomes a water pollutant.

b) Deinking

Deinking is the process that increases whiteness by separating ink particles in waste paper pulp, and makes it possible to raise whiteness to 55-62% from the 40-45% at the time of fiber separation. Primary deinking methods are flotation and washing, but the former is chiefly used in Japan because it requires less water and allows easy wastewater treatment. A representative machine is the flotator, in which pulp diluted to about 1% is allowed to flow slowly, while air is introduced from below the machine by an air tube to produced bubbles. Ink particles separated from the fibers attach themselves to the bubbles, thereby deinking the pulp.

For recycled office paper and other types that are more difficult to deink than waste newsprint, the deinking rate is improved by means such as using a two-stage flotator, combining deinking equipment for both flotation and washing, or screening after the deinking operation.

<Associated Environmental Problems>

The main environmental problem in the deinking of waste paper pulp is water pollution by fine fibers, ink, and other matter.

c) Bleaching

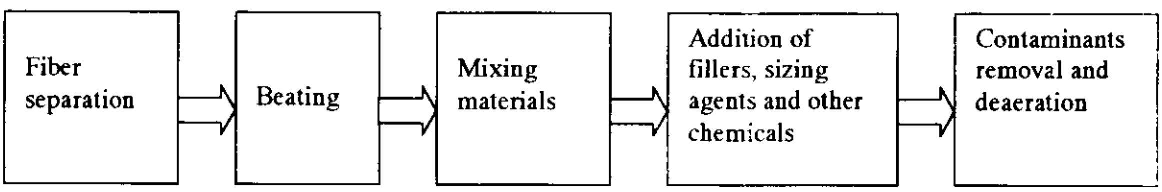
As deinking can attain only 55-62% whiteness, bleaching agents like hydrogen peroxide and sodium hydrosulfite are used for bleaching as with mechanical pulp when greater whiteness is required. When high whiteness is not required, one method used is to add bleaching chemicals such as caustic soda, sodium silicate, hydrogen peroxide, and surfactants, as well as auxiliaries, to the pulper that separates the waste paper fibers.

<Associated Environmental Problems>

Just as with mechanical pulp, the main environmental problems caused by waste paper pulp bleaching is water pollution by bleaching chemicals.

5.1.3 Stock Preparation

Stock preparation is the process for final preparation of the pulp for papermaking, and involves beating, stock mixing, addition of chemicals, and the like. The following diagram illustrates the main flow of the preparation process.



(1) Fiber Separation and Beating

First comes fiber separation of purchased pulp and broke. Fiber separation uses the same principle as the method used in making waste paper pulp.

After fiber separation, beaters beat the fibers to improve their moisture retention and strength. Beating is usually done at a concentration of 4-6%, and is performed separately for each type of raw material. Roughly there are two types of beating: Viscous beating that mainly turns the fibers into fibrils (i.e., splits them), and free beating, which mainly cuts the fibers. The way fibers are beat is crucial to how the web is formed.

(2) Mixing Materials

Stock materials are combined in prescribed amounts according to papermaking plans, and put in a mixing chest. Mixing also makes reuse of reclaimed materials such as broke from the papermaking and coating/finishing stages, and the whitewater from the stock preparation and papermaking stage.

(3) Addition of Fillers, Sizing Agents, and Other Chemicals

After combining the materials, various chemicals are added according to product use, such as fillers, sizing agents, retention aids, and strength additives.

(4) Contaminant Removal and Deaeration

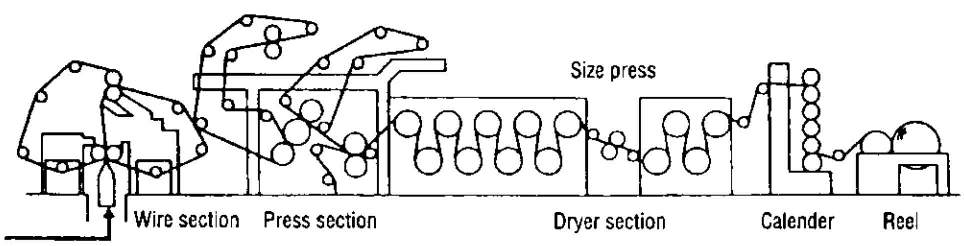
Just as in the pulp manufacturing process, screens and cleaners are used to remove contaminants, and deaeration is performed.

<Associated Environmental Problems>

The main environmental problem in the stock preparation process is water pollution. This stage emits cloudy water (whitewater) that contains fine fibers, fillers, and other materials, but this represents a relatively light pollution burden.

5.1.4 Papermaking

Paper making involves diluting and dispersing the prepared pulp stock to form a web, pressing to remove water and then drying in the dryers, applying sizing fluid, making the paper glossy, and finally winding the paper with reels. Fig. 5-6 shows the papermaking process.



Source: Japan Paper Association "Pulp and paper handbook 1998"

Figure 5-6 Papermaking process

(1) Wire Section

Pulp slurry is supplied through the sluice opening, spread out over wire mesh, and formed into a web while extracting water. At first the slurry has a concentration of 0.5%, which rises to about 20% after the wire section. Owing to structural differences among paper machines, they are categorized as fourdrinier, cylinder, or combination paper machines.

(2) Press Section

In this section the web (paper in the machine) is pressed to raise web concentration of 20% (80% water) to 40-50% (50-60% water) and form a stronger paper web. Pressing is accomplished by running the paper and felt between two rolls and applying pressure. Water leaving the paper is absorbed by the felt.

(3) Dryer Section

Here the wet paper from the press is heated by a dryer and dried until moisture content is 6-10%. Depending on the number of cylinders, dryers are either multi-drum or yankee dryers.

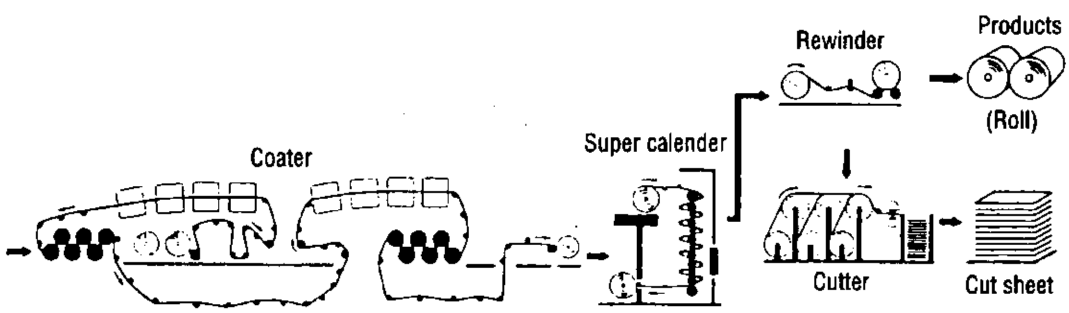
(4) Size Press, Calender, Reel

Starch or other materials are applied to paper in the dryer, which is part of the size press, to increase water resistance and surface strength. After paper emerges from the dryer it is pressed by calender rolls to give it smoothness and luster. Finally it is wound onto reels.

<Associated Environmental Problems>

The papermaking process yields much wastewater by pressing water out of the stock when forming a web, which makes water pollution the main environmental problem. Papermaking wastewater is cloudy white because it contains fine fibers and papermaking chemicals such as sizing agents, but it represents a relatively minor pollution burden. Normally after undergoing simple treatment, this effluent is reused in other processes.

5.1.5 Coating/Finishing



Source: Japan Paper Association "From person to person. From paper to paper"

Figure 5-7 Coating/Finishing Process

This process applies coatings depending on product quality and use, and finishes the product either in rolls or cut sheets. Fig. 5-7 illustrates the process.

(1) Coating

This process applies kaolin or other pigments to the paper surface to improve the appearance of the paper after printing. Methods are the on-machine method in which the paper machine and coater are directly connected, and the off-machine method in which they are separate. After application the coating material is dried in a dryer, and the calender gives the paper surface luster and smoothness.

(2) Finishing

This process finishes the product as roles, cut sheets, or other forms to accommodate customer needs.

<Associated Environmental Problems>

Coating and finishing cause no especially major environmental problems.

5.2 Environmental Measures

Present environmental measures in the papermaking industry can be roughly categorized into those for resource and energy conservation, and those for mitigating the environmental burden. The former shall be discussed in "6. Cleaner Production in the Pulp and Paper Industry."

5.2.1 Mitigating the Environmental Burden

The papermaking industry requires much water and energy for production, and creates a variety of environmental impacts including water pollution, air pollution, offensive odors, noise, vibration, and waste generation. For this reason the industry has implemented a number of measures to lessen its environmental burden.

The following sections will treat them separately.

(1) Water Pollution

Pulp and paper manufacturing processes use large amounts of water for dilution and washing. Reusable water is used repeatedly within processes, while other wastewater is discharged into the environment after treatment in facilities to reduce its environmental burden. Table 5-1 presents the main manufacturing processes that generate water pollutants, and shows that polluted water is emitted by nearly all processes. The main pollutants include bark, lignin, and other dissolved substances, digesting chemicals, bleaching chemicals, papermaking chemicals, fine fibers, and ink. Primary pollution abatement measures reduce the biological oxygen demand (BOD) and chemical oxygen demand (COD) caused by dissolved organic matter, and remove the suspended solids (SS).

Table 5-1 Process caused by main water pollution and pollution ingredient

Process		Main pollution ingredient
Wood preparation process		Bark
Pulp manufacturing process	Mechanical pulp	Dissolved ingredient of lignin
	Chemical pulp (digesting)	Dissolved ingredient of lignin, Digesting agents
	Chemical pulp (bleaching)	Dissolved ingredient of lignin, Bleaching agents
	Waste paper pulp (deinking)	Fine fiber, Papermaking agents, Ink
Papermaking process		Fine fiber, Papermaking agents

Table 5-2 shows effluent quality and amount, and the generally used treatment methods, for the main processes and their related facilities in the pulp and paper industry under the conditions imposed by the current state of facilities.

Table 5-2 Wastewater quality and quantity by main process type on pulp and paper industry

Process	Related facility	Quality of wastewater	Quantity of wastewater	General treatment method
Kraft pulp (KP)	Digesting facility Washing facility Bleaching facility	PH 7~9 BOD 300~700 COD_{Mn} 500~1500 SS 40~80 T-N 110 T-P 2	150~300 m^3 per one ton of pulp	Coagulating sedimentation method Activated sludge method
Sulfite pulp (SP)	Digesting facility Washing facility Bleaching facility	PH 3.5~4.5 BOD 300~500 500~1000 SS 50~300 T-N 100 T-P 3	150~300 m^3 per one ton of pulp (average: 300 m^3)	Coagulating sedimentation method Activated sludge method
Semi-chemical pulp (SCP)	Digesting facility Washing facility Bleaching facility	PH 3~7 BOD 200~600 COD_{Mn} 500~2000 SS 1000~3000 T-N 70 T-P 2	100~150 m^3 per one ton of pulp	Coagulating sedimentation method Activated sludge method
Ground pulp (GP) Thermo-mechanical pulp (TMP)	Chip dipping facility Refining facility Washing facility	PH 3.5~7.5 BOD 100~150 COD_{Mn} 200~300 SS 30~40	30~400 m^3 per one ton of pulp (average: 65 m^3)	Coagulating sedimentation method
Papermaking process	Papermaking facility	PH 8~9 BOD 150~200 SS 250~600	500~2000 m^3 / day	Flotation method Filtration method Sedimentation method

Note: Unit of BOD, COD_{Mn}, SS, T-N, T-P is mg / l
Source: Ministry of International Trade and Industry "Technology and Laws of Pollution Control"

The two ways of treating pollutants are physical/chemical and biological. In the former, the most often used method is coagulating sedimentation, which works by adding a coagulant to precipitate the fine suspended matter and pollutants in the wastewater. Other methods are simple sedimentation, pressure flotation, sand filtration, and activated carbon treatment. In the latter, many pulp and paper mills have been using biological treatment recently, which uses bacteria and other microorganisms to remove organic matters in wastewater with methods such as activated sludge and biofilm process.

These treatment facilities are built so that mills satisfy effluent standards, shown in Table 5-3, based on the Water Pollution Control Law. However, in actuality many mills have installed tertiary treatment facilities such as contact aeration and sand filtering because many prefectural governments have established Stricter Standards for enclosed and other important water areas with supplementary ordinances (which are allowed by Water Pollution Control Law).

Table 5-3 Effluent standards (Pulp and paper manufacturing industry)

Parameter	Water Pollution Control Law	Stricter Standards by Ordinance in Chiba Prefecture *1	Stricter Standards by Ordinance in Shiga Prefecture *2
BOD (mg/l)	160 (Daily average: 120)	10~60	20~120
COD_{Mn} (mg/l)	160 (Daily average: 120)	10~60	20~120
SS (mg/l)	200 (Daily average: 150)	20~120	70~150

Notes: *1; Different standard value is used by quantity of wastewater, water area and established date of manufacturing facility.
*2; Different standard value is used by quantity of wastewater and established date of manufacturing facility.

Table 5-4 Installations of wastewater treatment facilities according to treatment flow

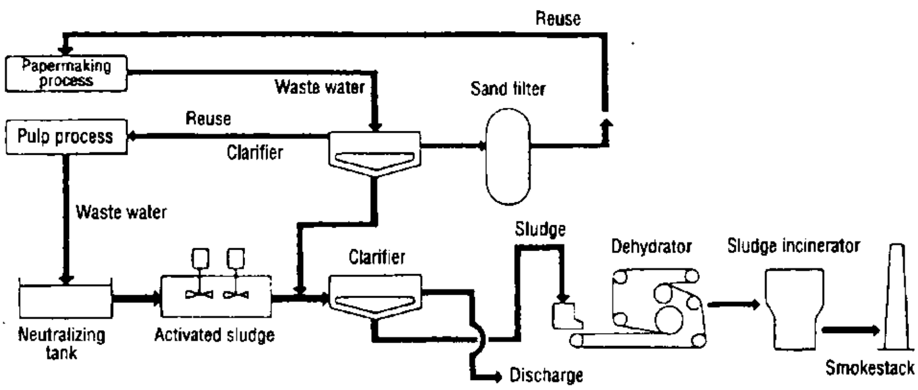
	Treatment flow	Target wastewater		
		Pulp	Papermaking	Waste paper, DIP
Single stage treatment	1. A (Simple sedimentation)	1	1	2
	2. A (Coagulating sedimentation)	11	39	8
	3. A (Pressure flotation)	4	19	9
	4. B (Activated sludge)	7	2	2
	Sub-total	23	61	21
Multi stage treatment	5. A+A	2	19	5
	6. A+B	26	24	22
	7. A+B+A	7	7	10
	8. A+B+A+A	2	2	2
	9. Others	-	1	3
	Sub-total	37	53	42

A: Physical and chemical treatment; Simple sedimentation, Coagulating sedimentation, Pressure flotation, Sand filtration, Activated carbon
B: Biological treatment; Activated sludge, Contact filtration, biological slime, Rotating biological contactor, Anaerobic treatment, Trickling filter

Note: Questionnaire in 1991, number of answer factory is 110, cover rate of production is about 83%
Source: Japan Paper Association "From person to person. From paper to paper"

Table 5-4 shows installations of wastewater treatment facilities according to treatment flow. As one can see, many mills treat wastewater from pulp and waste paper/DIP with a combination of physical/chemical and biological methods, and for papermaking wastewater many mills use single-stage treatment with only coagulating sedimentation.

Fig. 5-8 is a wastewater treatment flow example. Wastewater emitted by the pulp manufacturing process is pH adjusted in a neutralizing tank, undergoes activated sludge process and sedimentation treatment, and is then discharged. Wastewater from the papermaking process is put in a clarifier to remove solids, then some is reused for dilution when mixing stock, and some for dilution in the pulp manufacturing process. The rest is run through sedimentation treatment facilities once again, then discharged. Sludge separated by sedimentation is dehydrated and then incinerated.



Source: Japan Paper Association "Pulp and paper handbook 1998"

Figure 5-8 Wastewater treatment flow example

(2) Air Pollution

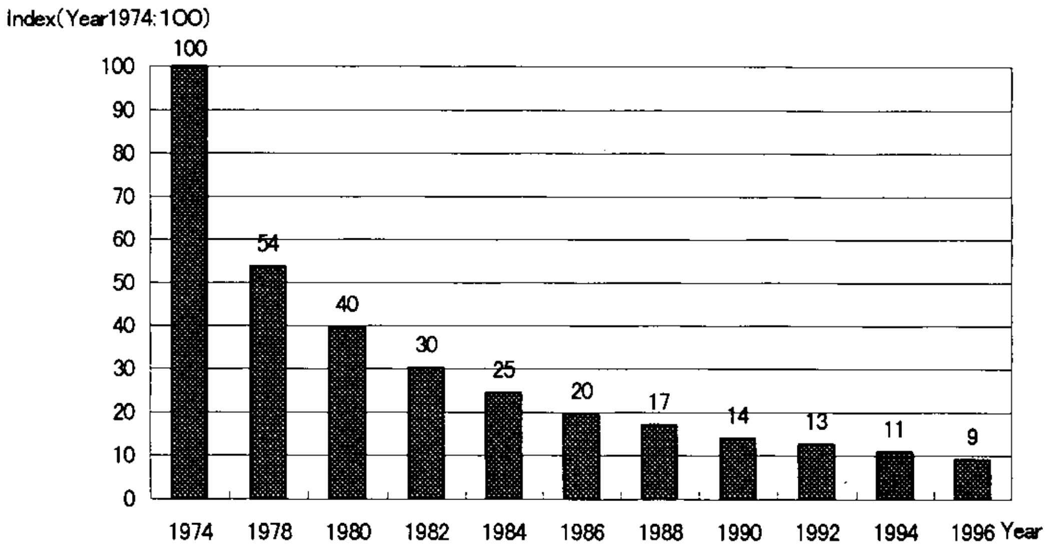
Pulp and paper manufacturing processes use a variety of boilers and incinerators that emit particulates, sulfur oxides (SOx), and nitrogen oxides (NOx). Another problem in recent years is the dioxins produced in sludge incinerators.

Pulp and paper mill boilers mostly use fuel oil C, which is cheap but high in sulfur. Other boiler types burn coal and petroleum coke, bark and wood scraps, or other fuel. A boiler type peculiar to the pulp and paper industry is the black liquor recovery boiler, which in Kraft pulp mills recovers the black liquor and burns the organic materials it contains, using the steam produced as one of the energy sources.

Pulp and paper mill incinerating facilities include sludge incinerators that burn sludge and other materials from effluent treatment facilities, and lime kilns that fire quicklime from the sludge (calcium carbonate) produced in the chemical recovery process of Kraft pulp mills.

Mills increase their particulate capture rate by upgrading their wet scrubbers, bag filters, and other filtering equipment.

Some ways mills cut their SOx emissions are using low-sulfur fuels and installing flue gas desulfurization equipment, the results of which appear in Fig. 5-9. Sulfur captured by flue gas de-SOx equipment is used as an ingredient in the digesting chemicals.



Source: Japan Paper Association "Pulp and paper handbook 1998"

Figure 5-9 Unit value of SOx emissions on pulp and paper industry

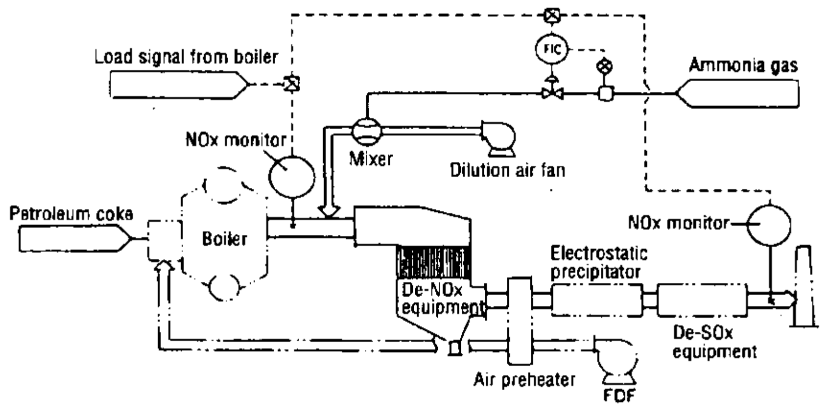
NOx emissions are reduced by switching to low-nitrogen fuels, as well as modifying combustion conditions and improving combustion methods. Some mills have installed flue gas denitrification equipment (dry process) that uses catalytic reduction with ammonia, which reduces NOx to N_2 gas. Table 5-5 shows the primary NOx reduction measures.

Table 5-5 Primary NOx reduction measures

Restraint of NOx generation	Fuel conversion	Conversion to low nitrogen fuel	
	Combustion improvement	Change of operating condition	Degrease of air ratio Degrease of heat load of combustion room Degrease of pre-heat temperature of air
		Remodeling of combustion equipment	Two-stage combustion Flue gas recirculation Bias combustion Blowing of water or steam Utilization of low NOx burner
Flue gas denitrification	Dry catalytic reduction process		

Source: Ministry of International Trade and Industry "Technology and Laws of Pollution Control"

Fig. 5-10 illustrates a flue gas treatment flow example. Flue gas from a boiler runs through de-NOx equipment using ammonia gas, an electrostatic precipitator, and de-SOx equipment to remove NOx, particulates, and SOx, respectively. Treated gas exits through a smokestack.



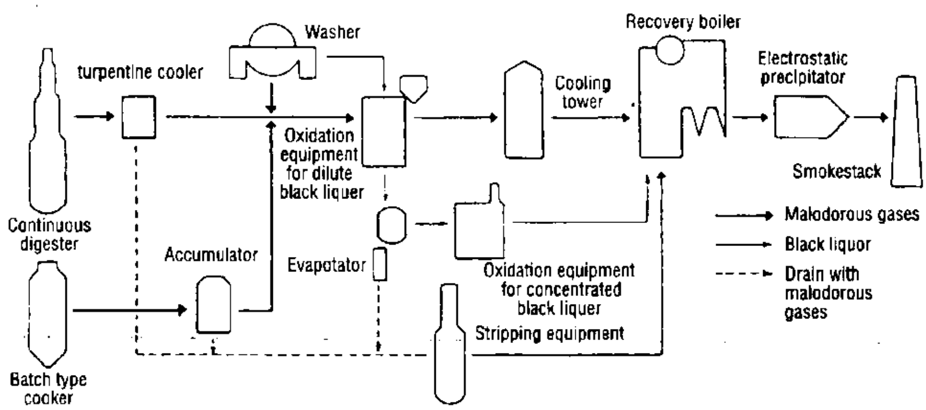
Source: Japan Paper Association "Pulp and paper handbook 1998"

Figure 5-10 Flue gas treatment flow example on a boiler

(3) Offensive Odors

Chemical pulp mills frequently emit disagreeable smells. Especially Kraft pulp mills emit offensive odors from the digester that cook chips, the evaporator that concentrate cooking liquid, and the recovery boiler that burn concentrated black liquor. Main sources of the offensive odors are sulfur oxides such as methyl mercaptan, hydrogen sulfide, methyl sulfide, and methyl disulfide.

To deal with this problem, malodorous gases are collected and burned. Treatment of wastewater contained malodorous gases involves the use of stripping equipment to separate the odor-causing constituents from the wastewater, and sending the resulting malodorous gases to incineration facilities along with the air supply. Fig. 5-11 illustrates one process for treating offensive odors.



Source: Japan Paper Association "Pulp and paper handbook 1998"

Figure 5-11 Offensive odor treatment flow example

(4) Noise and Vibration

Production machinery in the papermaking industry is large and in many cases runs around the clock, so that especially at night noise and vibration are problems. In recent years another problem is low-frequency atmospheric vibration, which affects people by causing headaches, unpleasant feelings, and the like. Table 5-6 shows how the industry deals with noise, vibration, and low-frequency atmospheric vibration.

Table 5-6 Noise, vibration, and low-frequency atmospheric vibration measures

Countermeasure for noise	Countermeasure of source	Control of generation of abnormal sound by maintenance of machine and equipment
	Establishment of silencer	Installation of silencer for blower, compressor, inlet and outlet port of internal combustion engine, inlet and outlet of wall of building
	Countermeasure in and around noise source	Installation of sound cover or sound screen
	Improvement of noise insulating efficiency of mill building	Increase of transmission loss of wall, and acoustic absorption treatment
	Control of noise propagation	Degrease by distance attenuation
	Shield of noise by building	-
Countermeasure for vibration	Countermeasure of source	Control of imbalance operation of rotor, maintenance of machine and equipment
	Control of vibration propagation	Application of distance attenuation, construction of ditch
Countermeasure for low-frequency vibration of air	Basic countermeasure is as same as noise and vibration control. It is important to plan the countermeasure on understanding of generating mechanism of low-frequency vibration of air	

Source: Sangyo Chosakai "Noise and vibration control equipment"

(5) Wastes

Table 5-7 lists the wastes generated by pulp and paper manufacturing processes. Cinders, sludge boiler ash, and sludge incineration ash account for nearly 70% of total wastes. Other major wastes are sludge from wastewater treatment processes, bark, and residues generated by manufacturing processes.

Because the papermaking industry's main raw materials are wood and other natural organic substances, the bark, residues, ash, and other materials from manufacturing processes are recyclable resources that are reused. Manufacturing processes also use chemicals, fillers, and other materials, but they use no hazardous heavy metals or organo-chlorine compounds like tetrachloroethylene.

Table 5-7 Wastes volume generated by pulp and paper manufacturing processes and reuse

Unit: 1,000 t/year

No.	Kinds of waste	Generated volume			Effective utilization (dry base)
		Gross	Dry base	Component ratio	
1	Waste of store place	39	17	1.1	0
2	Bark, saw dust	83	40	2.6	38
3	Loss paper, paper waste	19	16	1.1	10
4	Waste paper refuse	206	58	3.8	8
5	Pulp refuse	40	17	1.1	13
6	Grit, dregs	148	78	5.0	32
7	Sludge from wastewater treatment	371	145	9.4	62
8	Bark boiler ash	23	14	0.9	1
9	Boiler ash	21	13	0.8	2
10	Coal cinders	589	466	30.2	356
11	Sludge boiler ash	278	190	12.3	90
12	Sludge burned ash	496	357	23.2	174
13	Waste burned ash	7	4	0.3	0
14	Sludge of flue gas desulfurization	31	21	1.4	19
15	Waste oil	2	2	0.1	2
16	Waste paper, waste plastic	33	16	1.0	3
17	Coating waste	6	3	0.2	0
18	Sludge of clear water	22	9	0.6	0
19	Construction waste	31	29	1.9	2
20	Metal trash	32	22	1.4	14
21	Other sludge	23	12	0.8	3
22	General waste	12	10	0.7	0
Total		*2,509	1,540	100	828

*Generated volume is a round number in the unit 1,000 tons, therefore total is not fit.

About 30% of the wastes generated in manufacturing processes are used as a raw material for cement. Other uses include compost, soil conditioners, heat retainer for molten steel, and fuel.

(6) Dioxins

As part of the Environment Agency's initiative to control dioxins, in 1990 it investigated dioxin emissions from pulp and paper mills, and their surrounding environments. After assessing the results it announced countermeasures in 1991.

The study was performed mainly on total effluents at 60 mills producing pulp and paper and covered a broad spectrum comprising: wastewater from processes, wastewater sludge, ashes and dust from sludge incinerators, wastewater and other materials associated with final waste disposal sites, flue gas from black liquor recovery boilers, ambient air, public waters into which mill effluent is released, and the fish and shellfish from fishing grounds near mills.

Table 5-8 Result of urgent dioxin study concerned pulp and paper manufacturing factory

Subject of study	Facility of subject	Numbers of sample	2,3,7,8-TCDD detection ratio	Total dioxin concentration (Conversion to toxic equivalent) NATO·TEQ			
				Max.	Min.	Ave.	Medium
Integrated wastewater (Unit: ng/l)	Pulp and paper mill (60 mills)	60	5/60	0.090	0.000	0.005	0.001
Process wastewater (Unit: ng/l)	Virgin pulp mill (2 mills)	6: Bleaching process 2 Paper making process 2 Effluent before treatment 2	2/2 0/2 0/2	0.075 0.001 0.012	0.035 0.000 0.005	0.055 0.001 0.009	0.055 0.001 0.009
Wastewater treatment sludge (Unit: ppb)	Wastewater treatment sludge generated from virgin pulp mill (4 mills)	4: 1x4 mills	1/4	0.19	0.00	0.05	0.01
Ciders, dust (Unit: ppm) Exhaust gas ($Unit:ng/m^3N$)	Incinerator for wastewater treatment sludge generated from virgin pulp mill (4 mills)	12: 3x4 mills	C 1/4 D 2/4 G 2/4	C 0.03 D 12 G 0.73	C 0.00 D 0.00 G 0.01	C 0.015 D 3.1 G 0.41	C 0.015 D 0.10 G 0.44
Leachate of final disposal site of waste, Surrounding groundwater (Unit: ng/l)	Final disposal site of waste generated from pulp and paper mill (3 facilities)	7: Leachate 4 Surrounding groundwater 3	0/4 0/3	0.001 0.001	0.000 0.000	0.001 0.001	0.001 0.000
Exhaust gas of black liquor recovery boiler ($Unit:ng/m^3N$)	black liquor boiler (5 facilities)	5: 1x5 facilities	0/5	0.18	0.00	0.06	0.01
Surrounding ambient air ($Unit:pg/m^3N$)	Ambient air surrounding mill (3 areas)	6: 2x3 areas	0/6	2.1	0.00	0.97	1.0
Public water area (Unit: ng/l)	Sea area and liver to which wastewater of mill discharges (6 areas)	6: 1x6 areas	0/6	0.003	0.000	0.002	0.001
Fish and shellfish in surrounding fishery (Unit:ppt)	Fishery close by mill (15 water areas)	75: 5x15 water areas	1/75	3.5	0.00	0.23	0.00

Notes: C ; cinders, D; dust, G; exhaust gas

Source: Environment Agency, Government of Japan

Following are the main points of the investigation and assessment performed using study results.

A. The link between chlorine bleach and dioxin formation

- Because on the average mills that use chlorine emit more dioxins than mills which do not, it is necessary to reduce the use of chlorine in bleaching processes.
- It is important to appropriately manage operating conditions, such as by using no more than the necessary amount of sodium hypochlorite (NaClO), a chemical used in recycled paper mills and the like, and by exercising care in not letting the pH fall in bleaching processes.

• Chlorine is replaced by oxygen (O_2) and chlorine dioxide (ClO_2), chemical agents which are used in bleaching processes, and which present low possibility of dioxin formation.

B. The link between incineration facilities and waste treatment, and dioxin formation

• Controlling the formation of dioxins from incineration necessitates taking care to perform complete combustion by properly managing the process, and also paying careful attention to the operating conditions of flue gas treatment equipment.

C. Wastewater treatment

• It is effective to thoroughly remove suspended substances.

D. Total dioxins generated by pulp and paper mills

• Estimates on how much of the total dioxins generated at pulp and paper mills moves to environmental media suggest that the water, atmosphere, and wastes each receive tens percent, with another fraction going to paper products. This calls for balanced measures to suppress dioxin in the water, atmosphere, and wastes, as well as paper products.

The Environment Agency also evaluated the following assessment of environmental impacts.

"The two main routes through which people are exposed to the dioxins generated at pulp and paper mills are consumption of fish and shellfish from fisheries near mills, and breathing ambient air, but contamination of the environment around mills as ascertained by this study was judged to be of about the same extent as in the results of studies performed by the Environment Agency heretofore on fish and shellfish and ambient air in the general environment. Although assessments of dioxin toxicity are still in a state of flux at present, in view of the state of dioxin contamination in the general environment according to Environment Agency studies performed thus far, the assessment of groups including the Chemical Substance Experts Committee of the Environment and Health Subcommittee in the Central Council for Environmental Pollution Control is that, at this point in time, dioxins likely do not damage human health. Accordingly, pollution in the vicinity of pulp and paper mills as revealed by this study's results likely does not damage human health, but the basic position on dealing with dioxin pollution is that, just as with other pollutant sources, it is proper to reduce the formation of dioxins and their environmental concentrations, and desirable to quickly enact various measures for that purpose."

On the basis of that assessment, requests were addressed to the pulp and paper industry, involved administrative organizations, and other entities to enact the necessary measures.

5.2.2 Pulp and Paper Industry Initiatives for Environmental Measure

(1) Initiatives by the Industry Heretofore

a) Protecting Resources

On not a few occasions there are references to the pulp and paper industry as the prime destroyer of forests. The industry recognizes that securing wood resources is crucial to itself, and that this presents an important challenge in contributing to global environmental conservation. Efforts directed at growing trees in other countries have been made by means of company associations and the establishment of new companies.

b) Promoting Waste Paper Use

In the belief that it is essential to deal actively with matters such as protecting resources and managing municipal wastes, in 1990 the Japan Paper Association set a 55% target for the use of waste paper, developed the "Recycle 55 Plan," and encouraged waste paper use. In 1994 the association released "The Desirable State of Waste Paper Use from the Perspective of the Papermaking Industry," a report which included these items.

a. Current state of waste paper use
b. Progress report on the "Recycle 55 Plan"
c. The approach to the post-55 (year 2000) goal
d. Expansion of diverse uses for waste paper
  - Encouraging new uses for waste paper other than as material for papermaking
  - Expansion of use through thermal recycling (burning to recover heat, use in Refuse-burning power) and international recycling (waste paper trade)

Meanwhile, the Paper Recycling Promotion Center encourages new uses other than as raw material for papermaking, such as pulp molds and paper pallets.

In 1994 the Japan Paper Stock Association released the "Special Committee Report on Paper Recycling Problems," in which it discussed the way paper recycling should proceed henceforth, and the role of the paper recycling industry.

(2) Voluntary Action Plan for the Environment

At present the industrial community is conducting voluntary initiatives on the environment. The Japan Paper Association also recognizes the necessity and effectiveness of voluntary and positive efforts for resources and the environment by all parties, and in January 1997 established the "Voluntary Action for the Environment" program in response to the "Federation of Economic Organizations Environmental Appeal" (July 1996). Table 5-9 shows the basic policy and main plans for action, which involve an active response to deal with global warming, as well as efforts to build a material circular society, and to set up and firmly establish environmental management systems.

Table 5-9 "Voluntary Action Plan on the Environment" by Japan Paper Association (extract)

[Basic Principle]

1. Maximum efforts must be pursued for the solution of the global warming problem, including the international initiatives.
2. Creation of a circular society must be attempted, in which the environment is carefully protected and the resources are utilized sustainably and efficiently.
3. Further efforts should be made to build and standardize the environmental management systems.

[Action Plan]

1. Measures against the global warming include:

(1) To further promote energy efficiency (fossil fuel), absorption and stabilization of CO_2, control of CO_2 emission by circular use of carbon;
(2) To aim at a 10% reduction in basic unit of energy purchase per product by the year 2010, from the level of 1990; and
(3) To promote domestic and overseas reforestation with a target of expanding the owned or managed forest areas to 550,000 ha by the year 2010.

2. Creation of Circular Style Economy and Society, etc., includes:

(1) To attempt conservation of forest resources, as well as shifting to "raw materials to grow";
(2) To aim at a 56% use of recycled paper by the year 2000;
(3) To aim at a 60% reduction in final disposal (basic unit) per product of industrial waste by the year 2010, from the level of 1990;
(4) To promote measures against the environmental risk issue caused by low amount chemical substances; and
(5) To think globally and act locally.

3. Establishment and standardization of environmental management systems include:

- To make, implement and audit environmental management plans to improve environmental impacts at all stages, including extraction of raw materials, production, usage and disposal, with a perspective that it is not sufficient to just comply with environmental regulations; and
- To include environmental considerations into management decisions, and play an active role in environmental problems as an essential business activity.

4. Environmental considerations in overseas projects

Overseas projects must comply with the "10 categories of environmental consideration in overseas projects" outlined in the Global Environment Charter by the Federation of Economic Organizations, and further promote environmental considerations.

(3) Controlling Dioxins

During recent years dioxins has risen into the ranks of environmental issues. It is said that in the bleaching processes used by the pulp and paper industry, the lignin remaining in pulp and the chlorine used as bleach react to form very small amounts of dioxins.

Since 1990 Japan's administrative agencies and paper industry have been working on the dioxin problem. As shown in Fig 5-10, the Japan Paper Association published voluntary industry guidelines that set voluntary targets for AOX (Adsorbable Organic Halogens) in wastewater, and mill operating guidelines. The target was that Kraft pulp mills and sulfite pulp mills would by 1993 reduce their wastewater AOX to under 1.5 kg per ton of pulp, and this target was achieved on schedule. Operating guidelines comprised promotion of lignin reduction in the digesting process, better pulp washing, bleaching process improvement, coagulation and biological treatment of wastewater, and incineration of sludge from wastewater treatment.

Table 5-10 Guidelines of measures against dioxins, established by Japan Paper Association

[Voluntary target figure of AOX in discharged water]

The amount of organic chlorine contained in the water discharged from all the factories producing bleaching Kraft pulp and dissolved pulp must be restricted to 1.5 kg or below per pulp-ton, on the basis of the AOX measuring figure, by the end of the year 1993.

[Operational guidelines for factory facility]

The following operational guidelines are set for factory facility, in order to control the generation of dioxins at factories producing bleaching Kraft pulp and dissolved pulp:

(1) Lignin reduction must be promoted during the digesting process;
(2) The amount of lignin brought into the bleaching process must be reduced as much as possible, by washing thoroughly during the washing/screen process;
(3) During the bleaching process:
  A. The amount of chlorine used should be reduced, by introducing oxygen bleaching;
  B. The adding rate of chlorine, relative to the kappa number (index of lignin amount remaining in the pulp) should be lowered;
  C. Part of chlorine at the chlorine stage should be altered to carbon dioxide;
  D. Oxygen should be used in the alkaline stage;
(4) Coagulation treatment and biological treatment should be carried out during the discharged water treatment process; and
(5) The principle is that sludge from the wastewater treatment facility is incinerated.

Notes: It is said in general, when AOX decreases, a concentration of dioxins contained in AOX is also decrease. With less than 1.5 kg per one ton of pulp, a concentration of dioxins becomes a level of which detection is impossible.

Table 5-11 presents the results of a 1996 Japan Paper Association study of dioxins in the wastewater of all bleached pulp plants. Dioxin concentrations were substantially lower than in the 1991 study, and emission intensity was down 96%.

Table 5-11 Actual study results of dioxins

Unit: ppt (Conversion to toxic equivalent)

Organization of study	Japan Paper Association	Environment Agency	Japan Paper Association
Year of study	1991	1991	1996
Subject of study	Integrated wastewater of 18 mills of bleaching pulp production	Integrated wastewater of 60 mills included 34 of bleaching pulp production	Integrated wastewater of 32 mills of bleaching pulp production
Numbers of sample	18	60	32
Range of detection	0.000~0.095	0.000~0.090	0.000~0.006
Average value	0.010	0.005	0.001
Medium value	0.001	0.001	0.000

Source: Japan Paper Association "Pulp and paper handbook 1998"

Table 5-12 shows the AOX limits for various countries. Japan's targets are at about the same level or slightly stricter than those of Canada and Northern European countries.

Table 5-12 AOX limits for various countries

Name of country		Details of regulation
Japan		1.5 : Voluntary target value in end of 1993
Canada	British Columbia state	Discarded plan (proposal: less than 2.5 in end of 1991, less than 4.5 in end of 1994)
	Quebec state	Under the consideration: 1.0~2.5 in end of 1991
	Ontario state	Less than 2.5 : From end of 1990
	Manitoba state	Under the consideration: Less than 1.5 in end of 1991
	Alberta state	Less than 1.4~3.0 in end of 1990
United States		Under the consideration: Target in 1995
Finland		Under the consideration: Less than 1.4 in end of 1995
Norway		Under the consideration: Less than 2.0 in end of 1995
Sweden		1.5~2.0 : End of 1990, 1.0: end of 1995

Notes: Details of regulation is a value of AOX, and unit is kg per one ton of pulp
Source: Industrial Engineering Association "View to the solution of dioxins contamination problem"

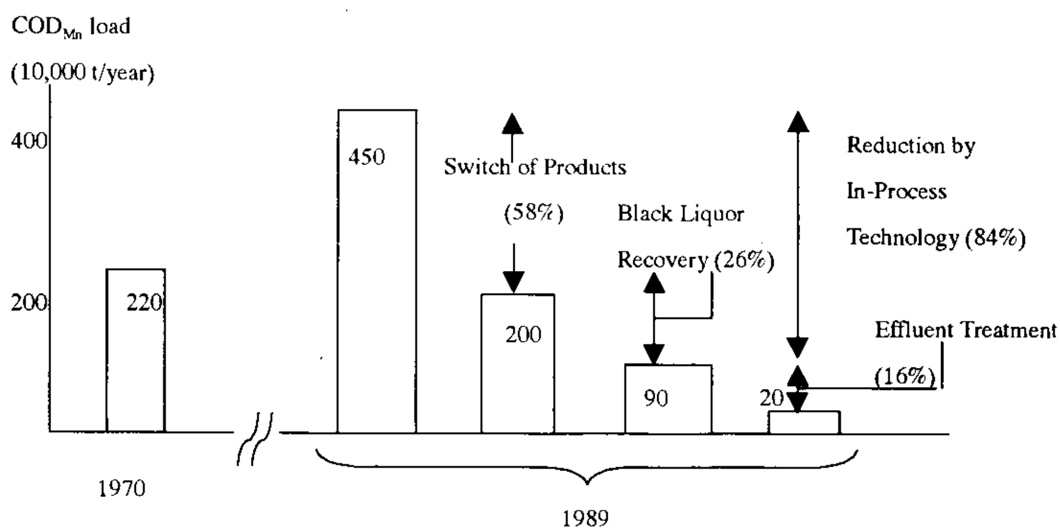
6. Cleaner Production in the Pulp and Paper Industry

6.1 Background

Cleaner production means reassessing raw materials and processing technologies, and improving or streamlining production processes themselves in order to reduce pollution. In other words, if factories control pollution by applying in-process technology, this will serve to conserve both resources and energy, and to cut production costs. Developed countries' experiences in pollution control clearly show that this is a superior and effective approach. Developing countries lack sufficient funds and technological prowess to apply to environmental measures, and owing to the great effectiveness in promoting industry and raising productivity, they want very much to embrace cleaner production as a means of working toward environmentally friendly sustainable development.

6.1.1 The Effectiveness of Cleaner Production

Fig. 6-1 is often invoked to illustrate the effectiveness of cleaner production in Japan's pulp and paper industry.



Notes: The largest bar in 1989 shows the estimated COD load with measures. The rightmost bar (the shortest one) in 1989 is the actual COD load with cleaner production technology and end-of -pipe measures. The two bars in the middle show the estimated loads with different cleaner production processes.

Source: "Japan's Experience in Urban Environmental Management" (W.B.)

Figure 6-1 COD_{Mn} load of waste water from pulp and paper industry

In the 1970s, Japan's pulp and paper industry produced about 13 million tons of paper and paperboard annually, and the industry's corresponding COD_{Mn} was 2.2 million tons/year. The industry's 1989 annual production was about 26.8 million tons, and a simple proportional calculation puts the corresponding COD_{Mn} at about 4.5 million tons. However, the actual COD_{Mn} was a mere 200,000 tons. The reasons for such a large reduction are a 58%

reduction through production process modifications and a 26% reduction through black liquor recovery, for a total 84% reduction attributable to cleaner production. By contrast, the pollution reduction achieved by effluent treatment facilities so-called end-of-pipe technology was a mere 16%.

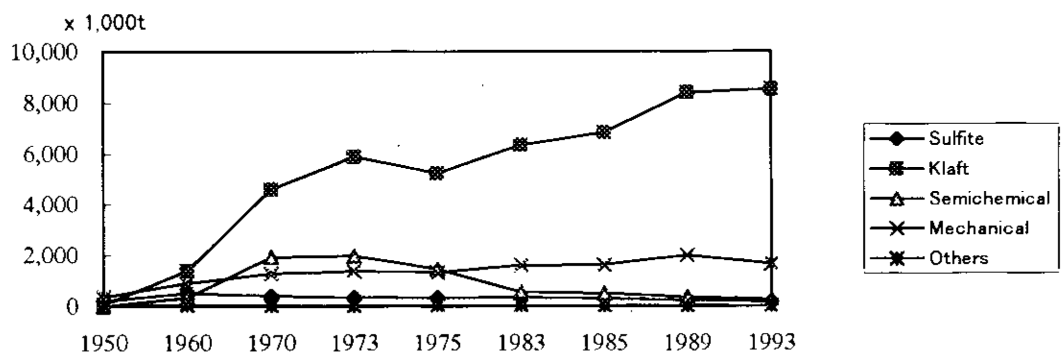
6.1.2 The Switch to Kraft Pulp

A look at the production processes responsible for that 58% reduction shows that mainly it was the result of a big shift from coping with problems in semichemical and mechanical pulp to the production of Kraft pulp.

Kraft pulping has a long history. Its advantages include a short cooking time, simple procedures, and strong pulp, but the disadvantage is that the resulting pulp has a dark brown color and is hard to bleach. Nevertheless, paper demand grew with Japan's postwar economic reconstruction, new production facilities were built to meet the demand, and beginning in the 1950s the industry rapidly increased production.

Wood used for pulping in the 1950s was mainly pine, but there were limits to how much could be supplied, and it became harder to obtain. The supply/demand problem was so serious that in 1958 the Ministry of International Trade and Industry had no choice but to limit pulp and paper production facilities by reason of insufficient logs. Hopes then turned to the use of hardwood trees as a wood resource, but a disadvantage of hardwood trees is that their fibers are shorter than those of softwood trees, thereby producing paper with less strength.

But at about this time Kraft pulp technology developed rapidly in other countries, solved the problem of strength in hardwood-based paper, and accomplished great strides in bleaching techniques. During the 1950s Kraft pulp factories using new technologies were built also in Japan, where papermaking technologies using hardwood gradually became established.

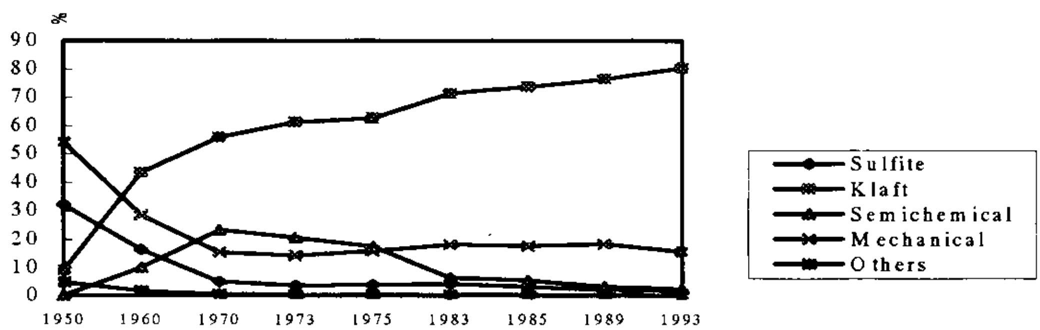


Source: This figure was prepared from numerical data in the "Pulp and Paper Handbook (Japan Paper Association)" and "Practical Knowledge of Pulp and Paper (Toyo-Keizai-Shinpo-Sya)"

Figure 6-2 Changes in production volume for various kinds of pulp

In the ensuing years the Japanese papermaking industry rapidly incorporated Kraft pulping, which could be adapted to nearly all types of wood including softwood, hardwood, and tropical wood. Kraft pulping therefore allowed the industry to expand production to meet quickly rising demand. Fig. 6-2 shows the changes in production volume for various kinds of pulp from 1950 to 1993, from which one can see that Kraft pulp has grown far faster than semichemical or mechanical.

Fig. 6-3 shows the proportions of various pulp types in total production. From 1950 to 1970 sulfite pulp and mechanical pulp fell precipitously, in contrast to which Kraft pulp accounted for an increasing percentage.



Source: This figure was prepared from numerical data in the "Pulp and Paper Handbook (Japan Paper Association)" and "Practical Knowledge of Pulp and Paper (Toyo-Keizai-Shinpo-Sya)"

Figure 6-3 Proportions of various pulp types in total production

And because Kraft pulp uses large amounts of digesting chemicals, it is economically advantageous to recover the chemicals by concentrating and burning the black liquor that is produced when lignin in the wood elutes into the digesting chemicals, and to recover the heat from incineration to generate steam. Owing to these advantages, black liquor burning and chemical recovery are basic parts of the Kraft pulp manufacturing process. So although paper manufacturers did not necessarily incorporate manufacturing methods using mainly Kraft pulp to be environmentally friendly, their choice in effect had the desirable consequences of conserving energy and reducing the environmental load of black liquor, which is the highest COD load in the pulp and paper industry.

6.1.3 Resource and Energy Conservation Measures

The aim of measures to conserve resources and energy, which are intimately linked to cleaner production, is to reduce to the maximum extent the use of wood, water, and other resources, and energy like fuel oil and electricity, which are consumed in manufacturing pulp and paper. Some specific measures are promoting the use of waste paper, installing energy-conserving facilities, and making improvements that lead to more efficient equipment and operations.

(1) Reducing Wood Use (Waste Paper Utilization)

Section 4.1, the overview of the pulp and paper industry, presented the amounts of waste paper consumed and recovered in Japan, whose waste paper usage rate is among the world's highest, at 53.4% in 1995. Underlying this high rate are efforts by consumers and technological development by papermaking companies. The latter includes environmentally considerate, cutting-edge technologies such as those for contaminant removal, deinking, and bleaching. Recent years have also seen corresponding legislation. The Law for the Promotion of Utilization of Recyclable Resources (Recycling Law), the Law on Temporary Measures to Promote Business Activities for the Rational Use of Energy and the Utilization of Recycled Resources, and the Law Concerning the Promotion of the Separation, Collection and Recycling of Containers and Packaging call on businesses to use reclaimed materials. Further, the "Ordinance Establishing Items to be Used as Criteria for Determinations Concerning the Use of Reclaimed Paper by Parties Running Papermaking Operations", which was established pursuant to the Recycling Law, sets forth a year 2000 target of 56% for the waste paper utilization rate in paper made by domestic producers, which is to be achieved by building facilities, improving technologies, formulating plans for waste paper utilization, and information provision.

(2) Reducing Water Use

Measures to reduce water usage roughly break down into two categories: Those to reduce the absolute amount of water used, and those that reduce the use of fresh water by reusing water.

One way of reducing absolute water use is to install replacement washing equipment. The usual way of washing pulp has been to dilute it with washing water and then dewater, which necessitated prodigious amounts of water, but developed in recent years is the replacement washing method such as diffusion washer, which uses washing fluid to push out impurities without diluting the pulp, thereby contributing greatly to water use reduction.

Ways to recycle water are the reuse of washing water in the pulp manufacturing process, and the use of whitewater, which is generated in large amounts in the papermaking process, as for diluting water when making pulp and mixing raw materials. Fig. 6-4 shows a representative reuse flow for the whitewater from paper machines.

It works by using dewatered, high-concentration whitewater in the first half of the wire section, and in the second half supplementing any insufficiency with dewatered whitewater. Whitewater is collected in the whitewater silo, then mixed with pulp using a fan pump, sent to the cleaner and screen, and then to the papermaking stage again.

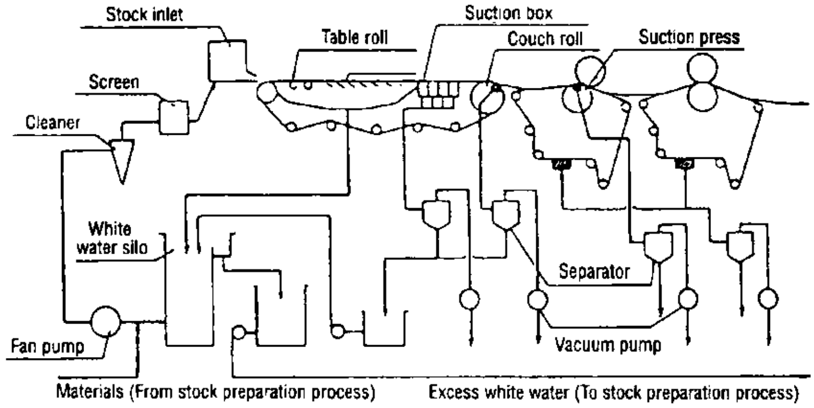


Figure 6-4 Representative reuse flow for the whitewater from paper machines

(3) Effective Energy Use

The pulp and paper industry is said to be energy-intensive like the steel industry, but the intensity of energy consumption in 1991 was 34% better than in 1973 owing to the industry's energy conservation efforts, such as recovering the waste heat, waste liquors, and wastes generated in manufacturing processes, and reusing them as energy. By way of comparison, improvements by the steel and cement industries over the same period were 22% and 30%, respectively. Measures implemented by the pulp and paper industry to conserve energy are modernization of production facilities, effective use of black liquor and other substances to cover in-house energy needs, and improvements in energy conversion efficiency. Fig. 6-5 illustrates the industry's energy flow.

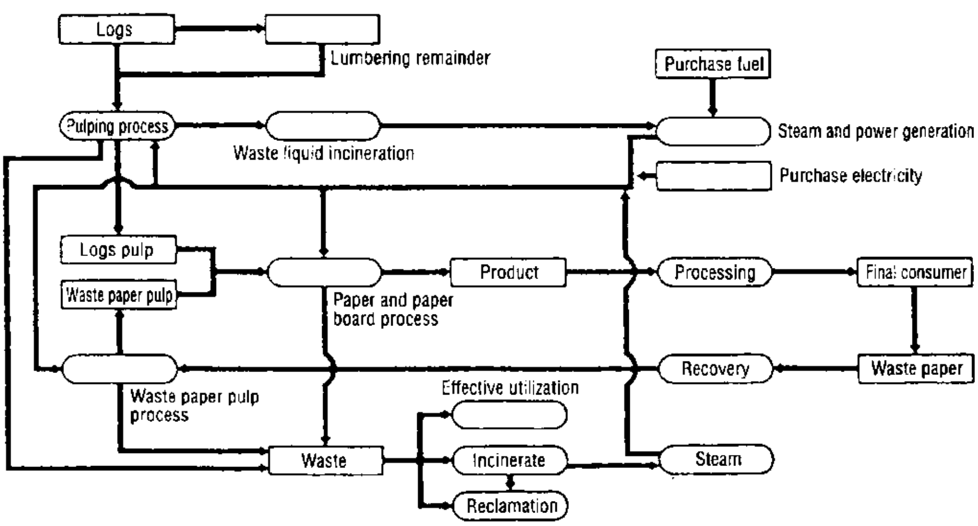


Figure 6-5 Energy flow on pulp and paper industry

Especially the black liquor recovery boilers that are generally an integral part of Kraft pulp manufacturing have made it possible to recover much energy through technologies that raised temperature and pressure. Kraft pulp, which accounts for over 80% of total domestic chemical pulp production, digests wood using a chemical mixture of caustic soda and sodium sulfide in a 7:3 ratio. A characteristic of Kraft pulp is the ability to recover heat and chemicals from the black liquor. Heat is obtained by concentrating black liquor to about 70% using evaporators, then burning the lignin and other organics in recovery boilers, thereby generating about one-third of the energy consumed in the pulp and paper industry's manufacturing processes. Chemicals are recovered as shown in Fig. 6-6. Sodium sulfate and sodium carbonate, which are transformed in the digesting process, are reduced to sodium sulfide and caustic soda, respectively, in recovery boilers and caustification equipment, then recycled and reused as digesting chemicals. Because over 98% of the chemicals are recycled, only slight amounts of new chemicals are needed.

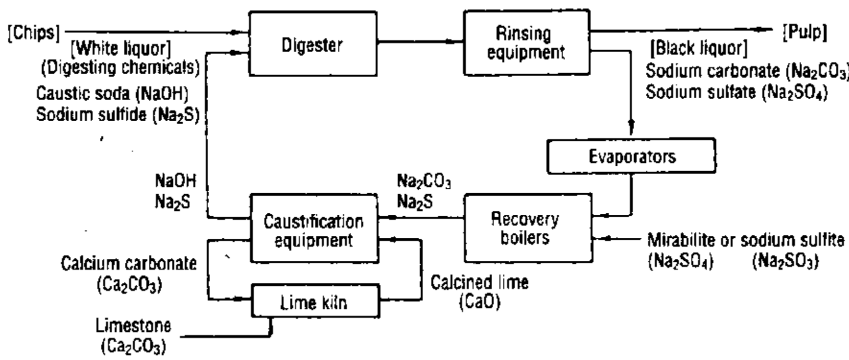


Figure 6-6 Chemicals recycle flow on the Kraft pulp

Improvements in energy conversion efficiency include higher temperature and pressure condition for boiler, switching from back pressure turbines to bleeder condensing turbines, and introducing combined cycle generation, which combines gas turbines and waste heat boilers.

As one component of Japan's energy conservation efforts, the government offers businesses tax incentives to encourage private capital investments. Table 6-1 shows two tax programs to encourage investment ("tax program to encourage investments for reform of the energy supply/demand structure" and "tax program to encourage undertakings to rationalize energy use").

Table 6-1 Tax program for energy conservation of pulp and paper industry

Name of tax	Subject	Mechanism
Tax program to encourage investments for reform of the energy supply/demand structure	Facility that energy is used effectively, Facility that alternative energy for oil is used, Facility for recycle paper manufacturing	Select from following two ways, *Tax deduction : 7% of acquisition price *Special repayment : 30% (According to facility, 50%, 75% or 100% of acquisition price is applied to subject)
Tax program to encourage undertaking to rationalize energy use	Facility concerned project on the support law for saving energy and recycling	The same as above (Limit of acquisition price is 2 billion yen, 75% of acquisition price is applied to subject)

Energy conservation technologies in the pulp and paper industry, which are eligible for incentives under the former program, include the following.

- Higher efficiency pulp digestion
- Higher efficiency pulp washing (adoption of the replacement washing method)
- Higher efficiency for drying in the papermaking process
- Higher efficiency for recovery boilers (improvement of energy conversion rate)
- Effective use of incineration waste heat
- More efficient conversion of electricity to torque
- Using waste heat from power equipment
- Rationalization of coal use
- Use of wastes as energy sources

Adoption of these energy conservation measures has reduced the energy to manufacture one ton of paper/paperboard by 28% over the last 15 years (see Fig. 6-7).

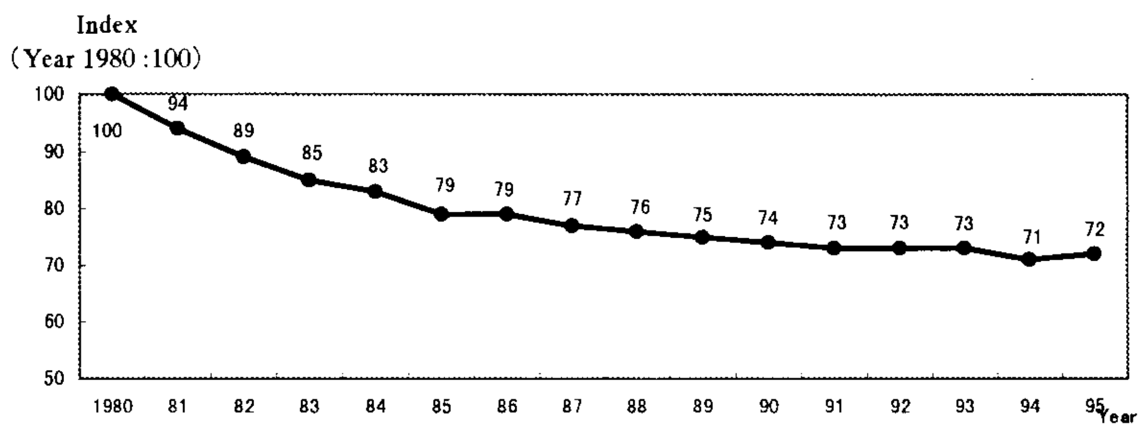


Figure 6-7 Energy to manufacture one ton of paper/paperboard

6.1.4 Environmental Burden Mitigated

Nearly all the measures for resource and energy conservation are laudable because, in addition to their originally intended purposes, they have also mitigated the environmental burden. But some process changes were meant primarily to lessen the burden on the environment, one of them being the adoption of oxygen bleaching technology to reduce the COD load and control dioxin discharges.

The industry generally uses chlorine as the bleaching agent because of its low cost. Another advantage of chlorine is that it quite selectively attacks lignin, and for those reasons it has been extensively used in the first stage of multi-stage bleaching. Additionally, chlorine that has reacted with lignin can be removed as chlorides of lignin by washing with water and using caustic soda. In recent years, however, chlorine bleaching is regarded as a problem because it generates dioxins and other chlorinated organic compounds, so in consideration of chlorine's environmental impacts, the main bleaching method is now oxygen bleaching, which uses oxygen or ozone in place of chlorine. Oxygen bleaching had problems such as oxygen's low selectivity toward lignin and its tendency to damage fibers, and the difficulty in using oxygen because it is difficult to mix with pulp. However, with advances in the technology since the 1980s, the oxygen bleaching equipment is placed at the head of the bleaching stage, where it substantially reduces the amount of chlorine used, and allows the removal of lignin. This also makes it possible to reduce dioxin emissions and mitigate the COD load. Currently about 98% of Japan's Kraft pulp production plants have incorporated oxygen bleaching. Fig. 6-8 shows the standard procedures for this method.

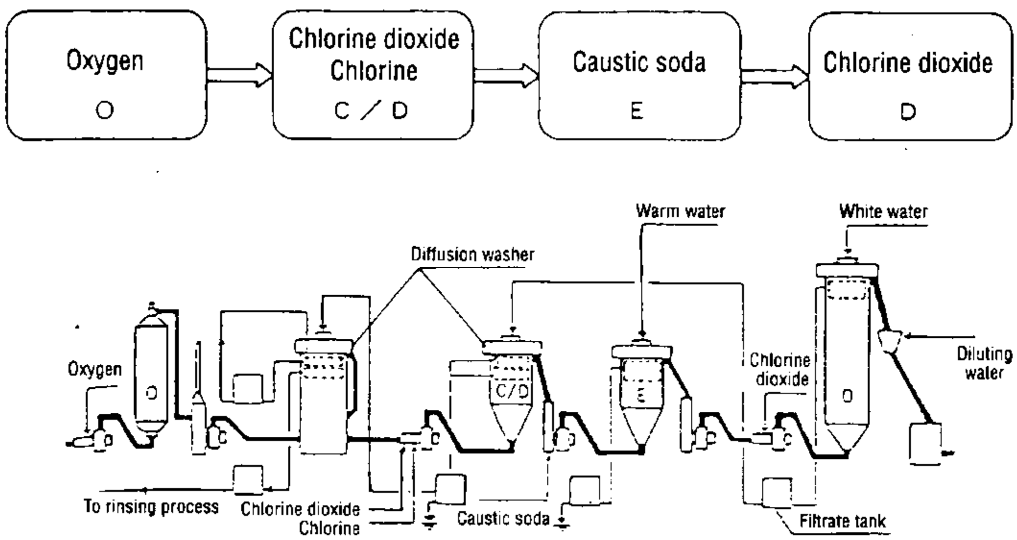


Figure 6-8 Standard procedures for oxygen bleaching

6.2 Case Studies

Here we chose three distinctive companies (two that use waste paper, and one that manufactures Kraft pulp) that received loans from the Japan Environment Corporation (JEC) for environmental measures, and examined them as specific case studies with attention to how they carry out production, and to environmental measures and cleaner production. Because we are examining individual factories, we will also describe their end-of-pipe technology for treating wastewater and flue gas.

6.2.1 Company A (Plant One)

Company A's Plant One is the main factory of the company, which has an annual turnover of 10 billion yen. Plant One produces 1,000 tons of toilet tissue paper a month from waste milk cartons and high-quality post-consumer paper (Plant Two, in another location, produces facial tissue, paper towels, and other products). It was the 1973 oil shock which led Plant One to start using milk cartons -- those discarded as industrial waste for faulty printing or formation -- owing to the shortage of post-consumer paper. Milk cartons are made from long-fibered softwood and are of high quality, but the polyethylene coating on both sides for waterproofing creates a disposal problem when the cartons are cooked, so they were formerly taboo.

Company A burned the polyethylene as fuel and supplied the waste heat to the papermaking process, making it successful in both reducing industrial wastes and saving energy.

Additionally, calling upon families to save milk cartons for recycling triggered a movement that spread nationwide, so that currently about 25% of the approximately 2,000 tons/month (i.e., about 500 tons/month) of cartons used as feedstock are cartons recycled by citizens.

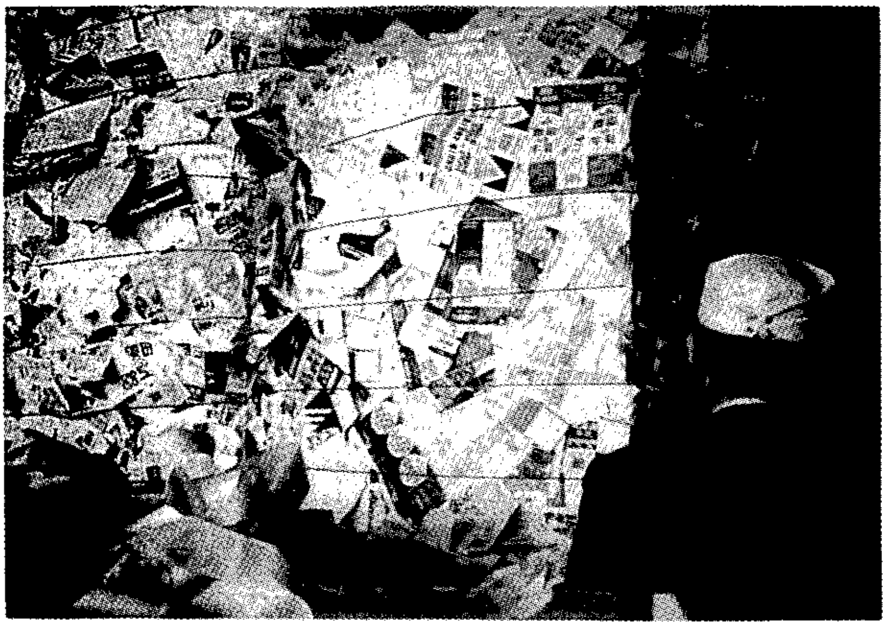


Figure 6-10 Cartons recycled by citizens

(1) Manufacturing Process

Fig. 6-11 shows the process of making recycled paper from post-consumer milk cartons. Cartons and other waste paper are cooked in spherical cookers or pulpers to reduce them to fiber, screened to remove contaminants, and then enter the papermaking stage. After cooking, the polyethylene coating is removed and incinerated in boilers for that purpose, and the heat is recovered as steam.

If milk cartons alone are used to make toilet tissue paper it will be too strong and dissolve in water with difficulty, so high-quality waste paper such as photocopying paper and newspaper advertising inserts are mixed in for 60-65% of the total content.

The spherical cookers used at this plant for cooking, which is one way of separating the waste paper fibers, are spherical batch ovens that revolve horizontally (producing three 20-ton batches daily). Since they use caustic soda as the cooking chemical they can use any kind of waste paper, and while separating fibers they also deink and decolor. These cookers were installed at this plant in 1975.

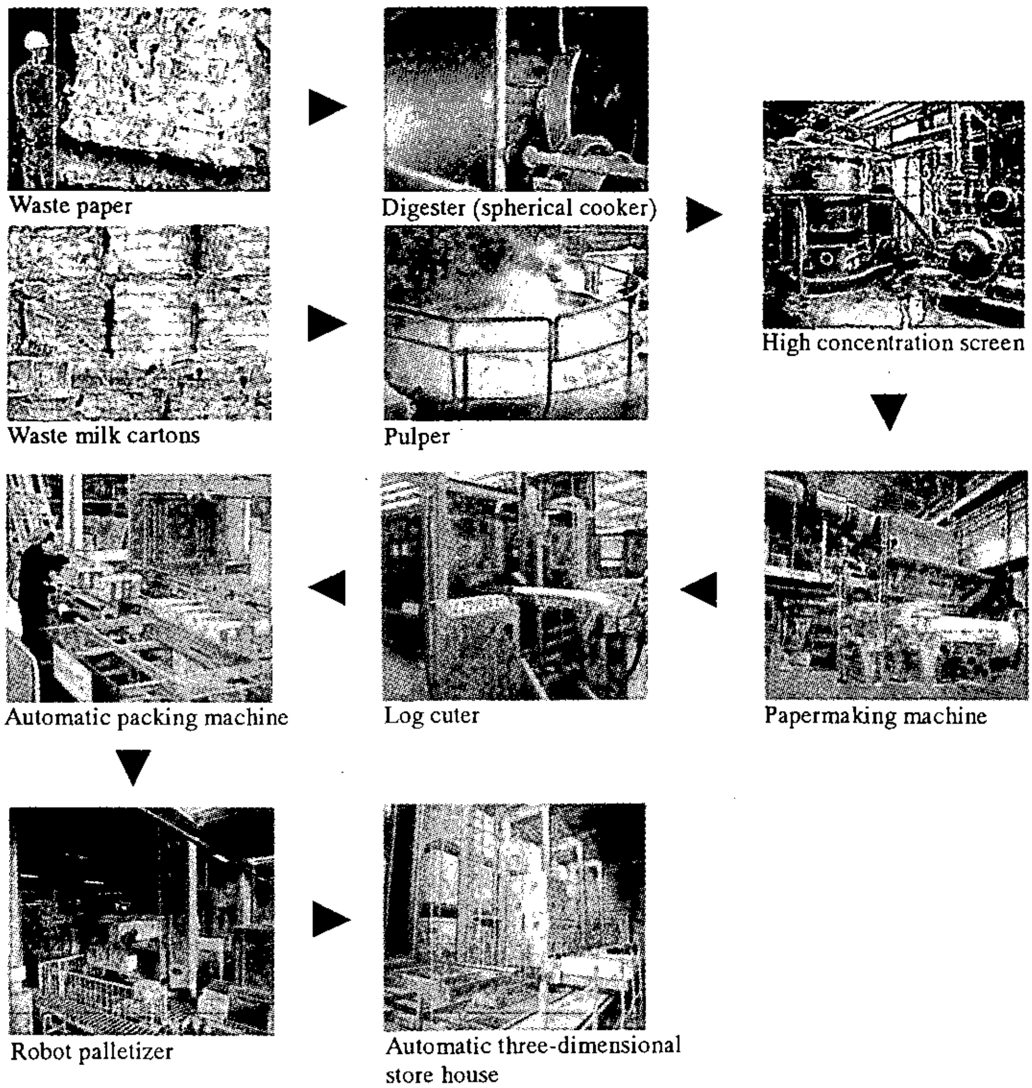


Figure 6-11 Process of making recycled paper

(2) Energy Recovery from Polyethylene Coating

Currently the process generates 1,000 tons/month (wet weight, 50% water) of polyethylene waste, which would cost about 8 million yen a month to discard as industrial waste. Instead, the plant burns the waste with total combustion at 900-1,000 °C in a combustion boiler and uses the steam (about 5 tons/hr) within the process. This saves the costs of waste disposal and fuel oil. Formerly the plant met nearly all process energy needs by burning the polyethylene, but due to business expansion and the addition of more facilities, it currently uses a fuel oil boiler for supplemental energy, but that boiler's fuel bill is held down to between 700,000 and 800,000 yen a month. The polyethylene boiler is fired 24 hours a day, but because the plant is almost idle for about 8 hours at night, the steam is allowed to escape unused. The company is presently considering the installation of an accumulator to use nighttime steam, which would make a further reduction in fuel oil use possible.

Figure 6-12 Polyethylene waste generated from process

Because the initial polyethylene boiler aged, the company replaced it in 1993 with the help of a JEC loan. About 400 million yen were needed to replace the boiler; about 80% of this was supplied by JEC, and the rest came out of the company's pocket.

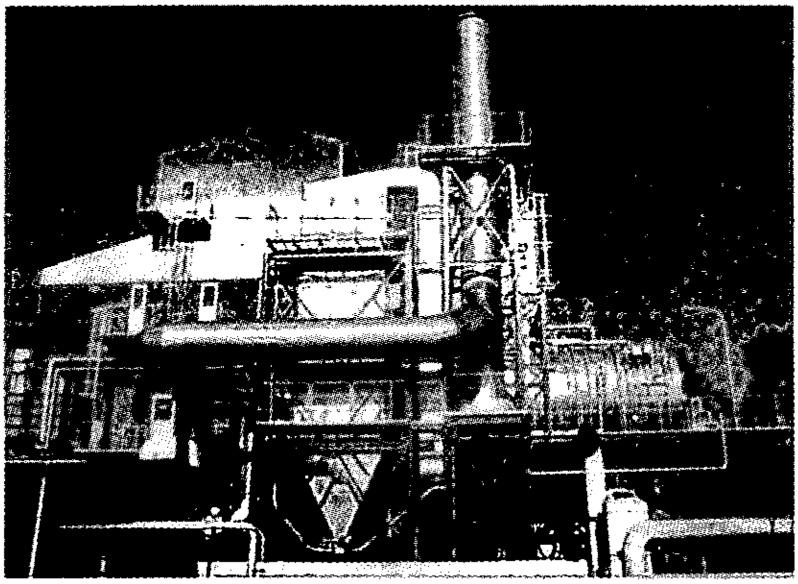


Figure 6-13 Waste polyethylene boiler

(3) Wastewater Treatment and Water Reuse

Primary treatment (coagulation and sedimentation) at this plant reduces its wastewater COD_{Mn} from 1,500 to 300 mg/l, and the plant obtains about half its daily water requirement of 1,200 m^3 in all processes by recirculating this treated wastewater. Wastewater released into public waters undergoes secondary treatment (biological), which reduces COD_{Mn} to 60 mg/l. In order to comply with effluent restrictions that became stricter in the early 1970s with passage of the Water Pollution Control Law, the company obtained JEC financing to install a high-rate coagulating sedimentation system in 1972, and biological treatment equipment (a trickling filter method) in 1974.

The high-rate coagulating sedimentation system adds a coagulant to treat the 2,400 tons/day of wastewater from the papermaking process and the 4,000 tons/day of wastewater from the pulp washing process. About 78% of the total approximately 51 million yen construction cost came from JEC financing, and the rest from the company. The biological treatment system receives 4,200 tons/day of wastewater from the primary treatment system (a sedimentation tank), and treats it in a trickling filter made with plastic. JEC financed about 78% of the approximately 142 million yen construction cost, with a bank providing about 21%, and the company the remainder.

(4) Effective Use of Paper Sludge

The paper sludge contained in wastewater was formerly discarded as waste, but because of complaints from people living nearby, the company installed a rotary kiln that burns the sludge and leaves the organic material, and provides for reuse of the material as the forming materials used in iron manufacture. This material sells for only 1.5 yen/kg, but in consideration of the cost entailed in discarding it as industrial waste, and the uncertainty about securing disposal sites in the future, reuse under present circumstances is not only cheaper, but also has a greater significance.

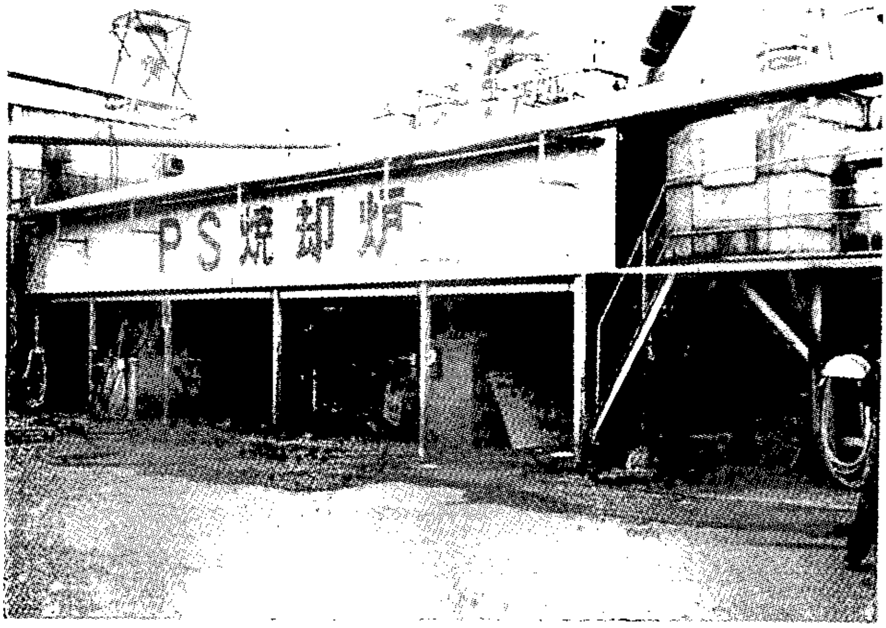


Figure 6-14 Rotary kiln for production of forming material

Installing this rotary kiln (in 1974) cost about 37 million yen, but JEC financing covered about 75%, private bank financing 15%, and the company 9%.

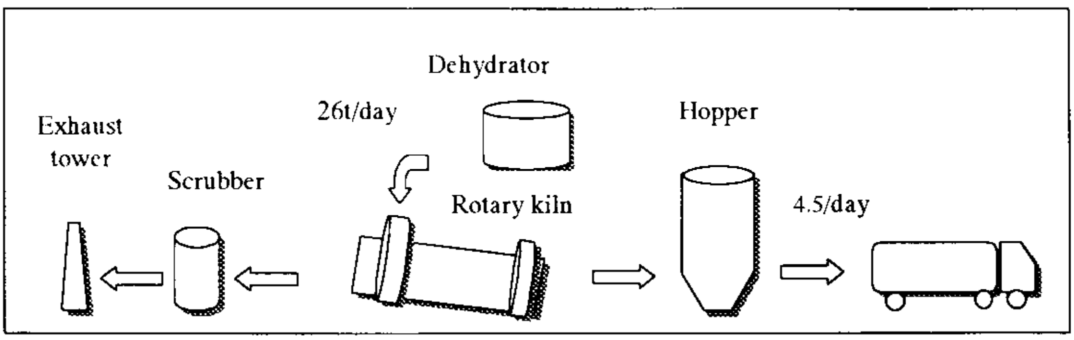


Figure 6-15 Flow of treatment by Rotary kiln

6.2.2 Company B

One of Japan's preeminent papermaking companies, Company B started pulping waste paper in the 1960s. It has waste paper recycling technologies, and especially an advanced deinking technology. It has reconciled that deinking technology, which satisfies the Japanese penchant for high whiteness in paper, with its compliance with effluent standards. Feedstock for the mid-sized factory is 92% waste paper pulp (500 tons/day newsprint, 300 tons/day magazines, 200 tons/day high-quality post-consumer waste, and a modicum of milk cartons) and 8% imported pulp, and its production volume is about 1,200 tons/day, and 400,000 tons/year.

(1) Manufacturing Process

Fig. 6-16 shows the steps in processing waste paper stock.

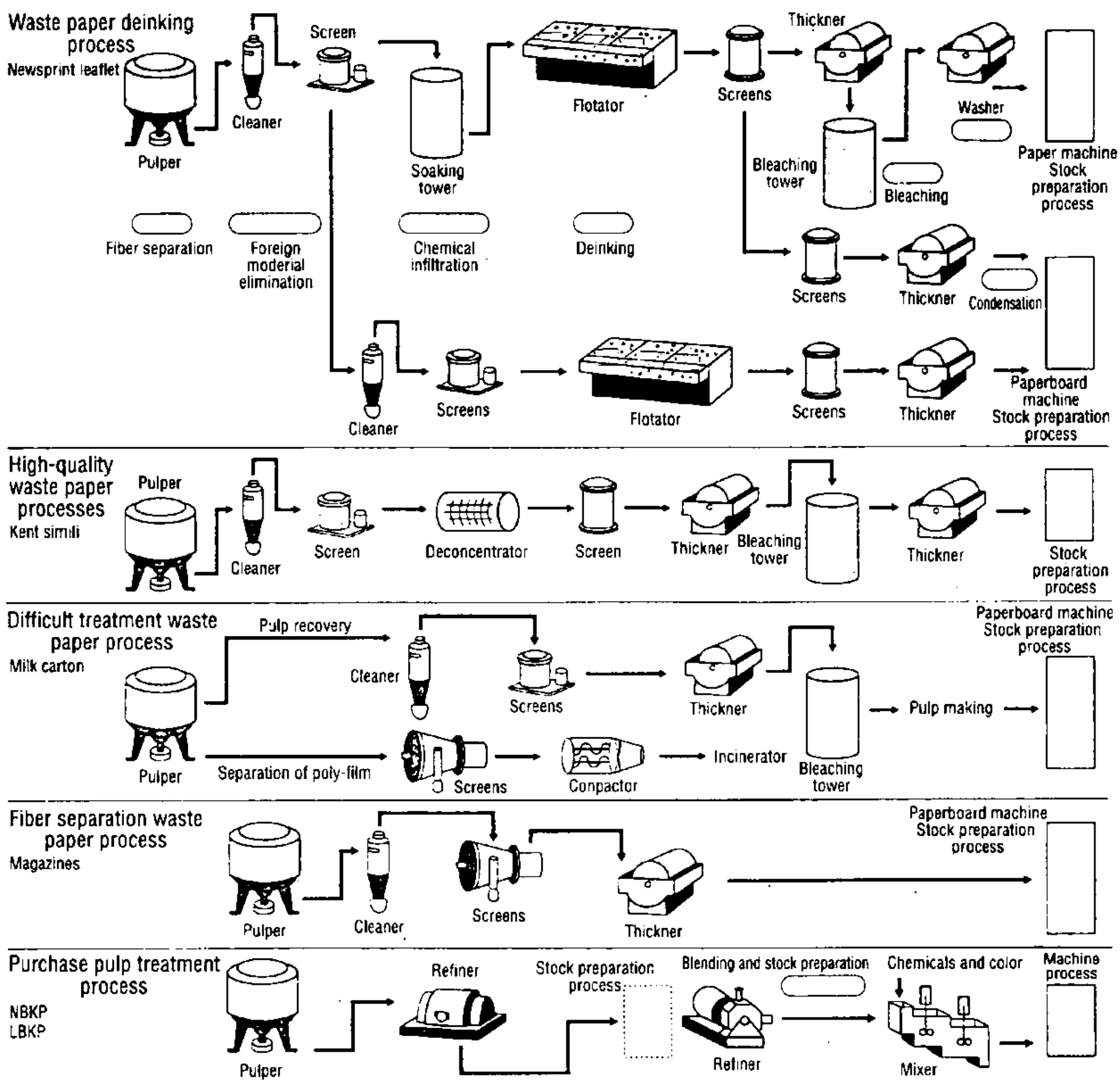


Figure 6-16 process of waste paper stock

Following are the improvements in this process that deserve special mention.

a) Flotator Installation

In using mainly waste newsprint to manufacture paper that must have a high degree of whiteness, the company has a deinking process that uses a flotator, whose deinking method consists of making ink particles stick to bubbles and float to the surface, where they are removed. A deinking agent (surfactant) is added to improve the separation of ink from water, to heighten the coagulation of ink particles, and for other reasons. Fillers such as calcium carbonate and kaolin are added to newsprint, which is made of mechanical pulp, because it must be thin and opaque, but these fillers are largely removed in deinking, and help reduce the COD component in the bleaching process. Formerly this factory used an aerator that pumped air into the pulper fluid, but installing a flotator with an automatic level gauge (see Fig. 6-17) allowed the company to reduce the use of chemicals and water, and to cut its electric bill to one-fifth.

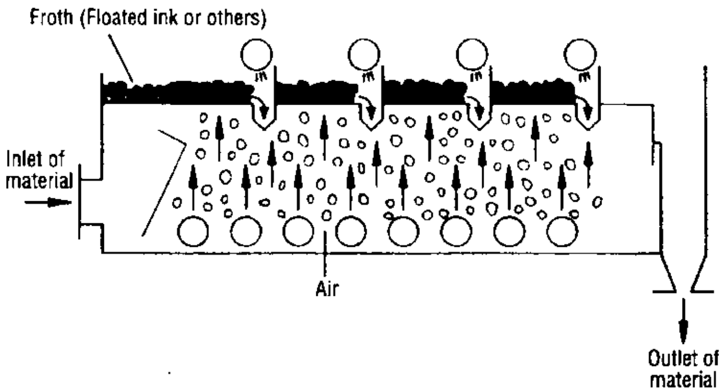


Figure 6-17 Principle of flotator

b) Deconcentrator Installation

In high-quality waste paper processes that treat types such as Kent simili, soaking raises the COD component. By mechanically lifting off the ink with a deconcentrator, the COD can be kept lower than when deinking with alkaline chemicals or heat.

c) Bleaching Innovation

The Japanese like very white paper, and even in recycled paper they seek a greater degree of whiteness than one would think necessary. For that reason, this factory bleaches one more time than usual. The factory has made some innovations including lengthened soaking time in order to decrease the amounts of chemicals added during the process of bleaching, and adding bleaching agents after reducing pulp water content in order to increase chemical concentration with the addition of only a small amount of chemical.

d) Quality Improvement Measures

The company is developing a technology to get the optimum values for paper quality and machines in order to achieve the same level of quality as virgin pulp.

e) Other

The glue used in magazines and other printed matter passes through screens, and presents the danger of causing coagulation in paper machines. For this reason the company is asking the magazine industry to use glue which does not cause such problems, and is performing research on methods that can remove glue in the deinking process.

(2) Treating Pollutants

This factory has implemented a variety of pollution abatement measures for effluent and gas emissions in compliance with legislation when it occurs and with restrictions pertaining to the area in which it is sited. Below are some examples of those that had JEC financing.

a) Installation of Flotation Equipment for Wastewater Treatment

In the latter half of the 1960s a sludge problem occurred in the bay into which this factory's effluent ultimately flows, and there were demands for improvement from fisherfolk and community residents. For this reason the factory, along with other major companies, received guidance from the national and local government for making improvements, and in 1970 provisions were made for the installation of wastewater treatment equipment by flotation separation to improve water quality. Making these improvements involved replacing the fiber separation and reaction tank, and installing the flotation equipment, concentration equipment, clarifier, hydroextractor, and sludge incinerator (a rotary kiln). Total coast was 813.7 million yen, of which JEC financing covered 49%, bank financing 49%, and the factory 2%. Table 6-2 shows the resulting improvements in SS and COD, and the factory was also to recycle part of its wastewater.

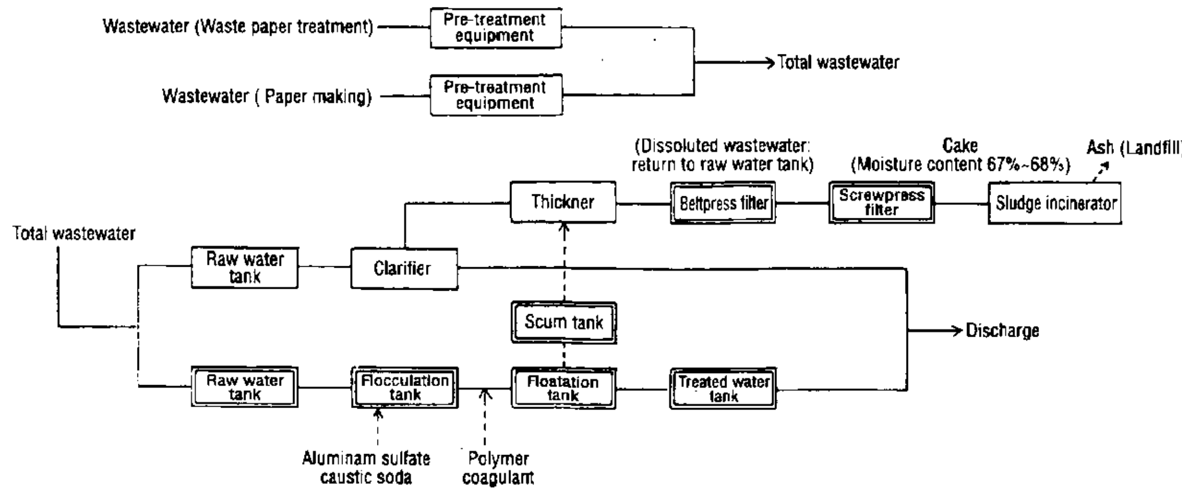
Table 6-2 Effect of improvements by waste water treatment facility

Parameter	SS (mg/l)	COD_{Mn} (mg/l)	Water volume of discharge (m^3/day)	Recycled water volume (m^3/day)
Before improvement	350	200	115,000	-
After improvement	80	50	86,000	29,000

b) Installation of Pressure Flotation Equipment to Improve Wastewater Treatment

Because passage of the Water Pollution Control Law meant that effluent standards would become stricter in stages, the factory added pressure flotation equipment to the downstream side of its integrated wastewater treatment facility (see Fig. 6-18). The result was improvements in the SS of discharged wastewater from 60 to 40 mg/l, and in its COD from 70 to 50 mg/l. The total cost of 159.8 million yen for the pressure flotation equipment (127.1 million yen) and the addition to hydroextractor equipment (32.7 million yen) was covered by about 44% JEC financing and 44% bank financing, with the factory covering the remainder.

The factory currently provides for compliance with effluent standards by incorporating an activated sludge facility into the wastewater system of its deinking process.



Notes: [ ] is a part of improvement in this time

Figure 6-18 Waste water treatment flow (pressure flotation)

c) Installation of Flue Gas Desulfurization Equipment

The factory installed flue gas de-SOx hardware on its New No. 1 Boiler, which has the largest emissions, in order to comply with stricter emission standards for sulfur oxides under the Air Pollution Control Law (K value restriction: See the standards according to environment-related laws in the reference materials) and total pollution load regulation under a agreement on pollution control with the city government. This equipment allowed the factory to switch from fuel oil with 1.5% sulfur content to that with 2.5% content, and to reduce its total SOx emissions from 67.2 to 11.2 Nm^3/hr, as well as to reduce its K value from 5.23 to 1.22 in response to the new K value standard of 4.67. Installing the flue gas de-SOx equipment cost 260 million yen for the de-SOx equipment itself (59% of the total cost), plus duct construction, electrical contracting work, foundation work, and other work. JEC financing covered 49% of the total, bank loans 49%, and the factory the remainder.

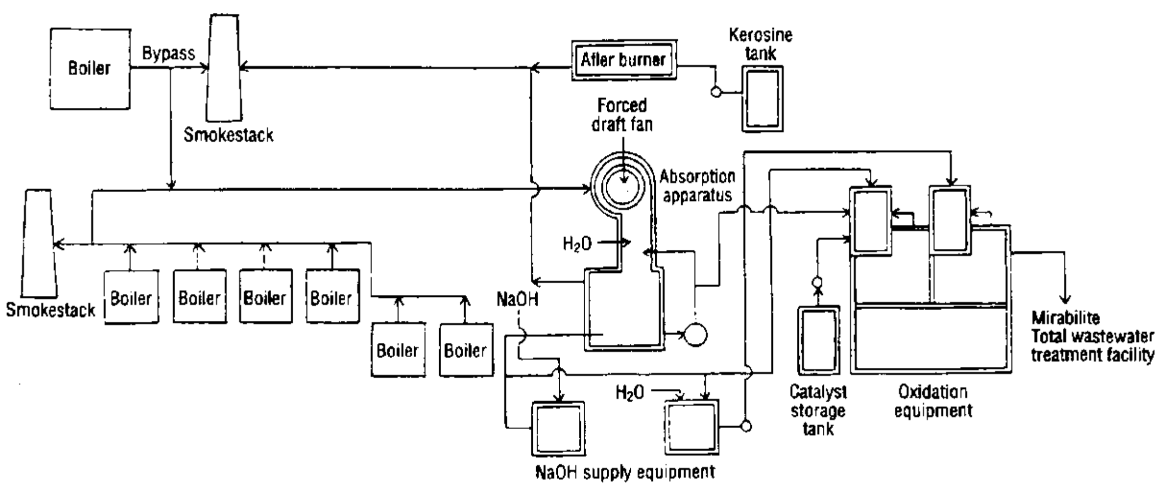


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Figure 6-19 Flue Gas Desulfurization Equipment

d) Addition to Sludge Incineration Facility

In 1974 the factory generated 30 tons of dehydrated sludge a day, of which 25 tons were incinerated and 5 tons were disposed in landfill directly. However, the addition of more chemicals in conjunction with upgraded wastewater facilities worsened the physical properties of the dehydrated sludge, which in turn reduced the capacity of incineration equipment, and caused the factory to landfill 15 tons of sludge a day. The factory therefore decided to add a rotary kiln to its sludge incineration facility. Total cost for the equipment was 155 million yen for the incinerator (accounting for 64% of the total), electrical equipment, and foundation work. JEC financing covered 49%, bank financing another 49%, and the factory picked up the remainder.

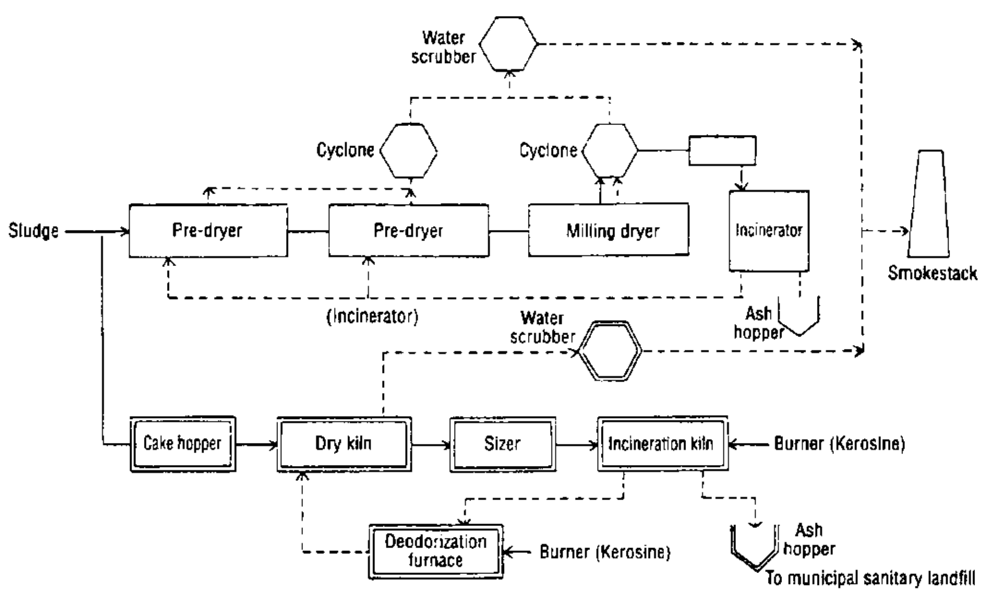


Figure 6-20 Sludge incineration facility

(3) Effective Use of Wastes

This factory currently generates 150 tons per day of paper sludge with a high inorganic content, yielding 70-90 tons of ash per day after incineration. A cement company accepts this ash for a fee and uses it as a substitute for cement clay. Some of the ash is used as soil conditioner.

6.2.3 Company C

One of Japan's preeminent papermaking companies, Company C manufactures pulp from wood chips. Its paper production capacity is 1,200 tons/day, and pulp production capacity is 1,500 tons/day. At first its factory controlled water pollution by treating wastewater with coagulation sedimentation, but it reviewed its processes in order to reduce its environmental burden when local regulations imposed stricter standards. Subsequently effluent standards became even more rigorous, so the company installed biological treatment facilities, and worked on implementing a closed loop system to the maximum possible extent in an effort to reduce the burden on treatment facilities.

(1) Manufacturing Process

Fig. 6-21 is an overview of the Kraft pulp manufacturing process. Until now chlorine has often been used in the pulp bleaching process, but owing to dioxin and other problems, oxygen bleaching is now used. By bleaching the pulp with oxygen before running it through the washer, the factory succeeded in lowering COD and lightening wastewater color.

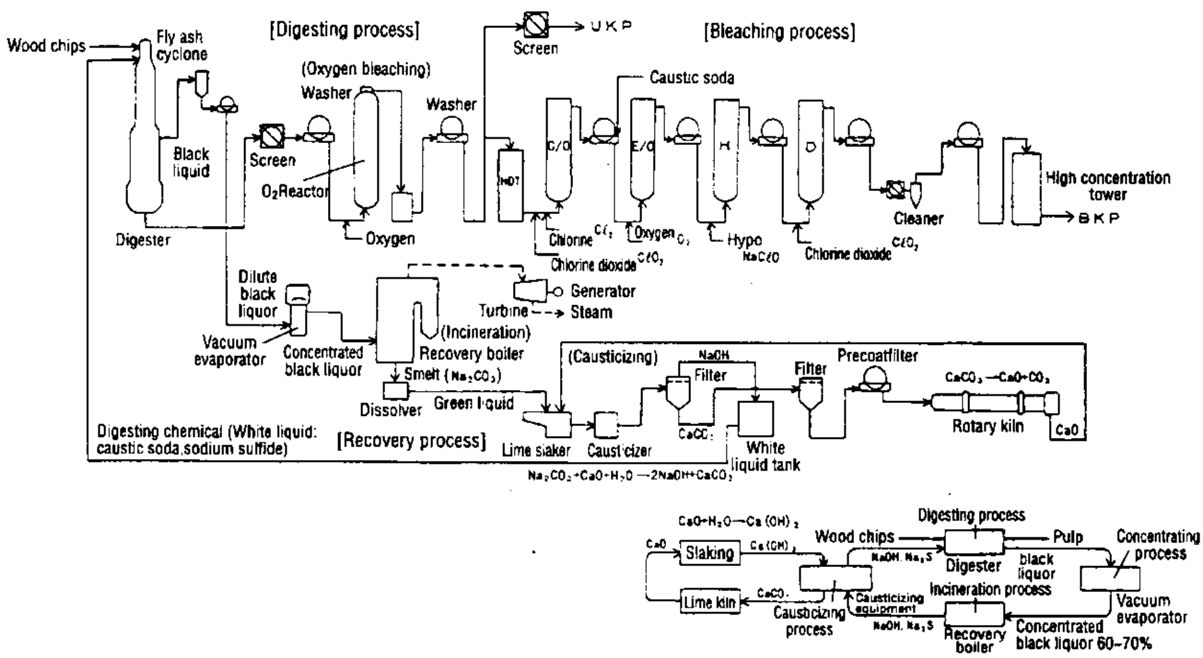


Figure 6-21 Kraft pulp manufacturing process

(2) Pollution Abatement

This factory has reduced its pollutant load by means of various process reviews. Deserving special mention are its installation of an O_2 reactor and recovery of chemicals and energy from black liquor. It initiated measures to mitigate water and air pollution in the latter half of the 1960s, and since 1970 it has endeavored to limit offensive odors, noise, and other problems. On a total of nine occasions (1970-1978) JEC helped finance some of the factory's various efforts at pollution abatement: six times for flue gas treatment equipment, once for wastewater treatment equipment, twice for offensive odor control equipment, and once for an industrial waste treatment facility. As Table 6-3 shows, at present air pollution control accounts for about half of all pollution abatement costs, followed by water pollution control at about 30%.

Table 6-3 Pollution control investment accounts

Unit: million yen

Measures	Account for facilities
Water pollution control	2,092 (31.1%)
Air pollution control	3,456 (51.3%)
Offensive odor control	717 (10.7%)
Noise control	237 (3.5%)
Waste management	231 (3.4%)
Total	6,733 (100.0%)

a) O_2 Reactor Installation

In the United States new paper mills incorporate the elemental chlorine free (ECF) bleaching process, but as hardly any new factories are built in Japan, they must work with existing equipment in mitigating pollution. For that reason Japan's paper mills have elected to reduce their chlorine use by installing O_2 reactors for oxygen bleaching in front of their preexisting chlorine bleaching processes. It is less expensive to build in the ECF method when building a new plant, but installing O_2 reactors is cheaper when using an existing system, and the latter way allows about the same dioxin reduction as the ECF method.

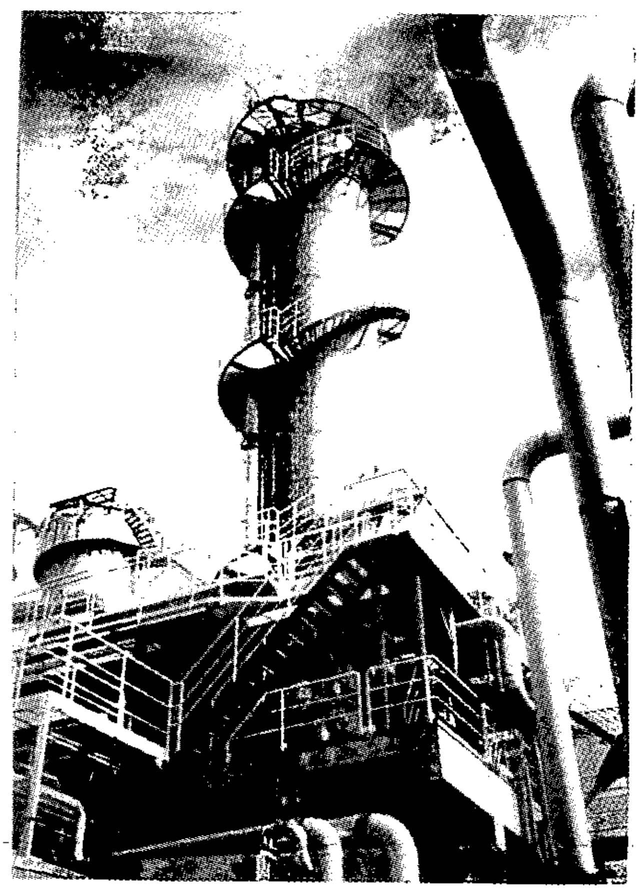


Figure 6-22 O_2 Reactor

This factory keeps pulp in the O_2 reactor for about one hour. Because the raw material for pulp is not always constant in quality, the factory has relied on experience to adjust -- while noting things such as waste liquor color -- the amounts of chemicals added, reaction time, temperature, and other parameters for the O_2 reactor and the subsequent bleaching process. Apparently it is often the case that, not only this factory, but the entire pulp and paper industry, has relied on trial and error, in conjunction with the equipment installed by engineers, to perfect manufacturing processes that are unique to each factory. By running pulp through the O_2 reactor in the first stage, this factory holds down to low levels the amount of chlorine added during the second stage in the form of bleaching agents such as chlorine and hypochlorous acid. Also, incorporating the O_2 reactor into the process lowered COD (lignin reduced by about 50%) and made it possible to recirculate and reuse wastewater (reuse was formerly difficult because when using chlorine the wastewater is acidic, at pH 2).

b) Recovery of Chemicals and Energy from Black Liquor

Chemical and energy recovery by a recovery boiler is part of the Kraft pulp manufacturing process. Because large amounts of chemicals are used in making Kraft pulp, it is sufficiently economically viable to recover chemicals. The recovery rate differs from one factory to the next. This factory initially recovered under 90%, but that rate is over 98% now. Recovery is not only meant to improve chemical yield, but is also an achievement of efforts directed at complying with effluent standards. Black liquor has a calorific value of 3,000-3,500 kcal/kg, and the factory generates electricity with the steam produced by the recovery boiler. This boiler provides about 85% of the factory's total electric power needs, and 70% of its total steam.

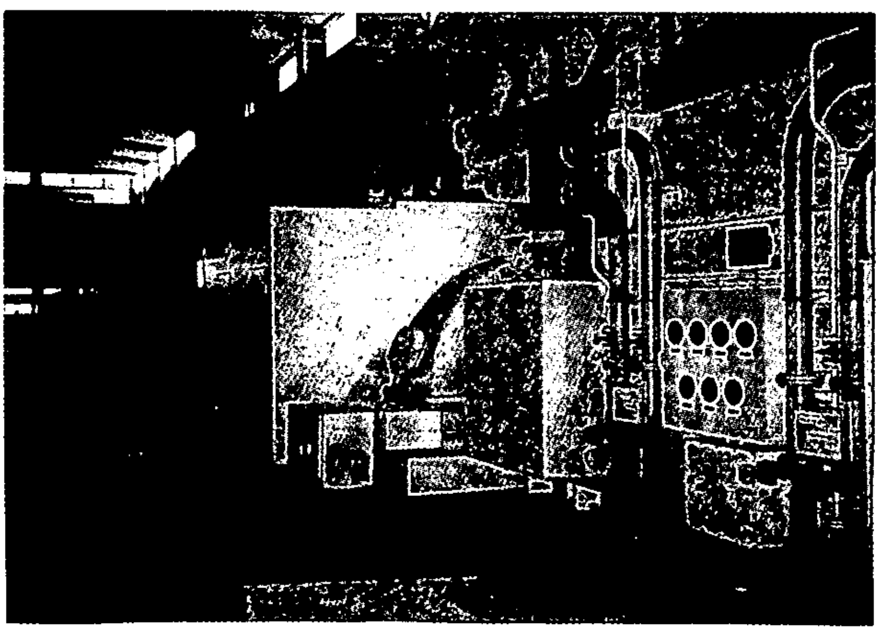


Figure 6-23 Recovery boiler and power generation equipment

c) Wastewater Treatment

A clarifier was installed in 1967 mainly to recover raw materials, and it treated 30,000 m^3 of wastewater daily, but as 100,000 m^3 out of the 130,000 m^3 wastewater generated daily was being discharged untreated, this caused a sludge pollution problem, which in 1971 occasioned the installation of a clarifier 75 m in diameter to remedy SS. Accordingly, SS dropped from 230 to 80 mg/l. Total cost was 350.25 million yen, of which 162.87 million yen was for the clarifier, 150.24 million yen for foundation work, and 37.14 million yen for a sludge treatment facility. Fifty percent of this was covered by JEC financing, and the other 50% by bank financing. In both 1988 and 1990 the factory installed contact aeration wastewater treatment equipment for biological treatment, and its effluent discharge concentration at present has an average COD_{Mn} of 59 mg/l (maximum 80 mg/l), and average SS of 13 mg/l (maximum 20 mg/l). Part of the treated water is reused. Stripping equipment that was installed to remedy the disagreeable odor of the COD component of wastewater and as a result is also useful in reducing the wastewater's COD load. All the ash yielded by burning the sludge generated by wastewater treatment are accepted by a cement company. Fig. 6-24 shows the factory's wastewater processing flow.

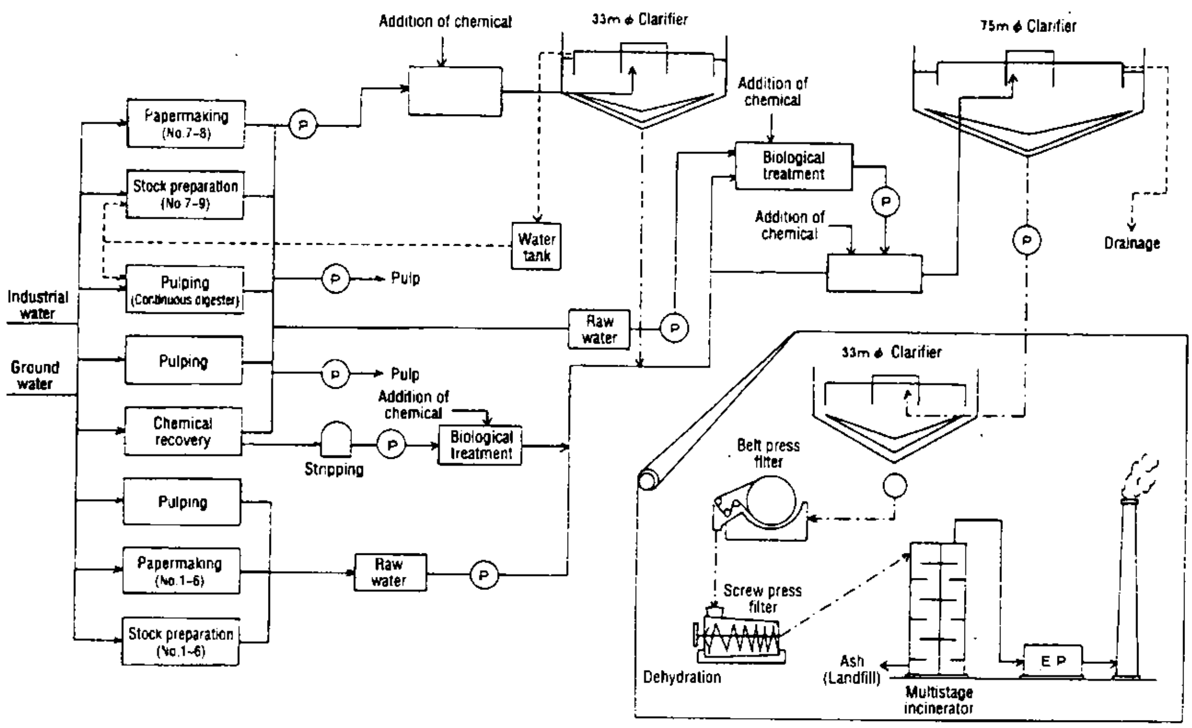


Figure 6-24 Factory's wastewater processing flow

d) Air Pollution Control

The main sources of air pollutants are boilers (a fuel oil boiler and a black liquor recovery boiler) and the rotary kiln for firing lime. Since 1967 the factory has by stages installed electrostatic precipitators and de-SOx hardware to control air pollution.

Precipitators were installed to comply with tougher emission standards for particulates. Table 6-4 shows two examples that received JEC financing.

Table 6-4 Dust and soot control examples

Year	Equipment	Detail of countermeasure and expenses of equipment (1,000 yen)	Supply rate of fund
1971	· Coal boiler · Recovery boiler · Dissolving tank · Lime kiln	· Construction of high stack 90,000 · Electrostatic precipitator (capacity: 330,000 m^3/h) 120,000 · Demister (capacity: 500 $m^3/min.$) 1,520 · Venturi scrubber (capacity: 500 $m^3/min.$) 41,000 Total 215,620	JEC loan 49.6% Bank loan 46.4% Self fund 4.0%
1971	· Recovery boiler · Dissolving tank	· Electrostatic precipitator (capacity: 100,000 m^3/h) 61,480 · Demister (2 sets) (capacity: 400 $m^3/min.$) 4,000 Total 65,480	JEC loan 45.8% Bank loan 45.8% Self fund 8.4%

To control sulfur oxides the factory uses low-sulfur fuel oil (1% S content) and built a high smokestack for diffusion, but because the factory itself wanted to exercise tighter control over pollution, and in order to comply with total SOx regulations that became applicable in 1975, year by year it has installed more de-SOx equipment using an alkaline absorbing solution. Four of those instances received financing from JEC (see Table 6-5).

Table 6-5 Installation examples of Flue Gas Desulfurization Equipment related to JEC Loan

Year	Equipment	Equipment capacity and expenses of equipment (1,000 yen)	Supply rate of fund
1971	Heavy oil boiler	Desulfurization equipment 60,600 Treating gas volume : 24,440 N m^3/h SOx exhaust volume : 31.2→1.56 N m^3/h Foundation work 4,053 Total 64,653	JEC loan 50.0% Bank loan 50.0% Self fund 0.0%
1974	Recovery boiler	Desulfurization equipment 164,000 Treating gas volume : 161,350 N m^3/h SOx exhaust volume : 35.7→3.6 N m^3/h Total 164,000	JEC loan 48.8% Bank loan 48.8% Self fund 2.4%
1975	Heavy oil boiler (2 boilers)	Desulfurization equipment 161,800 Treating gas volume : 32,000 N m^3/h × 2 SOx exhaust volume : 33.6→8.4 N m^3/h Foundation work, smoke duct 42,700 Total 204,580	JEC loan 48.9% Bank loan 51.1% Self fund 0.0%
1978	Recovery boiler	Desulfurization equipment 180,000 Treating gas volume : 208,000 N m^3/h SOx exhaust volume : 45.9→2.2 N m^3/h Other works 177,400 Total 357,400	JEC loan 49.0% Bank loan 49.0% Self fund 2.0%

Installing flue gas desulfurization equipment allowed the factory to switch from low-sulfur fuel oil to fuel oil with 2.5% S content. Further, the sulfur oxides emitted by the boilers decreased to between one-fourth and one-twentieth the previous levels, and the factory easily satisfied the total emission load standards. In addition, using caustic soda (NaOH) in the de-SOx equipment flue gas washing fluid made it possible to recover the sodium sulfite (Na_2SO_3) obtained by desulfurization and to use it as a chemical in the digester fluid.

The factory has controlled emissions of nitrogen oxides by installing low-NOx burners and reactors, thanks to which boilers and kilns operate at flue gas NOx levels of under the 100 ppm level. Fig. 6-25 illustrates the current particulate reduction flow of the entire factory.

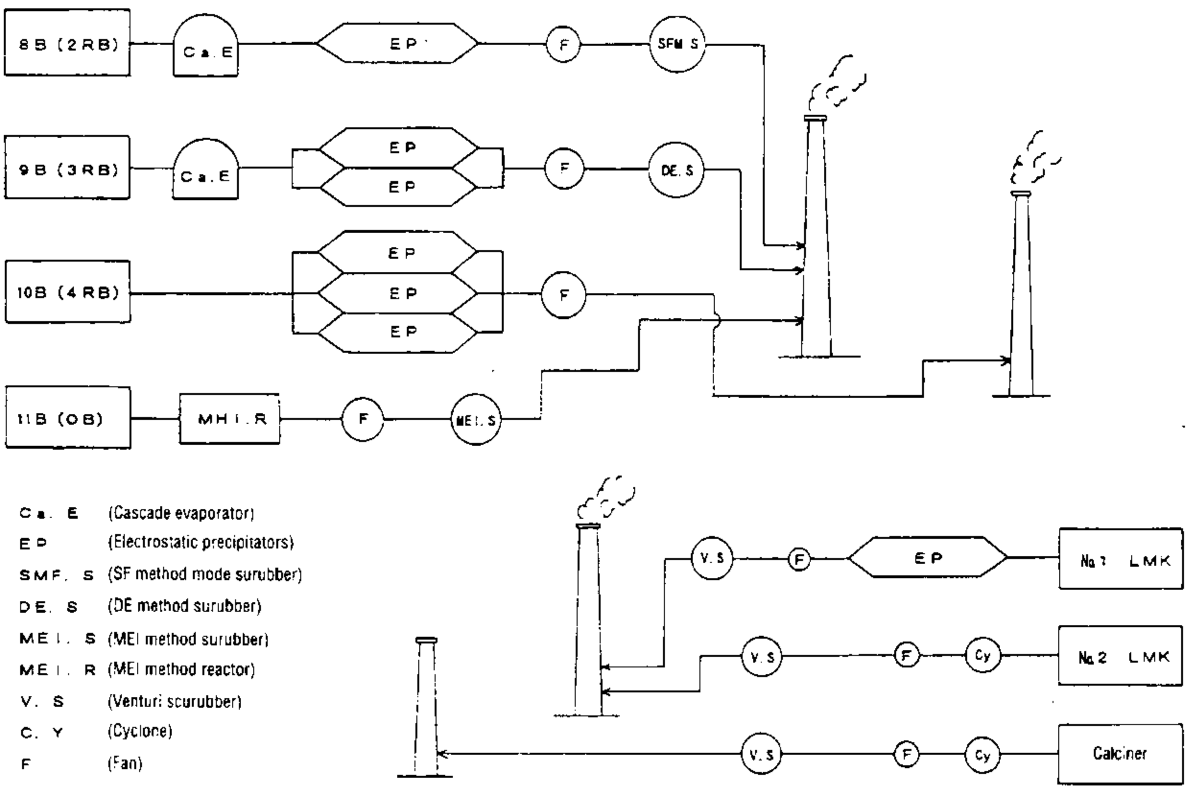


Figure 6-25 Dust and soot treatment flow

e) Offensive Odor Control

Sources of offensive odors include a variety of pulp/paper process equipment, black liquor tanks, and the stripping equipment that controls wastewater odor emissions. As it is most effective to decompose these gases by incineration, the factory collects them through ducts, and sends them for incineration along with combustion air to boilers, lime kilns (rotary kilns; see Fig. 6-25), and black liquor boilers.

The factory has made improvements on two occasions with JEC financing. One improvement was an apparatus that controls the offensive odor arising from concentrated black liquor by injecting heated air and oxidizing the liquor (see Fig. 6-27). This black liquor oxidation apparatus has a capacity of 150 m^3/hr, and an oxidation rate of 95%. Its cost was 71,570,000 yen, with 48.8% from JEC financing, 48.8% from bank financing, and 2.4% paid by the factory.

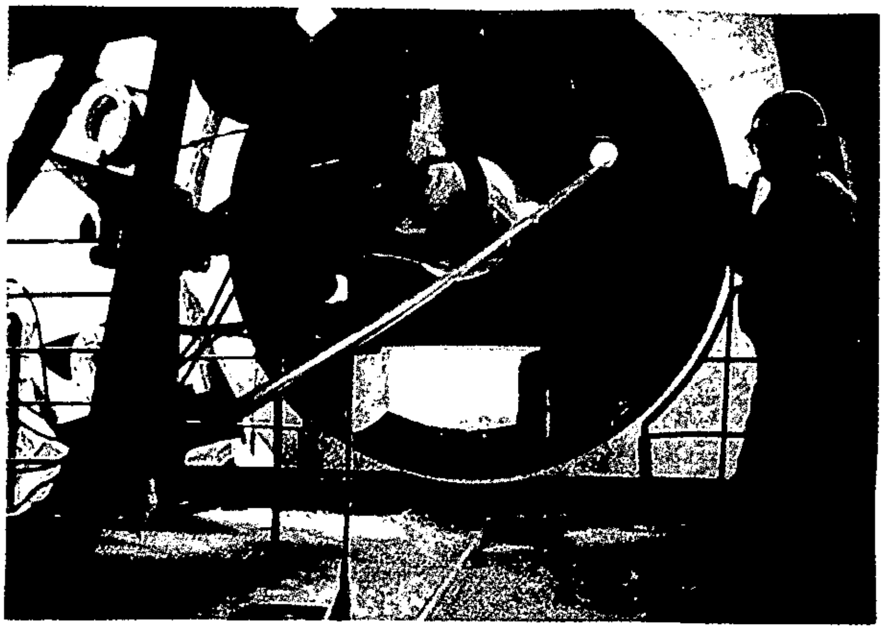


Figure 6-26 Rotary kiln

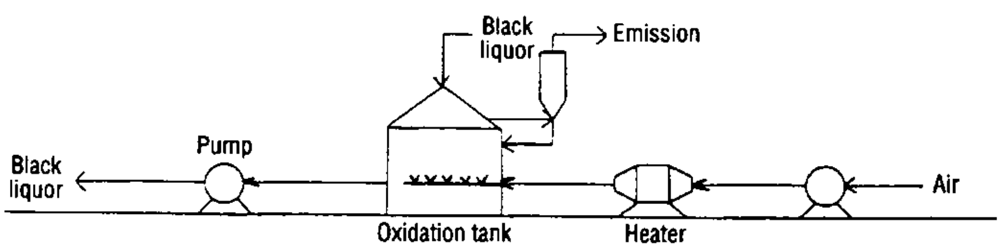


Figure 6-27 Black liquor oxidation apparatus

The second improvement consisted of measures to control offensive odor emissions from continuous digester filtrate tanks, concentrated black liquor tanks, and vacuum evaporators. The factory sealed two tanks and installed items including condensers, collecting tanks, mist separators, and air heaters, and feeds 8,170 m^3 of malodorous gases to recovery boilers an hour where they are burned (see Fig. 6-28). This improvement required 3,574 million yen, of which 49.0% was provided by JEC financing, 49.0% by bank financing, and 2.0% by the factory.

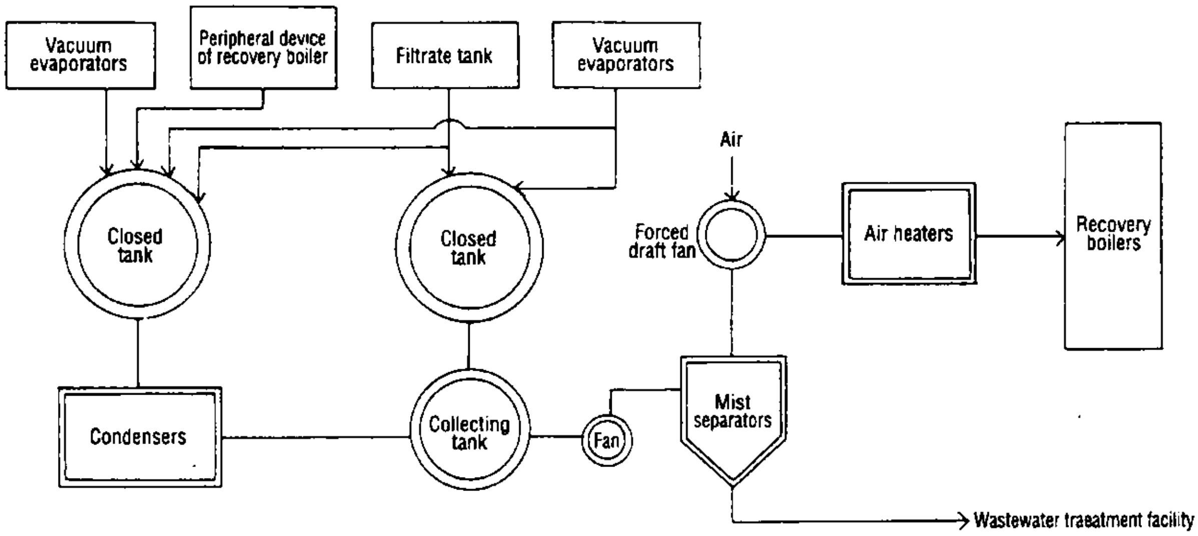


Figure 6-28 Odor collection and elimination of odor by burning

Further, the factory took ordinary actions on its own premises to prevent odors, such as completely plugging gaps in drainage ditch covers and pipe joints, and chinks in rooms. Further, certain people living in the factory's vicinity were asked to be monitors and call the factory each time offensive odors arise. Fig. 6-29 illustrates the factory's overall flow for odor treatment.

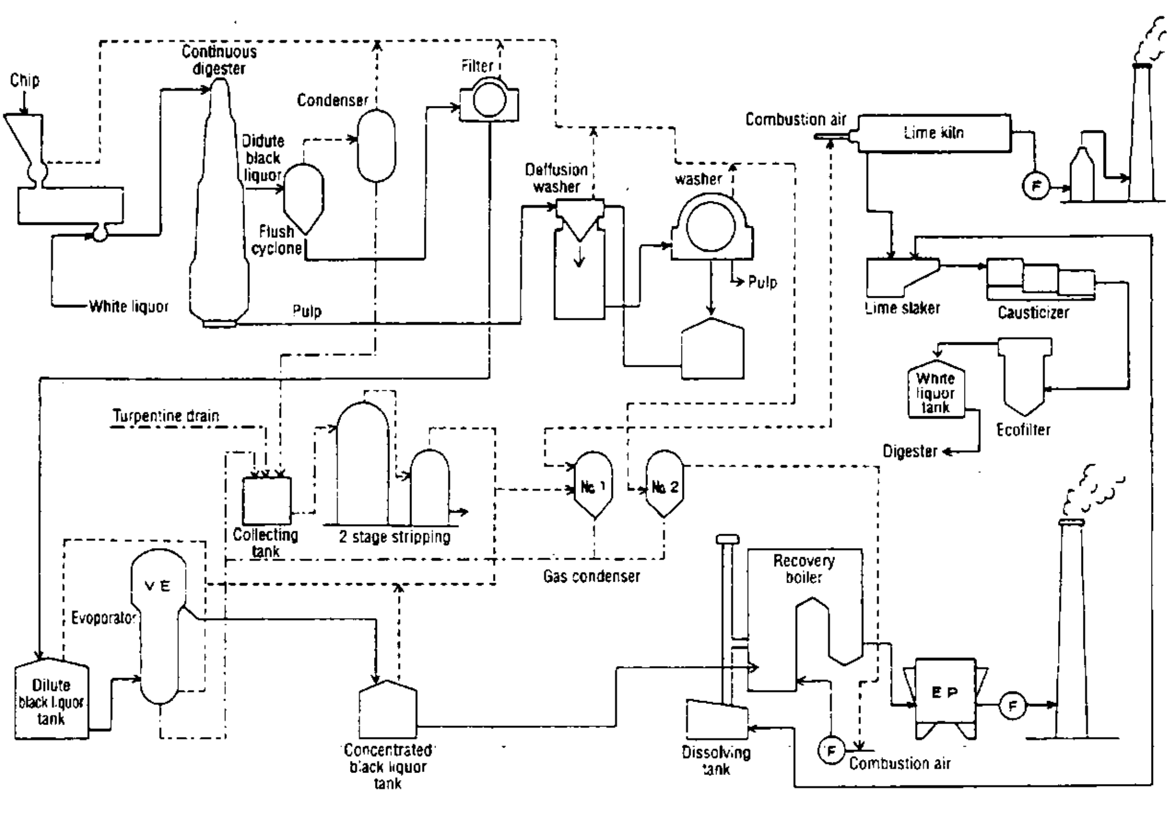


Figure 6-29 Factory's overall flow for odor treatment

7. Examples of JEC Financing

7.1 Overview of Financing for the Pulp and Paper Industry

Over the 31 years from 1966 to 1996 the Japan Environment Corporation financed 4,358 projects (5,712 individual facilities when counted by pollution type), for a total loan amount of approximately 984 billion yen. Among a total 27 industry types, loans to the pulp and paper industry comprised 729 individual facilities and about 95.8 billion yen in monetary terms, which is nearly 10% of the total. This demonstrates that the pulp and paper industry occupies a major position with regard to industrial pollution, and that much money has been invested in improvements.

7.1.1 Applications for Financing

Fig. 7-1 shows the number of financing applications made to JEC by the pulp and paper industry, and the number of pollution control facilities built in conjunction with applications. Loan applications are concentrated in the first half of the 1970s, during which pollution problems came to the fore and various emission regulations were toughened. The largest number of applications, 78, came in 1972. It was also the first half of the 1970s that had a large number of pollution control facilities built in conjunction with applications, and the trend during these years was to build multiple facilities under a single application. During 1974 in particular, 114 facilities were built under 67 applications. Applications started decreasing gradually in the second half of the 1970s, and since 1982 the annual number of applications has consistently been under five.

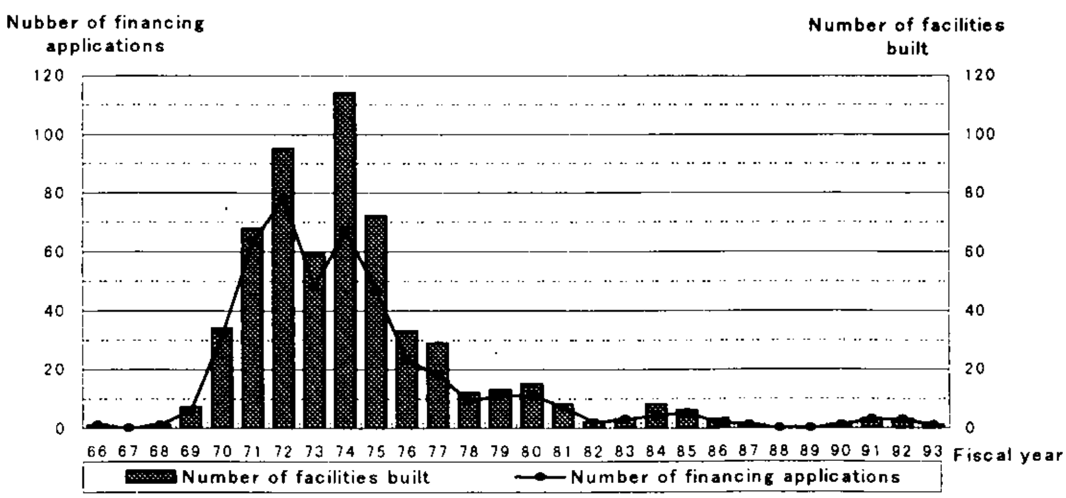


Figure 7-1 Number of financing applications made to JEC by the pulp and paper industry, and the number of pollution control facilities built

Fig. 7-2 shows the proportions of pollution control facilities, by facility type, installed with financing from 1966 to 1993 by the pulp and paper industry. The largest was wastewater treatment facilities at 52.9%, followed by smoke and soot control facilities at 22.6%. These two alone account for about three-fourths of the total. Other types in order from the largest are offensive odor control equipment (8.1%), waste treatment facilities (7.4%), noise and vibration control equipment (5.4%), treatment equipment for specified smoke substances (1.7%), dust control equipment (1.2%), and low-sulfur fuel storage facilities (0.7%).

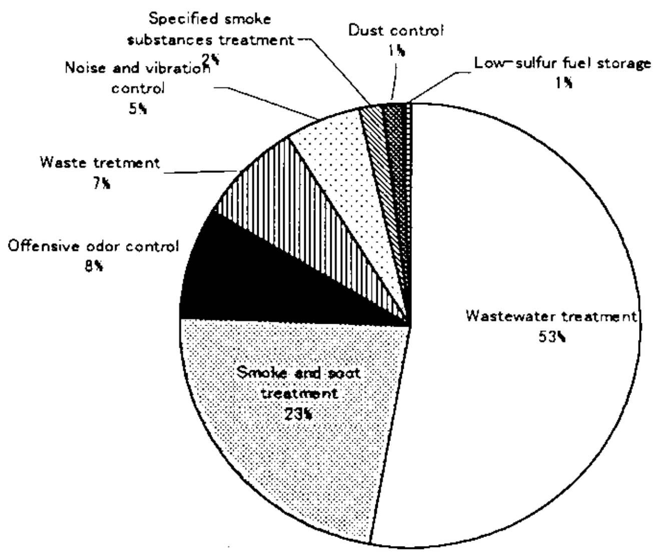


Figure 7-2 Proportions of pollution control facilities installed with JEC financing

Fig. 7-3 shows the proportions of pollution control facilities by facility type in five-year intervals. Financing was provided for wastewater and flue gas treatment equipment in the latter half of the 1960s, the reason being that financing eligibility in those years was limited to those two types plus facilities for the treatment of specified hazardous materials. During the first half of the 1970s, when loan applications jumped dramatically, other facility types were made eligible for financing: In 1971 facilities for noise control, dust control, and emergency low-sulfur fuel storage were added, and in 1972 those for offensive odor control and industrial waste treatment were added. For this reason companies began building a large variety of facilities other than those for wastewater and flue gas treatment, such as for offensive odor control, waste treatment, and noise control, a trend that continued until the first half of the 1980s. Starting in the latter half of the 1980s, when loan applications decreased, companies built mainly facilities for wastewater treatment, flue gas treatment, and waste treatment, but in the first half of the 1980s there was no construction of flue gas treatment facilities.

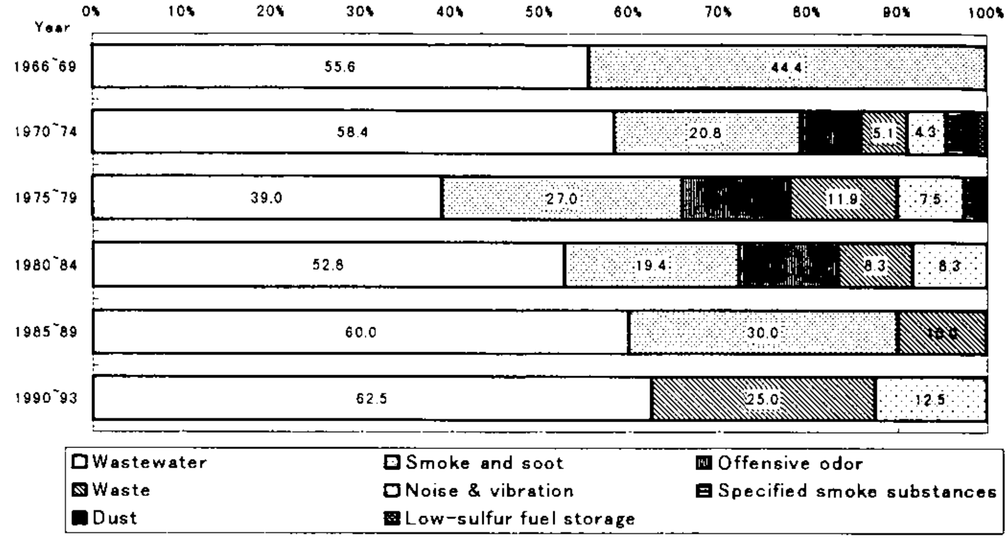


Figure 7-3 Proportions of pollution control facilities by facility type in five-year intervals

Figs. 7-4 through 7-11 show the numbers of pollution control facilities built by type. It is evident from these graphs that the construction of facilities for hazardous material treatment, flue gas treatment, and low-sulfur fuel storage happened only during short periods.

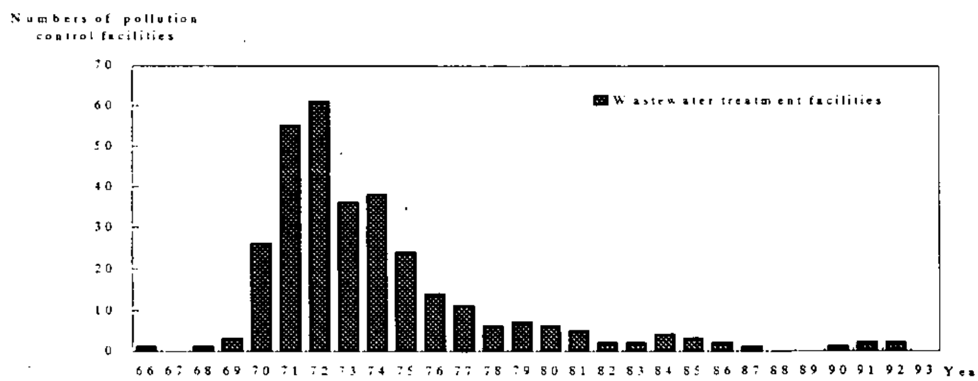


Figure 7-4 Numbers of wastewater pollution control facilities

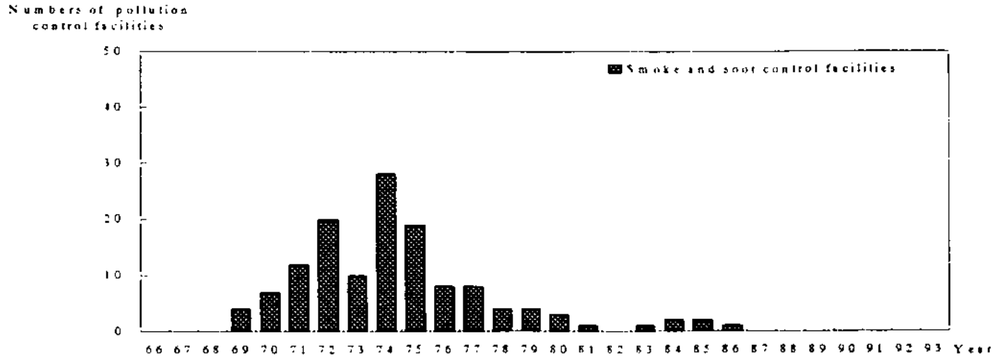


Figure 7-5 Numbers of smoke and soot pollution control facilities

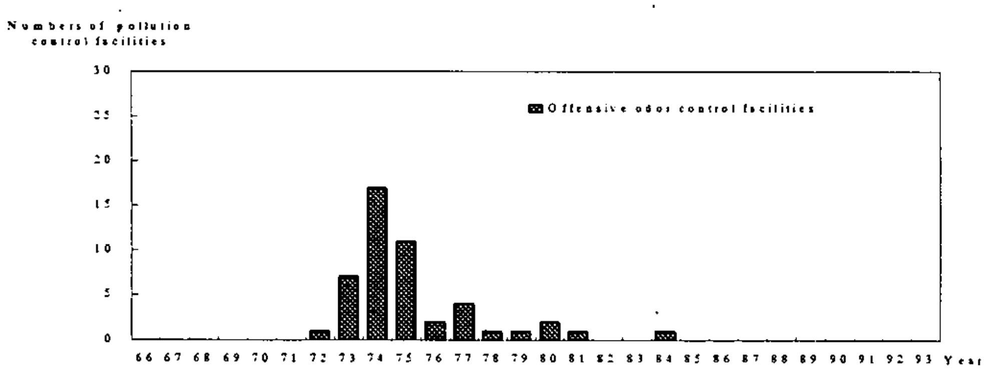


Figure 7-6 Numbers of offensive odor control facilities

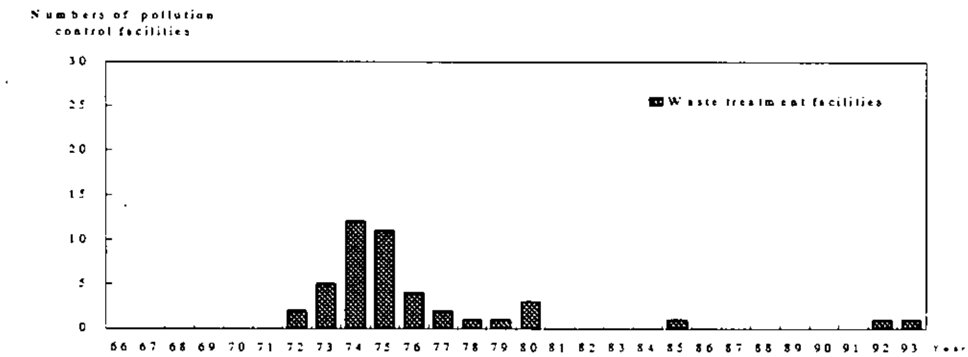


Figure 7-7 Numbers of waste control facilities

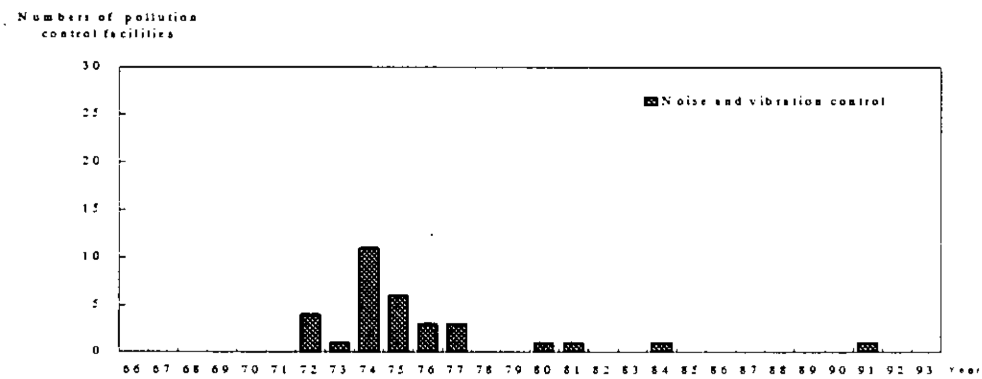


Figure 7-8 Numbers of noise and vibration control facilities

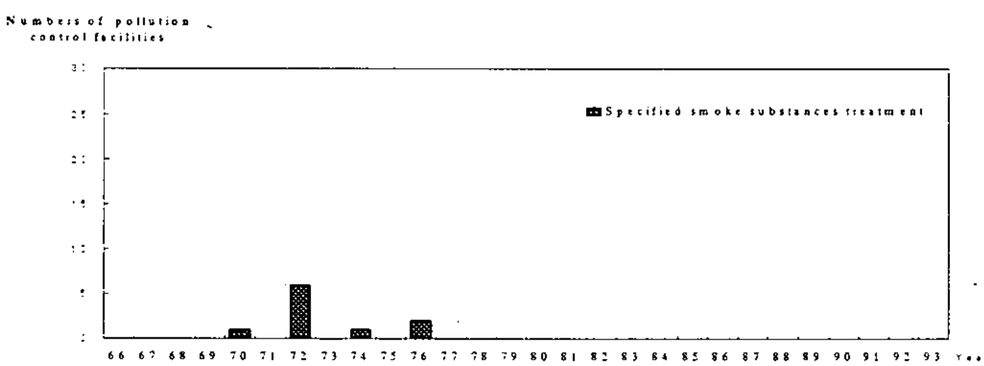


Figure 7-9 Numbers of specified smoke substances control facilities

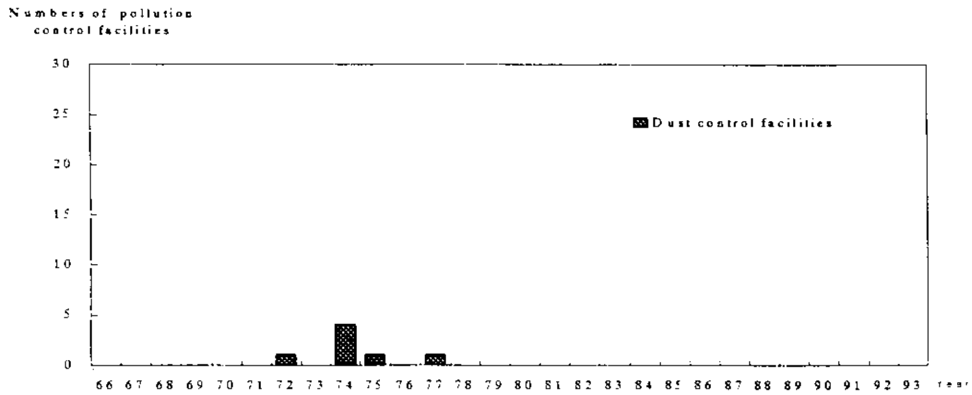


Figure 7-10 Numbers of dust pollution control facilities

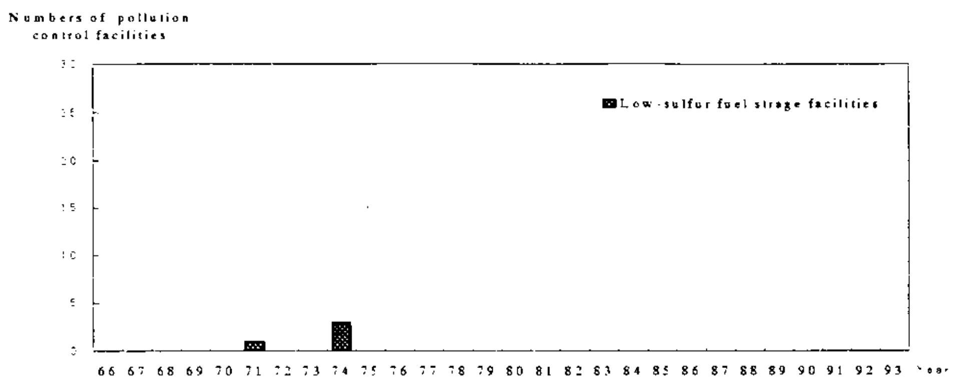


Figure 7-11 Numbers of low-sulfur fuel storage pollution control facilities

7.1.2 Pollution Control Facility Construction Spending and Loan Amounts

(1) Overview of the Entire Pulp and Paper Industry

Fig. 7-12 shows the spending for pollution abatement facilities, the amount of financing provided by JEC, and the number of facilities built. Both the capital outlays for facility construction and the amount of JEC financing grew during the first half of the 1970s, when there was a rapid increase in the construction of pollution abatement facilities. Amounts of both capital spending and JEC financing peaked in 1974 when the number of installations was the largest.

Fig. 7-13 shows capital spending for pollution abatement equipment related JEC financing from 1966 to 1993 by funding source. JEC loans were within 50% of project cost for large companies, and within 80% for small and medium enterprises (SMEs). The breakdown for actual fund procurement was 52.0%, or about half, for JEC, 30.7% for bank loans, and 17.3% for companies' own funds, making it evident that JEC financing plays a major role in assisting the construction of pollution abatement facilities.

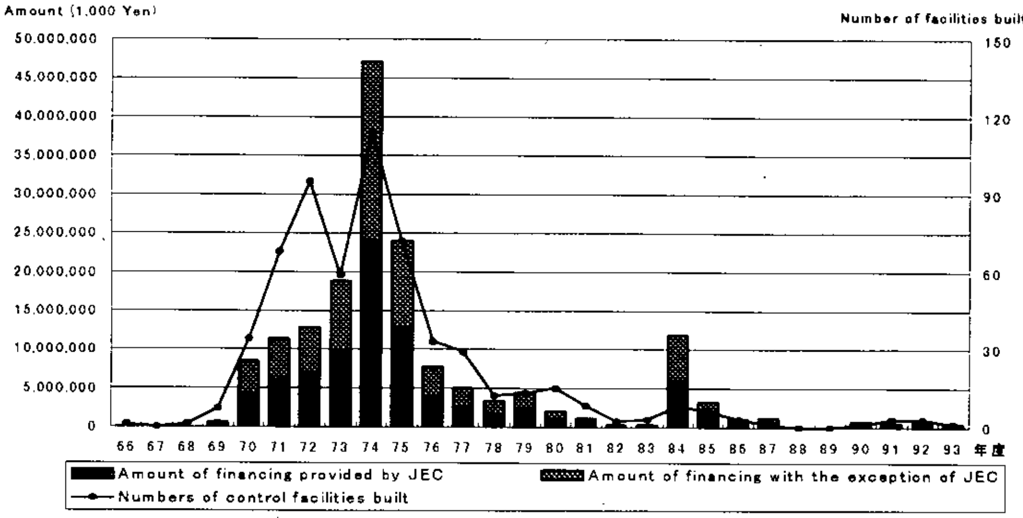


Figure 7-12 Amount of financing provided by JEC and the number of facilities built

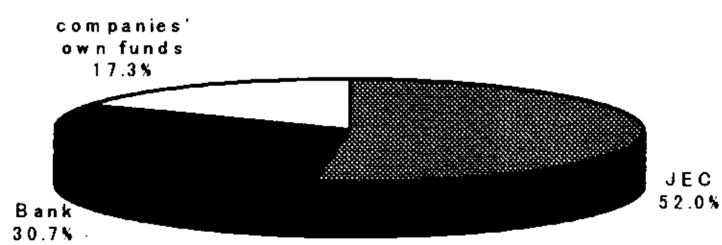


Figure 7-13 Capital spending for pollution abatement equipment related JEC financing

(2) Wastewater Treatment Facilities

Fig. 7-14 shows spending for the installation of wastewater treatment facilities, which account for the biggest portion of pollution abatement installations in the pulp and paper industry, and the amount of JEC financing, along with the number of new installations. Wastewater treatment facilities were concentrated in the first half of the 1970s, with the largest number, 61, being in 1972. On the other hand, spending on facility construction and JEC loan amounts both peaked in 1974, indicating that the actual construction of large-scale wastewater facilities was slightly behind spending.

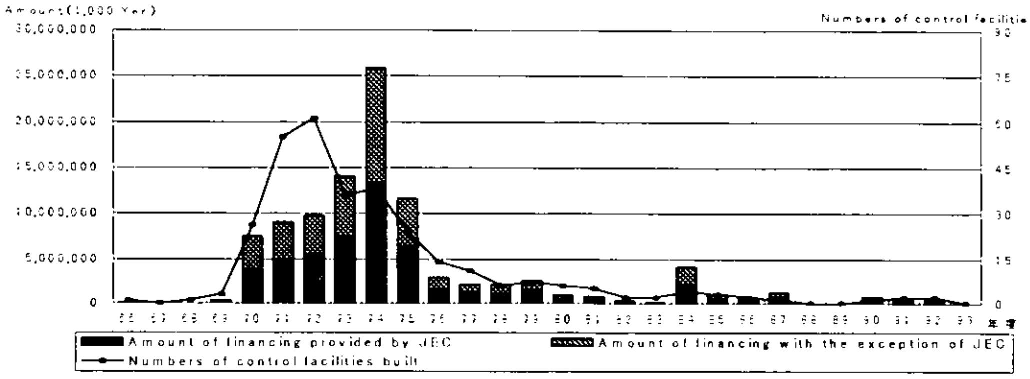


Figure 7-14 Spending for the installation of wastewater treatment facilities and the amount of JEC financing

(3) Flue Gas Treatment Facilities

Fig. 7-15 shows spending for the installation of flue gas treatment facilities and the amount of JEC financing, along with the number of new installations. The graph indicates that many flue gas treatment facilities were built throughout the 1970s. Especially in 1974 when SOx emission standards under the Air Pollution Control Law were toughened, the number of flue gas treatment facilities built was the highest at 28, and spending surged to nearly six times that of the previous year, demonstrating that the industry made great efforts to deal with flue gas emissions. Subsequently new construction gradually diminished, and since 1987 there have been no applications for loans to cover flue gas treatment facility construction.

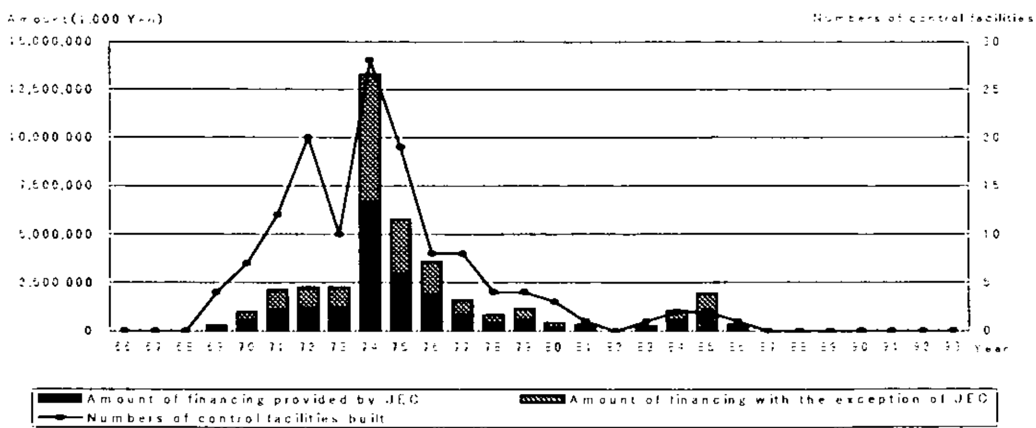


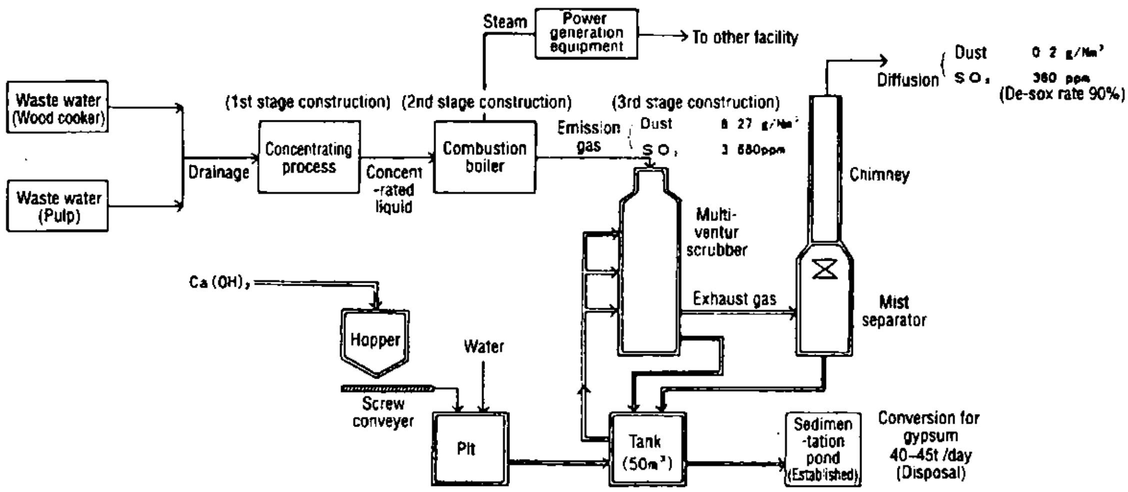
Figure 7-15 Spending for the installation of flue gas treatment facilities and the amount of JEC financing

7.2 Specific Financing Examples

Part 6, "Cleaner Production in the Pulp and Paper Industry," already offered some examples of financing, but this section shall provide an additional three examples of representative JEC-financed projects.

7.2.1 Company D (Wastewater and Flue Gas Treatment)

Because Company D, which produces mainly newsprint and printing paper, had an effluent BOD in 1972 of 1,000-1,200 mg/l, it was anticipated that the factory would not comply with the provisional standard of 600 mg/l that would, under the Water Pollution Control Law, come into effect in June 1974. The factory therefore decided to concentrate and burn digesting wastewater, which was its main BOD source. Equipment installation was divided into three phases: Waste liquor concentration equipment in phase one, waste liquor incineration equipment in phase two, and flue gas scrubbers in phase three. Steam generated by the concentrated liquor combustion boiler is used to generate electricity that is used throughout the factory. Fig. 7-16 illustrates the specifics of the construction plan.



Note : [box] is a part of improvement in that time

Figure 7-16 Specifics of the construction plan (Company D)

Tables 7-1 and 7-2 show the improvements that accrued from the new facilities. The BOD, soot and dust, and SO_2 were substantially reduced.

Table 7-1 Improvement effects by establishment of wastewater treatment facilities

	Before establishment			After establishment			Standards	
	No. 1 discharge channel	No. 2 discharge channel	No. 3 discharge channel	No. 1 discharge channel	No. 2 discharge channel	No. 3 discharge channel	General standards	Provisional standards
pH	3.3	6.8	3.6	5.9	6.8	5.9	5.8~8.6	5.8~8.6
BOD	1,080	5	1,200	600	5	595	120	600
SS	60	30	148	60	30	148	150	150

Note: 1. General standards have been applied since 24 June 1976.
Provisional standards were applied between 24 June 1974 and 23 June 1976.
2. Unit of BOD and SS is mg/l

Table 7-2 Improvement effects by establishment of flue gas treatment facilities

	Before establishment	After establishment	Standards
Soot and dust	8 g/Nm^3	0.2 g/Nm^3	0.4 g/Nm^3
SO_2	245.31 Nm^3/hr	24 Nm^3/hr	55.85 Nm^3/hr
Emitted concentration of SO_2	3,680 ppm	360 ppm	-

Table 7-3 shows how funds for facility construction were procured. Of the total 1,206,506,000 yen, JEC supplied 600 million yen (about 50%), banks 480 million yen (about 40%), and the factory itself 126,506,000 yen (about 10%).

Table 7-3 Procurement way of funds for facility construction

Unite: 1,000 Yen

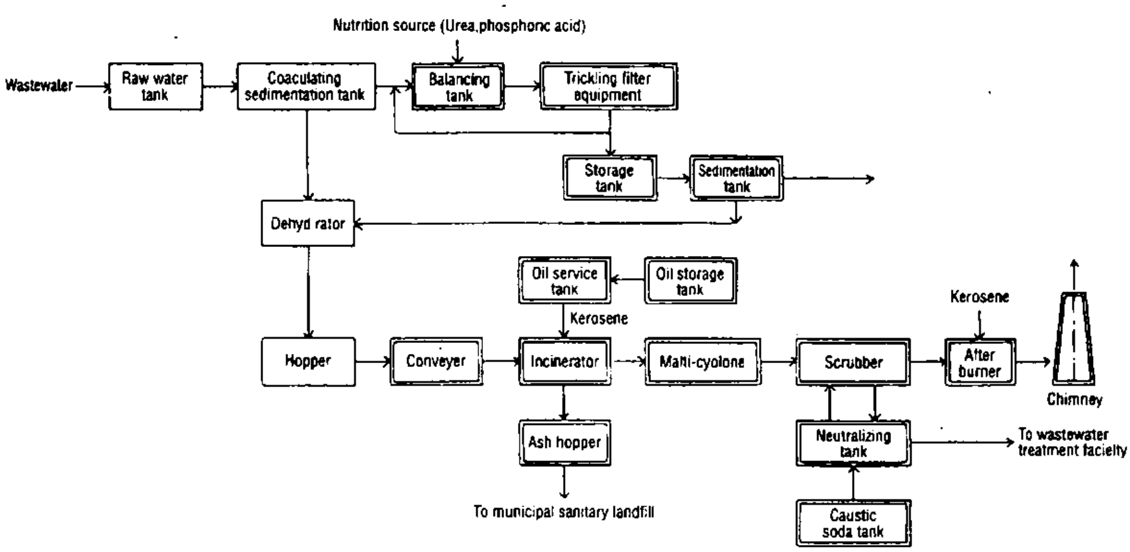
	Wastewater condensation facility	Wastewater incineration facility	Scrubber	Total
JEC	262,000	298,000	40,000	600,000
Bank	210,000	240,000	30,000	480,000
Own funds	52,000	59,000	15,506	126,506
Total	524,000	597,000	85,506	1,206,506

7.2.2 Company E (Wastewater and Industrial Wastes)

Company E, which manufactures toilet tissue papers, facial tissue, and other sanitary paper, installed a coagulation and sedimentation facility in 1972 with JEC financing to treat its wastewater. But in April 1974 the prefectural government enacted stricter standards, which put the factory's effluent over the COD standard. For this reason the factory decided to achieve adequate wastewater treatment by building a biological treatment facility. Additionally, the factory had until that time discarded the raw pulping-process sludge from its wastewater treatment system on its own land, but in September 1974 a city ordinance prohibited raw sludge dumping, which led the factory to build an incineration facility and burn the sludge. Fig. 7-17 illustrates the specifics of Factory E's installation plan.

Tables 7-4 and 7-5 show the result of the improvements, which were substantially reduced SS and COD. In addition to preventing secondary pollution from raw sludge dumping, the factory also meets national and city standards for the particulate emitted by sludge incineration.

Table 7-6 shows the funding procurement sources for constructing these facilities. Of the total 216,163,000 yen, JEC financing provided 160 million yen (about 74%), and bank financing 56,163,000 yen (about 26%), which made up the total.



Note [box] is a part of improvement in that time

Figure 7-17 Specifics of the construction plan (Company E)

Table 7-4 Improvement effects by establishment of wastewater treatment facilities

	Before establishment	After establishment	Stricter standards of prefectural government
pH	6.5	6~8	5~9
SS (mg/l)	40	20	90
COD_{Mn}	90~95	50	80

Table 7-5 Improvement effects by establishment of industrial waste treatment facilities

	Before establishment	After establishment	National standards	Municipal guiding standards
Raw sludge	Dumping	Incinerating	-	-
Soot and dust	-	0.05 g/Nm^3	0.7 g/Nm^3	0.05 g/Nm^3

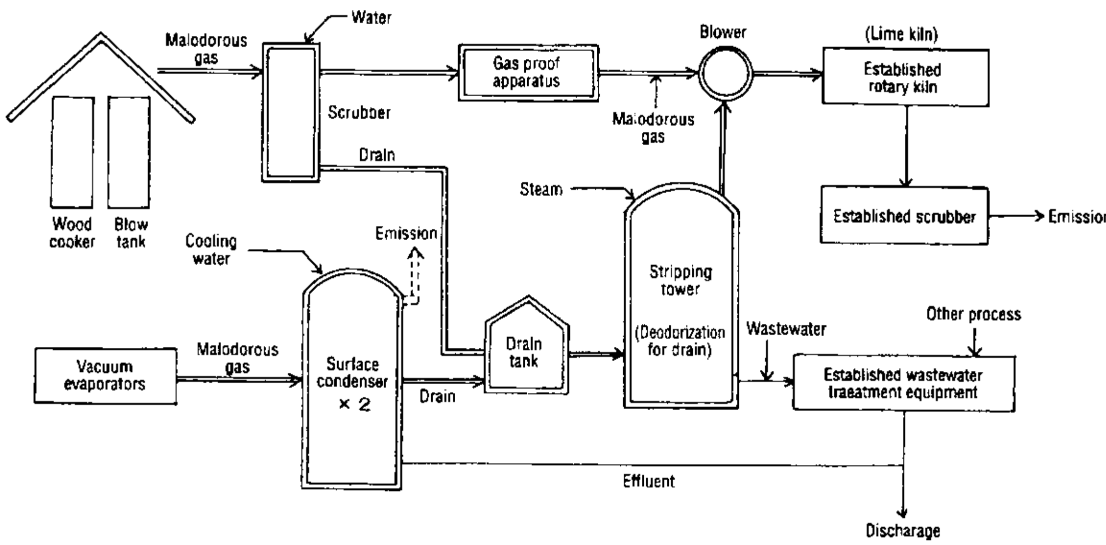
Table 7-6 Procurement way of funds for facility construction

Unite: 1,000 Yen

	Wastewater treatment facility	Industrial waste treatment facility	Total
JEC	64,000	96,000	160,000
Bank	27,739	28,424	56,163
Total	91,739	124,424	1, 206,506

7.2.3 Company F (Offensive Odor Control Equipment)

Company F, which manufactures paper and pulp, originally was not subject to legal restrictions on offensive odors emitted by Kraft pulp manufacturing plants, but restrictions were imposed in 1973 by a prefectural ordinance and again in 1974 by an agreement with the town government. The factory then burned malodorous substances in its existing rotary kiln, and decided to install equipment including a surface condenser, a stripping tower, and scrubbers. Fig. 7-18 illustrates the specifics of Company F's installation plan.



Note : [box] is a part of improvement in that time

Figure 7-18 Specifics of the construction plan (Company F)

Table 7-7 shows the result of the improvements, which were reduced concentrations of hydrogen sulfide, methyl mercaptan, and methyl sulfide, resulting in an effluent discharge with hardly any disagreeable odor. Table 7-8 shows the sources of funding for these facilities. Of a total 300,833,000 yen, a JEC loan provided 150 million (about 50%) and bank financing 150 million (about 50%), leaving the factory to come up with only 833,000 yen on its own.

Table 7-7 Improvement effects by establishment of Offensive odor control facilities

Unit : ppm

	Before establishment	After establishment	Stricter standards of prefectural government
Hydrogen sulfide	0.022	Less 0.02	0.02
Methyl mercaptan	0.015	Less 0.002	0.002
Methyl sulfide	0.034	Less 0.01	0.01

Table 7-8 Procurement way of funds for facility construction

Unite: 1,000 Yen

	Offensive odor control facilities
JEC	150,000
Bank	150,000
Own funds	833
Total	300,833

8. Environmental Problems in Japan, and Related Legal Controls

8.1 An Overview of the Development of Environment-Related Laws and Regulations

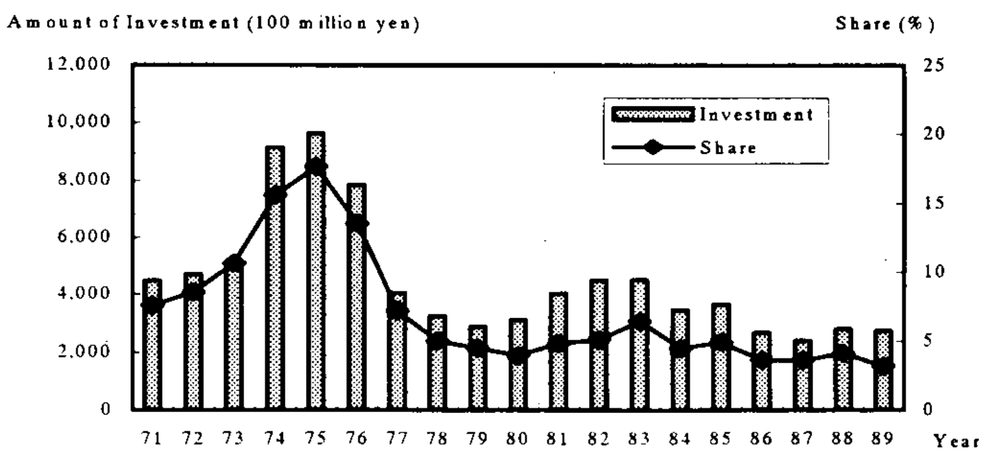
The post-World War II environment-related legal system had its inception in the creation of pollution control ordinances by local governments with major cities (1949 for Metropolitan Tokyo, 1950 for Osaka Prefecture, 1951 for Kanagawa Prefecture, etc.), which predated environmental legislation by the national government. From the latter half of the 1950s and through the 1960s Japan achieved rapid economic growth, and during these years the construction of petrochemical complexes started throughout Japan because the country switched from coal to oil for its energy source. In the 1960s the national economy began to develop very quickly on the basis of the "Income Doubling Plan," at which time the heavy and chemical industries were encouraged to develop quickly, and the petrochemical complexes began operations. The development of industry brought about industrial pollution, while the concentration of population in the cities caused deterioration of living conditions.

To deal with environmental deterioration, the government passed a variety of laws (at the end of the 1950s it passed two water pollution laws and the Sewerage Law, and soon afterward in the 1960s it passed a law restricting smoke from factories to serve as an air pollution-related law) that regulated pollutant emissions, and adopted a policy that encouraged the construction of pollution control facilities. It was under these circumstances that the Japan Environment Corporation (JEC) was established in 1965 to make use of government funds for pollution control.

In the 1960s pollution became a major issue, and the citizens' movements gained momentum, with the appearance of campaigns opposing the construction of petrochemical complexes. In the latter half of that decade pollution-induced health damage gained the broad attention of society, and a series of lawsuits was filed, including the 1967 lawsuit for asthma caused by the air pollution from the Yokkaichi petrochemical complex, the 1967 lawsuit against organic mercury poisoning in the Agano River basin in Niigata Prefecture, the 1968 Itai-itai disease lawsuit against cadmium poisoning in the Jinzu River watershed in Toyama Prefecture, and the 1969 Minamata disease lawsuit against organic mercury poisoning in Minamata City, Kumamoto Prefecture, which are known as the Four Great Pollution Lawsuits. In the face of such grave pollution problems, the government found it necessary to institute a system that would deal with pollution in a comprehensive and planned manner, which in 1967 led to passage of the Basic Law for Environmental Pollution Control, a law that set forth Japan's fundamental policy on pollution.

Such legislation notwithstanding, the pollution of the air and public waters and other environmental deterioration continued inexorably, until in the 1970s exhaust from motor vehicles using leaded gasoline caused lead poisoning, and other problems such as photochemical smog occurred. The public was so preoccupied with pollution issues that not a day went by without an appearance of the word "pollution" in the media, and the government put pollution at the top of its agenda. During the special Diet session in December 1970 the Basic Law for Environmental Pollution Control was revised, and for 13 other environmental laws legislators submitted either bills for passage or proposals for revisions, which all passed after hearings. As this session of the Diet concerned itself solely with the pollution issue, it is commonly known as the "pollution Diet session," which was the starting point for an extensive strengthening of pollution-related government administration.

While standards as defined by laws are the basis for regulating factories, some regions find it necessary to have standards that are stricter than the government's owing to natural or social conditions, for which reason the Water Pollution Control Law and Air Pollution Control Law allow stricter standards by prefectural ordinances. In addition, the 1964 agreement made between Yokohama City and a thermal power plant in the city was the first of many pollution control agreements between local governments and major companies located in their areas. These agreements apply standards that are more elaborate and/or stricter than those under laws and ordinances.

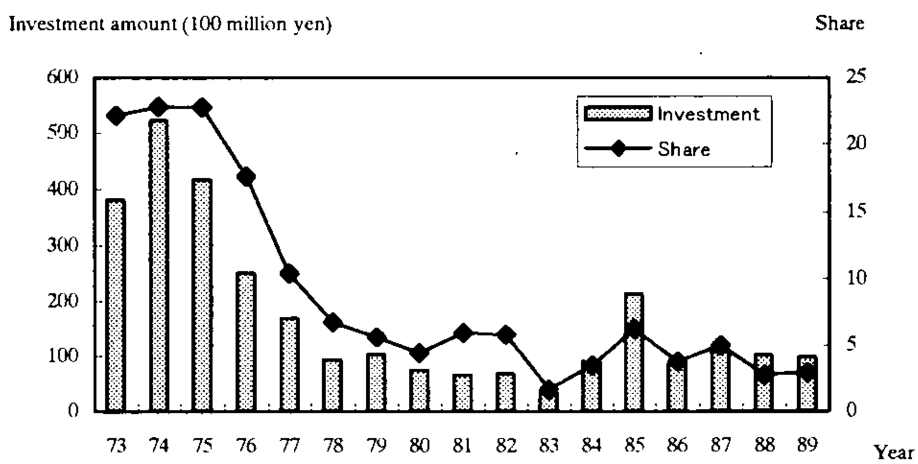


Source: Made using "Industry and Pollution" of SANGYO CHOSAKAI

Figure 8-1 Investment amount for environmental conservation and share for total investment in whole industries

Legal regulation and local government ordinances, as well as pollution control agreements, encourage private enterprise to make environmental conservation investments, whose aggregate amount increased rapidly beginning in 1970, and peaked in 1975 at an annual amount of 964.5 billion yen, which accounted for 17.7% of total capital investment.

Capital spending for environmental conservation in the pulp and paper industry has followed the same pattern, although such investment attained a high rate of over 20% earlier than the average for all industries, and peaked a year earlier, in 1974, at 52.2 billion yen.



Source: Made using "Industry and Pollution" of SANGYO CHOSAKAI

Figure 8-2 Investment amount for environmental conservation and share for total investment in pulp and paper industries

The main environment-related laws enacted or revised during the 1970s include the following: Revision of the Basic Law for Environmental Pollution Control (1970), revision of the Air Pollution Control Law (1970), enactment of the Water Pollution Control Law (1970), enactment of the Law Relating to the Prevention of Marine Pollution and Maritime Disaster (1970), revision of the Noise Regulation Law (1970), enactment of the Wastes Disposal and Public Cleansing Law (1970), enactment of the Pollution Control Public Works Cost Allocation Law (1970), enactment of the Law for the Punishment of Crimes Relating to the Environmental Pollution that Adversely Affects the Health of Persons (1970), enactment of the Offensive Odor Control Law (1971), enactment of the Nature Conservation Law (1972), enactment of the Pollution-Related Health Damage Compensation Law (1973), and enactment of the Vibration Regulation Law (1976).

In 1974, during these years when these environment-related laws were being legislated, the price of crude oil skyrocketed to four times the previous level in the first oil shock, and Japan's economy began the transition from rapid to stable economic growth. The oil shock encouraged businesses to conserve resources and energy, and they made exhaustive efforts to prevent leaks, recycle water, use heat effectively, and the like. Responses like these by companies, which included reviews of their production processes, not only had beneficial effects for disaster prevention, but in effect also gave companies a highly desirable orientation as regards environmental measures, which could also be called cleaner production.

With the arrival of the 1980s, controls on pollutants emitted by factories started functioning smoothly, and Japan appeared to be over the hump. But then a serious water pollution problem emerged in the form of eutrophication, caused mainly by graywater, in lakes and other enclosed bodies of water. The government responded by passing the Septic Tank Law (1983) and the Law Concerning Special Measures for the Preservation of Lake Water Quality (1984), and by revising the Water Pollution Control Law (1985) in order to restrict the concentration of nitrogen and phosphorus discharges affecting lakes.

After enactment of the Wastes Disposal and Public Cleansing Law in 1970 to deal with wastes, the only other action taken was a revision in 1977, but owing to the frequent illegal dumping of wastes, the inadequate maintenance and management of final disposal sites for industrial wastes, and other reasons, community resistance to the creation of final disposal sites grew stronger year by year, making their establishment extremely difficult, and resulting in the nearly total filling of final disposal sites in the greater Metropolitan Tokyo area and other areas. There being no other way to get around the situation than to thoroughly suppress the generation of wastes, reduce, and recycle, the government included these items in a 1991 revision of the Wastes Disposal and Public Cleansing Law, and enacted the Law for the Promotion of Utilization of Recycled Resources (1991) and the Law Concerning the Promotion of the Separation, Collection and Recycling of Containers and Packaging (1995).

Meanwhile, global environmental problems came into the spotlight from the second half of the 1980s. The Law Concerning Preservation of the Ozone Layer by Restricting Designated Substances (1988) was passed in response to the Vienna Convention to Protect the Ozone Layer and the Montreal Protocol, while the Law for the Control of Export, Import and Others of Specified Hazardous Wastes and Other Wastes (1992) was passed in response to the Basel Convention.

As the conservation of the global environment became a matter of urgency to humanity, it became increasingly vital to implement policy measures for environmental conservation in an integrated and planned manner. In 1993, therefore, the Basic Law for

Environmental Pollution Control was replaced by the Basic Environment Law, which set forth the basic orientation for the future.

8.2 Circumstances and Events Regarding Various Kinds of Pollution

8.2.1 Water Pollution

The pulp and paper industry grew quickly because of Japan's rapid economic growth, and the industry's water pollution became conspicuous in conjunction with that. In 1958 there was an incident in which Tokyo Bay fishermen forced their way into a paper mill near Tokyo, claiming their fishing had been damaged by the mill's effluent. In response to this incident, which had become a major social issue, the government enacted the Law Concerning the Preservation of Water Quality in Public Waters and the Factory Effluent Control Law at the end of that year. The latter half of the 1960s was a time when people became broadly aware of grave health damage caused by contamination of water, an awareness spawned by events such as the lawsuits for Minamata disease, which was caused by organic mercury contamination, and for Itai-itai disease, which was caused by cadmium contamination, but it was also a time when the papermaking industry called attention to itself in a big way. The Fuji City area has the highest pulp and paper industry concentration in Japan because of its abundant and high-quality groundwater from Mt. Fuji, but in the late 1960s the effluent from those factories ran into the bay at Tagonoura Port with hardly any treatment, turning into large amounts of sludge that accumulated in the bay (photo). In addition to being a hindrance to ships, the sludge gave off hydrogen sulfide and methane gas that had a large impact on the local populace.

Photo Tagonoura Port in 1969 - Provision by Fuji Municipal Government-

This situation led to strong demands for tougher regulation, and at the end of 1970, along with the passage of many other environmental laws, lawmakers enacted the Water Pollution Control Law, which integrated two water-related laws from 1958 and expanded the range of waters covered from designated areas to all public waters. The Water Pollution Control Law incorporated penal provisions for violations of effluent standards, and allowed prefectures to enact ordinances with even tougher standards. Because this happened to be a time when local anti-pollution movements were causing a major stir around the country, factories had to quickly take measures to treat their wastewater and get their effluent pollutant concentrations within standards as soon as possible so that they might continue production in a way that was acceptable to their local communities. For this reason factories hurried to install facilities that treat and clean wastewater from production processes, a method known as end-of-pipe technology.

In the Seto Inland Sea, Tokyo Bay, Ise Bay, and other large enclosed waters, the concentrations of industry and population limited the efficacy of controls employed until then, which had regulated the concentration of individual pollution sources, so in 1978 the Water Pollution Control Law was revised, and the Law Concerning Special Measures for Conservation of the Seto Inland Sea was enacted. With the intent to establish measures for reducing the overall pollutant load, these laws incorporated the total pollution load regulation system, which specified COD as an item showing the extent of water pollution.

In enclosed bodies of water, meanwhile, in order to improve water quality in lakes in which eutrophication was occurring, eutrophication abatement ordinances were established in 1979 by Shiga Prefecture for Lake Biwa, and in 1980 by Ibaraki Prefecture for Lake Kasumigaura. Further, in 1984 the Law Concerning Special Measures for the Preservation of Lake Water Quality was established, leading to the adoption of elaborate measures for enclosed bodies of water that differed from measures for other public water areas. In 1982 the government created environmental quality standards (EQS) for nitrogen and phosphorus, which cause eutrophication in lakes, and in 1985 it partially revised the Water Pollution Control Law, adding nitrogen and phosphorus to the effluent standards for designated inland waters. Likewise for the ocean, in 1993 the government created EQS and effluent standards for nitrogen and phosphorus.

To strengthen regulation of hazardous substances, in 1989 the Water Pollution Control Law made two organic chlorine solvents subject to effluent standards, and prohibited the permeation of effluent containing hazardous substances into the ground. In 1993 the law's total list of hazardous substances was increased to 26 by the addition of 13 items, including organic chlorine compounds and agrichemicals.

Dioxins are present in not only the gases from waste combustion, but also in the effluents from pulp and paper mills. For this reason the Environment Agency quickly carried out a study and in 1991 released the "Results of an Urgent Study on Dioxin from Pulp and Paper Mills." Based on those results, in 1992 the Agency asked the pulp and paper industry and the prefectures to enact remedial measures on dioxin generated at pulp and paper mills.

8.2.2 Air Pollution

Just as with water pollution, regulations on air pollution began with pollution control ordinances passed by local governments for major cities. Beginning about 1960 some areas of Japan had severe air pollution caused by petrochemical complexes, large power plants, and other heavy and chemical industries, and the occurrence of asthma among people living near the petrochemical complex in Yokkaichi City developed into a social issue. With the quick growth of industrial activities, air pollution tended to spread over broad areas that crossed the borders of local governments, which triggered demands that the national government take positive action to deal with the problem. It was under these circumstances that the Smoke Emissions Control Law was enacted in 1962 as Japan's first air pollution-related law. This law imposed restrictions on SOx and particulate concentrations only in designated areas, with the upshot being that while dust fall amount tended to decline owing to the installation of dust collectors and the switch from coal to oil for fuel, SOx pollution became even worse.

Because there was pressure at that time to remedy air pollution more quickly than other kinds of pollution, the intent of the 1967 Basic Law for Environmental Pollution Control was carried over in the 1968 enactment of the Air Pollution Control Law in order to implement integrated and effective controls from a new perspective. But as air pollution continued to broaden geographically and to diversify, there were strong demands for strengthened remedies that would include prevention. Thus at the end of 1970 the Air Pollution Control Law was revised to cover the entire country instead of just designated areas, to control more pollutants, to incorporate provisions including penalties, and to allow tougher restrictions by prefectural ordinances.

Sulfur oxides were the controlled air pollutants of the greatest consequence at that time, but as regulations were imposed on individual sources, in areas with many factories they accumulated and produced high concentrations. In 1974, therefore, the Air Pollution Control Law was revised so that was subject to total pollution load, and NOx too would be subject to total pollution load regulation in 1981. Subsequently SOx remedial measures brought about substantial improvements through the installation of flue gas desulfurization hardware and fuel switchover (including the direct desulfurization of fuel oil to lower its sulfur content, and switching from fuel oil to natural gas), and cutting ambient air SOx concentration to an annual average of about 0.010 ppm, a decrease to one-fourth or one-fifth of the level around 1970. In recent years there is hardly any area in Japan that exceeds the SO_2 EQS (daily average value below 0.04 ppm). NOx, on the other hand, have remained unchanged during recent years, the reasons being that to cut NOx emissions factories have introduced improved combustion technologies (low-NOx burners, two-stage combustion, flue gas recirculation, etc.) and switched fuels (for example, from fuel oil to natural gas). Additionally, some thermal power plants, steel mills, and other large emission sources have made considerable improvements such as installing flue gas denitrification equipment. In the cities, however, motor vehicles make a big NOx contribution, so that tougher per-vehicle restrictions failed to mitigate ambient air NOx concentration owing to increasing fleet size. This necessitated a new regulatory framework to reduce total motor vehicle NOx emissions, and in 1992 the government enacted the Law on Special Measures for Total Emission Control of Nitrogen Oxides from Motor Vehicles in Designated Areas, which created a system for tougher controls in major cities where NOx pollution was especially severe.

The regulation of atmospheric emissions of hazardous substances had been accomplished by controlling target substances ((1) cadmium and its compounds, (2) chlorine and hydrogen chloride, (3) fluorine, hydrogen fluoride, and silicon fluoride, (4) lead and its compounds, and (5) nitrogen oxides) as hazardous substances under the Air Pollution Control Law. Subsequently damage to human health by asbestos became a social issue, and that substance was made subject to regulation as a specified particulate substance by a 1989 revision of the Air Pollution Control Law. Further, the government began a consideration of as yet unregulated hazardous substances, resulting in the creation of an item in the Air Pollution Control Law called "Promotion of Remedial Measures for Hazardous Air Pollutants," to which benzene, trichloroethylene, and tetrachloroethylene were added as designated substances.

Because dioxins are formed by the incineration of wastes, air pollution near waste incineration facilities has become an issue during recent years. The Environment Agency performed a comprehensive study on the desirable forms of risk assessment and emission reduction measures, and made an interim summary of its findings in December 1996. The Ministry of Health and Welfare reviewed its guidelines for controlling dioxin emissions at waste incineration facilities, which it had formulated in 1990, and created new guidelines in January 1997. In August 1997 the government released its "Five-Year Plan Concerning Dioxin Countermeasures", and a revision of the Air Pollution Control Law that same month added remedial measures for dioxins at waste incinerators and the electric furnaces used in steelmaking.

In the pulp and paper industry, sources of smoke and soot that pollutes the air are the boilers that produce the large amounts of steam used in manufacturing processes, the combustion equipment for black liquor recovery (used as boilers), sludge incinerators, lime kilns, and other equipment. Pollutants formed are particulates, SOx, and NOx. As a means of controlling SOx, many factories desulfurize their boiler flue gas and recover the sulfur to obtain the sodium sulfite used as cooking liquor.

In 1988 the Law Concerning Preservation of the Ozone Layer by Restricting Designated Substances was enacted to deal with controlled CFCs in response to the Montreal Protocol for protection of the ozone layer, a global environmental problem affecting the atmosphere. Acid rain necessitates an international response because it is a wide-area problem caused by air pollutants that are transported long distances across national borders. A concept for an East Asian acid rain monitoring network including Japan was developed, and in March 1998 the first intergovernmental meeting of involved countries was held in Yokohama. In the area of global warming, the Third Conference of the Parties to the United Nations Framework Convention on Climate Change (Kyoto Conference) was held in Kyoto in December 1997, and consideration is underway on legislation and other ways of reducing total greenhouse gas emissions.

8.2.3 Offensive Odors

Offensive odors are the most frequent cause of complaints from people living near pulp and paper mills. Methyl mercaptan, hydrogen sulfide, methyl sulfide, methyl disulfide, and other compounds are the sources of disagreeable odors from mills directly. Furthermore sludge from effluent was another cause indirectly. In Fuji City, which hosts a concentration of Japan's pulp and paper mills, effluent was discharged into the water at Tagonoura Port where sludge accumulated and produced foul-smelling hydrogen sulfide, leading to a public outcry.

The first legislation to deal with offensive odors was the 1971 Offensive Odor Control Law, which initially regulated five substances (ammonia, methyl mercaptan, hydrogen sulfide, methyl sulfide, and trimethyl amine). From this point in time pulp and paper mills made positive odor control efforts. In 1976 the law added methyl disulfide, acetaldehyde, and styrene to its list of controlled substances. In 1989 it added four short-chain fatty acids, and in 1993 it added 10 substances that cause organic solvent and burning odors, making for the present total of 22 controlled substances.

While the limiting of substance concentrations promises adequate control of the odors emitted by the pulp and paper industry, it cannot deal with complaints about the diverse odors emitted by food manufacturing, services, and other industries. Therefore in 1995 the government implemented a control standard that uses an "odor index" based not only on a method using instrumental analyses to determine odor intensity, but also on a sensory test (the triangle odor bag method) that measures odor using the human olfactory sense.

8.2.4 Wastes

For a long time the Public Cleansing Law governed the legal treatment of wastes, but in 1970 the Wastes Disposal and Public Cleansing Law was enacted to deal comprehensively with wastes. This law roughly divides wastes into municipal solid wastes (MSW) and industrial wastes, and regulates sludge from pulp and paper manufacturing processes, which are generated in large quantities, as industrial waste. At first landfilling sludge and other such wastes in final disposal sites was the least expensive, so the industry took the easy way out and depended on landfilling, with hardly any efforts being made for reduction and reuse. Later the leachate and other substances from landfills adversely affected community environments, and the public sought tougher regulation of landfilling, which led to a revision of the law and issuance of the "Order Establishing Technical Standards for Final Disposal Sites" in 1977. Despite these changes, there was still great distrust of waste landfilling among people living near disposal sites, which made the construction of final disposal sites increasingly difficult, and that posed the considerable challenge of how to reduce the amount of wastes disposed. Against this backdrop, the Wastes Disposal and Public Cleansing Law was revised in 1991 in order to facilitate waste reduction and reuse, ensure appropriate disposal, and prepare disposal facilities. As disposal costs in the pulp and paper industry grew year by year, the industry made waste reduction efforts that included incinerating sludge, the use of that ash as heat retainer in blast furnaces, and the use of ashes from coal-fired boilers as cement feedstock. In 1991 the Law for the Promotion of Utilization of Recycled Resources was enacted in order to ensure the effective use of resources and to reduce the generation of wastes. This law regards the pulp and paper industry as one in which the use of recycled resources is technologically and economically possible, and an industry in which reuse is especially necessary to provide for the effective use of recycled resources. The law specified waste paper as a recycled resource covered by its provisions, and required the expanded use of waste paper in paper manufacturing.

With MSW there were likewise calls for reduction and full use of recycled resources, so in 1995 the Law Concerning the Promotion of the Separation, Collection and Recycling of Containers and Packaging was enacted to deal with containers and packaging, which account for a large part of MSW, and for which recycling and reuse are technologically possible. The law's aim is to build a system to facilitate the reuse of this waste in merchandise.

Subsequently there were growing demands for appropriate handling of wastes, which led to the June 1997 revision of the Wastes Disposal and Public Cleansing Law in order to promote the reduction and reuse of wastes, to revise the procedures for establishing waste disposal facilities, to rework measures for dealing with illegal dumping, and other purposes. The law's enforcement order was revised twice that year for purposes including the following: In August for dioxin countermeasures and for eliminating the size requirement in permits to build final disposal sites; and in December to upgrade landfilling standards relating to stable industrial wastes, to strengthen landfilling standards for hazardous industrial wastes, to broaden the scope of industrial wastes that fall under construction and demolition wastes, and to establish disposal standards and toughen storage standards for PCBs.

In order to internationally address the transfrontier shipment of hazardous wastes, the Law for the Control of Export, Import and Others of Specified Hazardous Wastes and Other Wastes was enacted in 1992 as the domestic counterpart of the Basel Convention in order to provide for the regulation of the import, export, transport, and disposal of specified hazardous wastes. In September 1993 Japan became a party to the Basel Convention.

8.2.5 Noise

The 1968 Noise Regulation Law controls three categories of noise: (1) Noise arising from business activities at factories and operation sites, (2) construction noise, and (3) motor vehicle noise. Factories subject to the law are those with types of facilities that the law specifies, and specified facilities used in the pulp and paper industry are wood processing machines (drum barkers, chippers, grinders) and paper machines. Of the factories with such facilities, those subject to the law are factories sited in areas designated by prefectural governors as those with a requirement to protect the living environment of residents from noise, such as residential neighborhoods and the vicinities of hospitals and schools. Since a general overhaul of the law in 1970 there have been no significant revisions.

8.2.6 Vibration

The Vibration Regulation Law was enacted in 1976. It has three categories, as in regulating noise, for classifying types of vibration: (1) Vibration arising from business activities at factories and operation sites, (2) construction vibration, and (3) road traffic vibration. Factories subject to the law are those with specified facilities, which in the case of the pulp and paper industry are wood processing machines (drum barkers and chippers). Area designations are the same as under the Noise Regulation Law. Since enactment of the law there have been no significant revisions.

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Main Group Related Pulp and Paper Industry

1. Japan Paper Association
   Pulp and paper hall 3-9-11 Ginza Chuo-ku Tokyo 104, JAPAN

2. Japan Technical Association of Pulp and Paper Industry
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[Reference Materials]

1. Standards According to Environmental Laws

1.1 Water Pollution Control Law

(a) Uniform Effluent Standards Pertaining to the Living Environment

Parameter	Standards	Notes
Hydrogen ion concentration (pH) Discharge to the area except sea Discharge to the sea area	 5.8~8.6 5.0~9.0	Establishment in 1971
Biochemical Oxygen Demand (BOD)	160 mg/l (daily average : 120 mg/l)	Establishment in 1971
Chemical Oxygen Demand (COD_{Mn})	160 mg/l (daily average : 120 mg/l)	Establishment in 1971
Suspended solids (SS)	200 mg/l (daily average : 150 mg/l)	Establishment in 1971
N-hexane extracts Content of mineral oil Content of animal and vegetable oils	 5 mg/l 30 mg/l	Establishment in 1971
Content of phenol	5 mg/l	Establishment in 1971
Content of copper	3 mg/l	Establishment in 1971
Content of zinc	5 mg/l	Establishment in 1971
Content of soluble iron	10 mg/l	Establishment in 1971
Content of soluble manganese	10 mg/l	Establishment in 1971
Content of chromium	2 mg/l	Establishment in 1971
Content of fluorine	15 mg/l	Establishment in 1971
Coliform group number	daily average: 3,000 pieces/cm^3.	Establishment in 1971
Content of nitrogen	120 mg/l (daily average : 60 mg/l)	Lake: application in 1985 Sea: application in 1993
Content of phosphorus	16 mg/l (daily average : 8 mg/l)	Lake: application in 1985 Sea: application in 1993

Note: Effluent standards concerning nitrogen and phosphorus apply only to lakes and ocean areas designated by the Minister of State and Director General of Environment Agency as presenting the possibility of a marked increase in phytoplankton because of nitrogen and phosphorus supply, and to effluents discharged into public waters that empty into these lakes and ocean areas. Lakes subject to the standards were designated in 1985, and designated ocean areas were established in 1993.

(b) Uniform Effluent Standards Pertaining to the Toxic Substances

Toxic Substances	Standard Value	Notes
Cadmium and its compounds	0.1 mg/l	Establishment in 1971
Cyanide compounds	1.0 mg/l	Establishment in 1971
Organic phosphorus compounds (parathion, methyl parathion, methyl demeton and EPN only)	1.0 mg/l	Establishment in 1971
Lead and its compounds	0.1 mg/l	Establishment in 1971
Hexavalent chrome compounds	0.5 mg/l	Establishment in 1971
Arsenic and its compounds	0.1 mg/l	Establishment in 1971
Total mercury	0.005 mg/l	Establishment in 1971
Alkyl mercury compounds	Not detectable	Establishment in 1971
PCBs	0.003 mg/l	Establishment in 1975
Trichloroethylene	0.3 mg/l	Establishment in 1989
Tetrachloroethylene	0.1 mg/l	Establishment in 1989
Dichloromethane	0.2 mg/l	Establishment in 1993
Carbon tetrachloride	0.02 mg/l	Establishment in 1993
1,2-dichloroethane	0.04 mg/l	Establishment in 1993
1,1-dichloroethylene	0.2 mg/l	Establishment in 1993
Cis 1,2-dichloroethylene	0.4 mg/l	Establishment in 1993
1,1,1-trichloroethane	3.0 mg/l	Establishment in 1993
1,1,2-trichloroethane	0.06 mg/l	Establishment in 1993
1,3-dichloropropene	0.02 mg/l	Establishment in 1993
Thiuram	0.06 mg/l	Establishment in 1993
Simazine	0.03 mg/l	Establishment in 1993
Thiobencarb	0.2 mg/l	Establishment in 1993
Benzene	0.1 mg/l	Establishment in 1993
Selenium and its compounds	0.1 mg/l	Establishment in 1993

(c) Provisional Standards

When standards were applied in conjunction with the 1971 enforcement of the Water Pollution Control Law, for a certain period of time (five years) the government allowed provisional standards more lax than the law's standards for industries in which it was deemed difficult to accommodate the law's standards. This table shows the provisional standards that applied to the pulp and paper industry.

Provisional Standards of Water Pollution Control Law

Parameter	Type of manufacturing industry	Permissible limits (mg/l)	Duration
BOD	Sulfite pulp	520 (daily average 400) 390 (daily average 300)	June 24 1971~June 23 1973 June 24 1973~June 23 1976
	Chemi-ground pulp (except for padding) Semi-chemical pulp (except for padding)	1,300 (daily average 1,000) 390 (daily average 300)	June 24 1971~June 23 1973 June 24 1973~June 23 1976
	Dissolved sulfite pulp	1,600 (daily average 1,200) 780 (daily average 600)	June 24 1971~June 23 1974 June 24 1974~June 23 1976
	Chemi-ground pulp (for padding) Semi-chemical pulp (for padding) Bleaching straw pulp	1,300 (daily average 1,000) 780 (daily average 600)	June 24 1971~June 23 1973 June 24 1973~June 23 1976
COD_{Mn}	Kraft pulp	260 (daily average 200)	
	Dissolved Kraft pulp	390 (daily average 300)	
	Lime straw pulp	780 (daily average 600)	
	Sulfite pulp	1,000 (daily average 800) 780 (daily average 600)	June 24 1971~June 23 1973 June 24 1973~June 23 1976
	Chemi-ground pulp, Semi-chemical pulp, Bleaching straw pulp	1,600 (daily average 1,200) 780 (daily average 600)	June 24 1971~June 23 1973 June 24 1973~June 23 1976
	Dissolved sulfite pulp	1,800 (daily average 1,400) 1,000 (daily average 800)	June 24 1971~June 23 1974 June 24 1974~June 23 1976
SS	Bleaching straw pulp	330 (daily average 250)	
	Lime straw pulp	650 (daily average 500)	
N-hexane extracts (animal and vegitable fats)	Pulp	50	

(d) Total Pollution Load Regulation

Total pollution load regulation was established in 1979 to strictly regulate effluent from certain operation sites in the watersheds of Tokyo Bay, Ise Bay, and the Seto Inland Sea in order to preserve water quality in these enclosed bodies of water.

This system specifies the reporting volume of effluents from industrial processes, which corresponds to categories including industry type as established according to what an industry does, and it specifies the pollutant load permitted for effluents as based on a fixed COD_{Mn} concentration that is established by prefectural governors. Each factory or business establishment is to measure its own load and report on how it is abiding by its maximum allowable load. This system has been made stricter three times, and the fourth revision is nigh. The allowable effluent load is set in the following manner.

$$L = (C_j \times Q_j + C_i \times Q_i + C_o \times Q_o) \times 10^{-3}$$

Where:

- L is the pollution load allowed for discharged effluent (kg/day)
- C_j, C_i, and C_o are the fixed COD_{Mn} established by the prefectural governor (mg/l); known as C values

  j, i, and o indicate when they were set.
- Qj, Qi, and Qo are the reporting process effluent volumes corresponding to C_j, C_i, and C_o.

Under the third total pollutant load standards, the following C values became applicable on or after April 1, 1994 in accordance with the dates set.

(1) Set prior to or on June 30 1980 : C_o

(2) Set between July 1, 1980 and March 31, 1989, inclusive : C_i

(3) Set on or after April 1, 1989 : C_j

C values are set for each industry type or other classification for total pollution load regulation standards.

1.2 Air Pollution Control Law

Control substances	Example of substances	Cause of generation	Facility	Method of control	Control measure
Smoke and soot	Sulfur oxides SO_2, SO_3	Combustion of fuel or others	Smoke and soot emitting facility	Emission standard · Volume control (k value control) · Total pollution load	· Improvement order · Direct application of punishment provisions
	Soot	Combustion of fuel or others	Smoke and soot emitting facility	Emission standard · Concentration control (kinds and scale of facility separately)	· Improvement order · Direct application of punishment provisions
	Toxic substance NOx, Cd, Pb, HF, Cl_2, HCl		Smoke and soot emitting facility	Emission standard · Concentration control (kinds of facility and substance separately)	· Improvement order · Direct application of punishment provisions
	Specific toxic substance (non designation)	Combustion, synthesis, decomposition, press	Smoke and soot emitting facility	Emission standard · Volume control (k value control)	· Improvement order · Direct application of punishment provisions
Dust	Specific dust · Asbestos	Decomposition, cutting, grind	Specific dust emitting facility	Concentration Control (on the borderline of site)	Improvement order
	General dust · Cement powder, coal powder, iron powder	Crush, separation, pile	Dust emitting facility	Standards of structure, utilization and management	Order to suit for standard
Toxic air pollution substance	Benzene, trichloroethylene, tetrachloroethylene, dioxins	Drying, distillation, reaction, mixing, washing, dissolution, combustion	Designated substance emitting facility	Restraint standard for designated substance	Self management
Automobile exhaust gas	CO_2, HC, Pb	Movement of vehicles	Specific vehicle	Maximum permissible limit · Consideration by maintenance standard	· Traffic control · Order for maintenance

(1) SOx Emission Standard (k value)

$$q = k \times 10^{-3} \times He^2$$

Where:

- q is allowable emission volume (0 °C, 1 atmosphere, m^3/hr)
- k is the area constant
- He is effective stack height (m)

This standard is applied each stack. The smaller the value of k, the stricter the standard. There are 16 levels throughout the range from 3.0 to 17.5. Special emission standards are applied in areas with a concentration of facilities. There are 3 levels throughout the range from 1.17 to 2.34.

(2) SOx Total Area-Wide Pollution Load Regulation

SOx total pollution load regulation is used in areas where it is deemed difficult to comply with environmental standards owing to a concentration of many smoke sources. Prefectural governors prepare total pollution load reduction plans for those areas, and establish total pollution load regulation standards according to those plans. These standards are allowable emission standards for the total pollution of factories whose aggregate sulfur oxide emissions are determined by totaling the SOx emitted by their specified facilities. Two methods are used to calculate the regulated emission amounts. One involves reducing the increase in the permitted SOx amount in accordance with the increase in the amount of raw material or fuel used; the other involves controlling the SOx level so that it matches the maximum combined ground-level concentration fixed by the prefectural governor. The former works in the following way.

$$Q = a \cdot W^b + r \cdot a \{(W+Wi)^b - W^b\}$$

Where:

- Q is the total permitted quantity of SOx emissions (m^3/hr at 0°C and 1 atmosphere)
- W is the total (kl/hr) amount of raw materials and fuel in fuel oil equivalent (excluding Wi)
- Wi is the total amount in fuel oil equivalent (kl/hr) of raw materials and fuel at facilities installed after the date specified by the prefectural governor
- a is a constant fixed by the prefectural governor to attain the emission reduction target
- b is a constant fixed by the prefectural governor 0.8 or larger but under 1.0 in consideration of factors including the distribution of factories by size and their use of raw materials or fuel
- r is a constant fixed by the prefectural governor 0.3 or larger but under 0.7 in consideration of factors including the kinds of facilities installed at various factories

1.3 Offensive Odor Control Law

(a) Regulation Standards at Site Boundaries

Regulation standards at site boundaries are the values fixed by prefectures, which are within the atmospheric concentration ranges specified for malodorous substances in the table below.

	Malodorous substances	Range of atmospheric regulation standards (ppm)
1	Ammonia	1~5
2	Methyl mercaptan	0.002~0.01
3	Hydrogen sulfide	0.02~0.2
4	Methyl sulfide	0.01~0.2
5	Methyl disulfide	0.009~0.1
6	Trimethyl amine	0.005~0.07
7	Acetaldehyde	0.05~0.5
8	Propionaldehyde	0.05~0.5
9	Normal butyraldehyde	0.009~0.08
10	Iso-aldehyde	0.02~0.2
11	Normal valeraldehyde	0.009~0.05
12	Iso-valeraldehyde	0.003~0.01
13	Iso-butanol	0.9~20
14	Ethyl acetate	3~20
15	Methyl Iso-butyl ketone	1~6
16	Toluene	10~60
17	Styrene	0.4~2
18	Xylene	1~5
19	Propionic acid	0.03~0.2
20	Normal butyric acid	0.001~0.006
21	Normal valerianic acid	0.0009~0.004
22	Iso-valerianic acid	0.001~0.01

(b) Regulation Standard at Smokestack Openings

Following are the regulation standards at smokestack openings for malodorous substances emitted from smokestacks at least 5 m high (effective stack height) as corrected for the flow rate, emission speed, and emission temperature of the emitted gases (excluding methyl mercaptan, methyl sulfide, methyl disulfide, acetaldehyde, styrene, propionic acid, normal butyric acid, normal valerianic acid, and iso-valerianic acid).

$$q = 0.108 \times He^2 \times Cm$$

Where:

- q is the allowable flow rate of the specified malodorous substance (in m^3/hr at 0°C and 1 atmosphere)

- He is effective smokestack height (m)
- Cm is the regulation standard value (ppm) set for the site boundary

(c) Regulation Standard According to Maximum Permissible Level of the Odor Index

The odor index is a method that involves using the human olfactory sense to measure the intensity of an odor collected on site, and without specifying odor constituents. This measurement method is also called the triangle odor bag method, and works by having an odor judge determine how much a sample containing the odor must be diluted until it can no longer be distinguished from an odorless sample.

Regulation standard according to odor index: Value set by the prefectural governor

* Environmental sample (site boundary):

$$Y = 10\log(M \times 10^{\frac{r_1 - 0.58}{r_1 - r_0}})$$

Where:

- Y is the odor index : Value set by the prefectural governor in the range of 10-21.
- M is the initial dilution multiple
- r_1 is the average correct solution rate for the initial dilution multiple
- r_0 is the average correct solution rate when the initial dilution multiple is multiplied by 10

* Smokestack sample:

$$Y = 10 \log X$$

Where:

- Y is the odor index : Value set by the prefectural governor
- X is the threshold value at each panel

(d) Regulation Standard for Malodorous Substance in Effluent

The regulation standard for malodorous substance in effluent is calculated in the following manner for the four substances of methyl mercaptan, hydrogen sulfide, methyl sulfide, and methyl disulfide.

$$C_{Lm} = k\ C_m$$

Where:

- C_{Lm} is the maximum permissible level of a specified malodorous substance in effluent (mg/l)
- k is the value (mg/l) from the following table corresponding to the amount of effluent

discharged outside the facility site

- C_m is the regulation standard value (ppm) established in (a) for the site boundary

Value of k

	Volume of wastewater (m^3/s)		
	0.001 or less	0.001~0.1	0.1 or more
Methyl mercaptan	16	3.4	0.71
Hydrogen sulfide	5.6	1.2	0.26
Methyl sulfide	32	6.9	1.4
Methyl disulfide	63	14	2.9

2. Year Conversion Indexes for Improvement Costs

Year	All commodities	Construction materials	Durable consumer goods	Foreign exchange rate (yen/US$)
1965	43.7	40.4	81.6	360.00
1966	44.7	43.3	81.4	360.00
1967	45.6	45.6	81.3	360.00
1968	45.9	45.6	81.0	360.00
1969	46.9	46.7	81.1	360.00
1970	48.6	49.0	82.6	360.00
1971	48.2	47.0	81.2	308.00
1972	48.6	49.7	91.3	308.00
1973	56.3	64.1	84.9	308.00
1974	74.0	79.6	102.9	308.00
1975	76.2	73.9	103.7	308.00
1976	80.0	78.3	102.6	308.00
1977	81.5	82.5	102.5	308.00
1978	79.5	84.0	101.5	234.00
1979	85.3	94.0	101.2	206.00
1980	100.5	105.0	102.9	242.00
1981	101.9	101.3	102.6	210.00
1982	103.7	100.9	102.1	233.00
1983	101.4	100.2	100.6	237.00
1984	101.1	101.3	100.3	231.00
1985	100.0	100.0	100.0	254.00
1986	90.9	97.5	97.4	185.00
1987	87.5	98.7	94.5	151.00
1988	86.6	100.4	90.9	127.00
1989	88.8	104.9	86.2	130.00
1990	90.6	108.6	84.6	150.00
1991	90.0	110.9	83.2	135.00
1992	88.6	110.2	82.9	130.00
1993	86.1	109.3	81.3	118.00
1994	84.3	106.5	79.4	107.00
1995	83.5	105.9	77.6	93.00

Source: Japan Statistical Yearbook (data from 1997, 1990, 1984, 1979, 1974, and 1969 editions normalized with the 1985 value as 100)

Items to note when using the conversion indexes

(1) Use the basic category grouping index of the overall wholesale price index for the all commodities column, and use the index according to special group classification at the demand stage and the index according to type of use for the construction materials and durable consumer goods columns.

(2) Items to note in making determinations when performing conversions, depending on the facilities and equipment being considered

a. When considering a number of items overall: all commodities column

b. When considering the intermediate materials used in construction work: construction materials column

c. When considering equipment and other final goods: durable consumer goods column

Postscript

This manual was implemented in FY1997 by the Overseas Environmental Cooperation Center, Japan (OECC) under a commission from the Japan Environment Corporation (JEC).

Since its founding in 1965, JEC has for many years provided financing mainly for pollution control measures carried out by private enterprises, and the number of loans is now over 5,000. These financing files contain valuable information such as the events leading to improvements made by companies to control pollution, types of improvements made, the beneficial effects, and the costs of making the improvements.

This book was written as part of the technical manual preparation project for various industry types, in progress since 1995, in order to provide developing countries with information about pollution control technologies on the basis of JEC project cases. The theme of this third technical manual is the pulp and paper industry. The first was the 1995 manual on the plating industry and the marine products processing industry, and the second was the 1996 manual on the textile dyeing and finishing industry, and the meat processing industry.

This publication was drafted originally in Japanese, by Mitsuhiro Yamamoto of OECC, and Hiroto Ofkawa, Kumiko Shiinoki, and Kumiko Shida of the Environmental Control Center Co. Ltd. In addition to JEC, information for writing this book was obtained in cooperation with the Fuji City Municipal Office, the Research Institute of Shizuoka Prefecture, the Japan Paper Association, the Japan Technical Association of the Pulp and Paper Industry, and three papermaking companies. We wish to express our appreciation to them here.

The pulp and paper industry was one of the industries that contributed most to pollution during the 1970s, which was a time of grave pollution problems in Japan. In the process of writing this book we became aware once again that the current state of pollution control was attained by the all-out efforts of supporting organizations such as government administration and JEC, as well as the companies and the industry themselves. In the preparation of this book, it was the writers' intent to incorporate, to the greatest extent possible, the elements of cleaner production, which is currently of great demand in the developing countries. In addition to the superior technologies for and experience in treating emitted pollutants (end-of-pipe technologies), Japan has many experiences, so called cleaner production, in the implementation of measures that were triggered partly by the oil shocks.

These technologies were definitely not carried out in a short time, many results were obtained through trial and error. Unfortunately, the experiences were on the verge of disappearing with the generation of Japanese who implemented those measures, instead of being made available to others. It was our expectation that henceforth it will be possible for Japan to make available even more of the technologies that developing countries so badly want.

We hope that this book will be of use to developing countries that are working to remedy pollution, and that it will make even a small contribution to global environmental conservation.