Chapter 2

Environmental Conservation by Japanese Companies

:Case Studies of Corporate Practices and Policies

Japanese companies that have expanded their business to Thailand have been voluntarily and vigorously promoting their environmental practices under various conditions such as limited social infrastructure.
Chapter 2 introduces 16 cases of practical environmental measures by Japanese companies in Thailand, mainly manufacturing companies, based on the information collected by a field survey. The survey was conducted to study more than 10 member companies of the Japanese Chamber of Commerce, Bangkok. After summary of those companies' environmental practices and policies described in Section 1, 16 cases are introduced in following sections: Section2; 5 Cases of Meeting Strict Wastewater Standards, Section 3; 5 Cases of Establishing an Environmental Management System, Section 4; 3 Cases of Adopting Locally Tailored Environmental Practices, Section 5; 3 Other Examples of Innovative Environmental Practices.

Section 1
Japanese Companies in Thailand and their Environmental Conservation

This study covers field surveys conducted from November 1998 to January 1999 for more than 10 Japanese companies that have already expanded their business to Thailand. Since most of them were manufacturing companies, the survey team visited as much as possible their plant where actual measures were taken for environmental problems, and collected data for their various environmental practices while inspecting their production lines and processes. When the survey team visited Thailand, it had only passed one and half year since Asian currency and economic crisis had occurred. Thai economy was still showing no sign of recovery while Japanese newspaper was largely reporting news of recession such as production cut at Japanese automobile manufacturing companies in Thailand. From Section 2 in Chapter 2, 16 examples are introduced to explain the specific environmental practices that are taken by Japanese company in Thailand. Every Japanese company in Thailand, under severe economic situation or limited social infrastructure related environmental problem, is making sincere effort to steadily promote environmental activities by elaborating various ideas.

1. Environmental Conservation by Japanese Companies

(1) Innovation as the hallmark of corporate environmental practices

All of the Japanese companies studied during the course of this survey expressed a similar awareness that "implementing environmental measures is essential for operating successfully in Thailand; we must never cause environmental problems." The general impression gained from the survey was that Japanese companies are tackling environmental measures head on, treating them not as a special issue, but as much part and parcel of running a company as labor relations. Many of the companies that acknowledged their corporate responsibility to set up proper environmental measures also voiced the opinion that a committed approach to environmental practices has considerable cost benefits, helping to reduce production costs and to enhance the image of the company and its products.

The environmental practices of Japanese companies are focused primarily on preventing pollution from wastewater. Going beyond mere compliance with the basic standards, however, many of the companies studied in the survey are aiming to meet stringent standards of their own, and are trying to reduce their energy consumption and waste generation to target levels that they have set themselves. It was also evident that Japanese companies are strongly driven to obtain ISO 14001 certification, the international standard of environmental management. More than twenty Japanese companies in Thailand are already accredited, and many are now preparing to obtain ISO 14001 certification. There are even cases where an affiliate in Thailand has been accredited ahead of its parent company in Japan.

Among the companies investigated, some are adopting innovative activities that are difficult to implement even in Japan, such as recycling and enterprise-wide environmental programs that encompass not only subsidiaries but also Thai-based agents and local distributors across the whole country. A Japanese company has begun afforestation programs in Thailand that have no direct bearing on their business activities, and there is an observable trend toward contributing to environmental conservation in a committed, long-term way.

It should be noted, however, that the Japanese companies covered in this survey were predominantly large companies, mainly in the manufacturing sector, and many of them are subsidiaries financed by well-known parent corporations in Japan. These factors mean that the picture presented by the survey respondents does not necessarily reflect the general situation of Japanese companies operating in Thailand. We were unable to obtain precise information about the environmental activities of small companies, or of industries other than manufacturing.

(2) Wastewater treatment as the focus of industrial pollution controls

Given that water pollution is the most pressing of Thailand's environmental problems, the industrial pollution controls being used by Japanese companies are primarily focused on wastewater treatment.

As discussed in Section 5 of Chapter 1, industrial effluent standards are stricter in Thailand than in Japan for biochemical oxygen demand (BOD) and most pollution parameters, and a few of the parameters regulated in Thailand do not even exist in Japan. For this reason, many Japanese companies have installed advanced wastewater treatment facilities at enormous expense, such as

treatment plants that incorporate activated carbon adsorption, a level of processing seldom seen in Japan. In industrial estates, which have their own central treatment plant, some companies are carrying out pre-treatment, to a degree that would be considered overly cautious by Japanese standards, to eliminate heavy metals and other contaminants before discharge into the estate's treatment facility.

Another concern of Japanese companies in Thailand was the question of hazardous waste. As mentioned in Chapter 1, despite strict laws and regulations, Thailand has only two treatment facilities that can process hazardous waste appropriately. This inadequate infrastructure makes treatment in compliance with the regulations generally difficult in practice. The implication is that, in reality, a large amount of hazardous waste in Thailand is illegally dumped.

All the Japanese companies covered in this survey are going to considerable expense to carry out hazardous waste treatment as required by law. However, with only two treatment plants, one in Bangkok and the other southeast to Bangkok in Rayong province, companies located in northern Thailand or other places that are hundreds of kilometers from either treatment site are burdened with very high transportation costs in addition to the waste processing fees. Moreover, the only company authorized to run treatment facilities and to collect and carry hazardous waste is the joint public-private company, General Environmental Conservation Public Company Limited (GENCO), which is partly funded by the Ministry of Industry (MOI).

Factory wastes other than hazardous wastes have some market value in Thailand, and are mostly collected by private operators. To this end, Japanese companies tend to sort their wastes into separate and distinct stockyards within the factory, while also endeavoring to reuse and recycle each type of waste with a view to reducing waste volumes.

In regard to air pollution control, most Japanese companies in this survey had installed dust collector and other equipment for preventing air pollution, had switched to less polluting fuels, and were regularly monitoring and reporting factory emissions to the authorities. There was also one Japanese company, involved in constructing and running an industrial estate, that was carrying out regular air quality monitoring at locations both inside and outside the estate because of concerns about possible effects on the local inhabitants.

In another case, a Japanese company had implemented odor controls after complaints about foul smells from people living in the vicinity of the factory. Complaints about solvent odors and burning smells from coating processes are common in Thailand. This Japanese company, however, had installed a pyrolytic processing system and had modified its coating process, investing considerable capital in plant and equipment to completely eliminate the odor problems.

2. Cross-Corporate Initiatives to Share Environmental Information

Apart from adopting practical environmental measures, Japanese companies in Thailand are clearly making cooperative efforts to share environmental information.

The Japanese Chamber of Commerce, Bangkok, which represents many Japanese companies in

Thailand, makes environmental information readily available to its members. The Environment Committee, set up as a cross-sectoral committee separate from the Chamber's industry-specific committee structure, plays a major role in distributing environmental information. Established in October 1993, the Environment Committee consisted of 23 members, as of fiscal 1998. Its activities include presentations about new solutions being implemented by Japanese companies in Thailand, and seminars with invited speakers from the Thai government. The Environment Committee also distributes environmental information through the Chamber of Commerce newsletter and is involved in publishing such information itself. Recent publications include *Thailand's Enhancement and Conservation of National Environmental Quality Act and Related Major Legislation*, *The Factory Act and Related Ordinances*, and *The Environment of the Kingdom of Thailand*.

Other initiatives to share information were observed among Japanese affiliates. For example, a number of corporate groups have joined forces to share environmental information and to work together toward achieving ISO 14001 certification. Another corporate group is providing information outside of its own organization to Japanese affiliates in the same industrial estate.

Japanese companies have a long history of expansion into Thailand, but one in particular has worked in Thailand for about twenty years. It offers a variety of environment-related services to other Japanese companies, primarily in the design, construction, operation and management of water treatment systems, and provides companies with environment-related information as well.

Although not an example of cross-corporate information sharing, the Environmental Research and Training Center (ERTC) holds ten different training courses, including wastewater treatment technologies, water quality analysis, air pollution management and waste management, for the staff of private-sector industries. The ERTC, part of the Ministry of Science, Technology and Environment (MOSTE), was built in Pathum Thani province with funding assistance from Japan. Until 1997, the Japan International Cooperation Agency (JICA) sponsored technology assistance projects at the ERTC.

3. Thailand's Economic Crisis and its Impact on Environmental Practices

A major interest in carrying out this survey was to discover how the environmental activities of Japanese companies in Thailand were affected by the currency and economic crisis in the Asian region, which began in Thailand in July 1997.

In the course of the survey, companies mentioned that they had suffered economically from diminished revenues, for example, but there was little evidence of any impact on environmental practices. Consequently, a simple questionnaire was sent after completion of the survey to those companies that had taken part, in order to ascertain the effects of the economic crisis on their environmental policies. Of the twelve companies that responded, eleven replied that "business performance (sales and production) was affected" by the crisis, the one exception being a company that exports nearly all its products to other countries. However, all twelve respondents agreed that the crisis had "hardly any effect on corporate environmental practices."

In response to a question about the relationship between business performance and the amount

of money spent or invested in environmental measures, except for one company which checked the "Don't know" box, the other eleven companies said that they have "constant levels of expenditure and investment, regardless of business performance." A follow-up question asked about expenditure and investment adjustments, should the current economic crisis continue for a long time. To this question, only two companies said that they would reduce expenditure and investment levels "to some extent," while all the other companies answered "no change."

Although the questionnaire covered only a small sample, these findings indicate that Japanese companies in Thailand are not scaling down their environmental initiatives, regardless of economic hardships.

The questionnaire also asked companies' opinions about the effects of the currency and economic crisis on the Thai government's environmental policies. Nine companies said, "the crisis had an impact." Specifically, respondents pointed out that "the government has cut back its budget for expenditure related to environmental conservation, and policy implementation is behind schedule, especially measures that cost money." In addition, some respondents noted a tendency for the economy to take precedence over environmental conservation, and for environmental regulations to be less severely enforced. Among other responses was a concern about the increased incidence of illegal dumping of waste by Thai companies.

4. Environmental Challenges and Approaches to Workable Solutions

As indicated by this survey, Japanese companies in Thailand are not simply following environmental regulations, but are promoting innovative methods of environmental measures. However, they face a number of problems, such as access to accurate information and the lack of facilities offering environmental measurement and analysis. The companies surveyed are taking positive steps to overcome these difficulties, and have sound environmental practices and policies in place.

The main environmental challenges, and corporate efforts, can be summarized as follows:

• Access to accurate information about laws and regulations:
Many companies have set up internal systems and procedures to obtain accurate information. As well as doing their own translations to understand the laws, orders and notifications published in the Thai language in the Government Gazette, Japanese companies are now appointing graduates in environmental engineering and related disciplines to positions related to environmental management.

• Compliance with strict standards:
Because water quality and other environmental standards in Thailand are generally stricter than in Japan, Japanese companies are spending large amounts of money on equipment to control pollution and meet allowable limits. As well as taking proper care in the operation and management of such equipment, companies are providing technical training to Thai staff involved in environmental controls. In regard to the hazardous waste, Japanese companies are complying with treatment regulations, but are required to bear the high costs including transportation to Thailand's scarce treatment plants.

• Initiatives to ensure the reliability of environmental measurements:
Japanese-affiliated companies are taking various initiatives to ensure that environmental measurements are accurate and highly reliable. For example, the companies sometimes forward samples for analysis to their parent company in Japan. In such cases, there are no lab facilities in Thailand capable of measuring and analyzing a substance that is subject to regulation, or there are no means of checking the reliability of factory measurement such as emission because Thailand do not have enough organization equipped with facility to analyze the measurement.

• Closer liaison with government authorities:
To liaise more closely with environment-related government authorities and to obtain up-to-date government information, Japanese companies are making an effort to train staff who can undertake public relations roles. In addition, a growing number of companies are engaging in corporate activities that imply long-term commitment, such as participating in the activities of the Federation of Thai Industries and other organizations, and building ties with local companies.

Section 2
Cases of Meeting Strict Wastewater Standards

The Thai companies of Japanese capitals covered in this research have a corporate principle in common that they should never cause environmental problems by the effluents from their plants and are very serious in preventing such incidents. Sections 2 to 5 present summaries of their environmental measures based on the information obtained from the plant visits and associated interviews. The summaries focus on their wastewater treatment but also present their positive efforts for waste treatment, air pollution prevention and odor prevention measures. Many of the official effluent standards for wastewater in Thailand have been set after American and European Standards and some Thai standards are very stringent in terms of international comparison. This section presents cases in which Japanese companies cope with such stringent standards by installing advanced wastewater treatment facilities and operating them properly. This section also outlines treating technologies, amounts of wastewater treated, analyses of water and operating conditions of the facilities to the extent of the information provided by the plants.

Case 1 Advanced Wastewater Treatment to Remove Traces of Heavy Metals

1) Outline of the Company

Company A (Company I of Case 9)
Business line: General electric machinery manufacturing
Number of employees: 2,900
Start of operation: 1996
Location of the plant: In an industrial estate for division companies of the same group in Samut Prakan, 30 km to the east of Bangkok
Japanese equity ratio: 49%

2) Background

Company A used be a division of one general electric machinery company until the company started conducting its separation to make division companies in 1996. In 1998 eight manufacturing companies and one managing company were formed. These companies were located in the same industrial estate except for one company, and manufacture a variety of products such as color television sets, household audio-players, audio-players for automobiles, electric fans, printed circuit boards for manufacturing machines, speakers, automotive switches and other six items.

This area is close to Bangkok and therefore designated as the First Area according to the industrial classification of the Office of the Board of Investment (BOI) of the government, where the most advanced measures for environmental conservation should be taken. Very strict standards are imposed on the plant partly because of agricultural land still remaining in the vicinity. Company A has pronounced in its corporate motto environmental conservation as the first priority item. The company therefore has decided to employ the most advanced technologies in the planning of wastewater treatment facilities. The company has built advanced wastewater treatment facilities because the printed circuit board plant, in particular, produces a wastewater stream containing heavy metals.

3) Measures Taken by the Company

a. Wastewater Treatment

The printed circuit boards are manufactured by etching the thin film of copper coated on the plastic board by chemicals in forms of electric circuits. The wastewater stream from this etching process contains heavy metals. Figure 2-2-1 shows the wastewater standards set by the Ministry of Industry (MOI). The standards for Ba (barium), and Ni (nickel) are not specified by the Japanese effluent standards. The standards for Cr^{6+} (hexavalent chromium) and Cr^{3+} (trivalent chromium), 0.25 mg/liter and 0.75 mg/liter respectively, are both much lower than the Japanese standard of 2.0 mg/liter. The standard for BOD, 20 ppm, is also a very strict one. Highly advanced water treating processes are therefore required to satisfy all these standards.

The plant of company A has already replaced chlorinated organic compounds with pure water in the washing process. In the process of producing pure water by using the reverse osmosis membrane, a large amount of wastewater (RO drain) is produced. This wastewater does not contain harmful substances, though its salt concentration is relatively high.

Figure 2-2-1 Effluent Standards Set for Company A

(mg/liter)

Item	COD	BOD	SS	TDS	Tempe-rature	pH	HCN	H_2S	Oil	Tar
Standard	120	20	50	3000	40 ℃	5.5-9.0	0.2	1.0	5	ND

Item	Free-Cl	Zn	Cr^{6+}	Cr^{3+}	Hg	Cd	Mn	Pb	Cu
Standard	1.0	5.0	0.25	0.75	0.005	0.03	5.0	0.2	2.0

Item	Ni	As	Ba	Se	T-N	Formalde-hyde	Phenols	Pesticides	Color/odor
Standard	1.0	0.25	1.0	0.02	100	1.0	1.0	ND	Not object

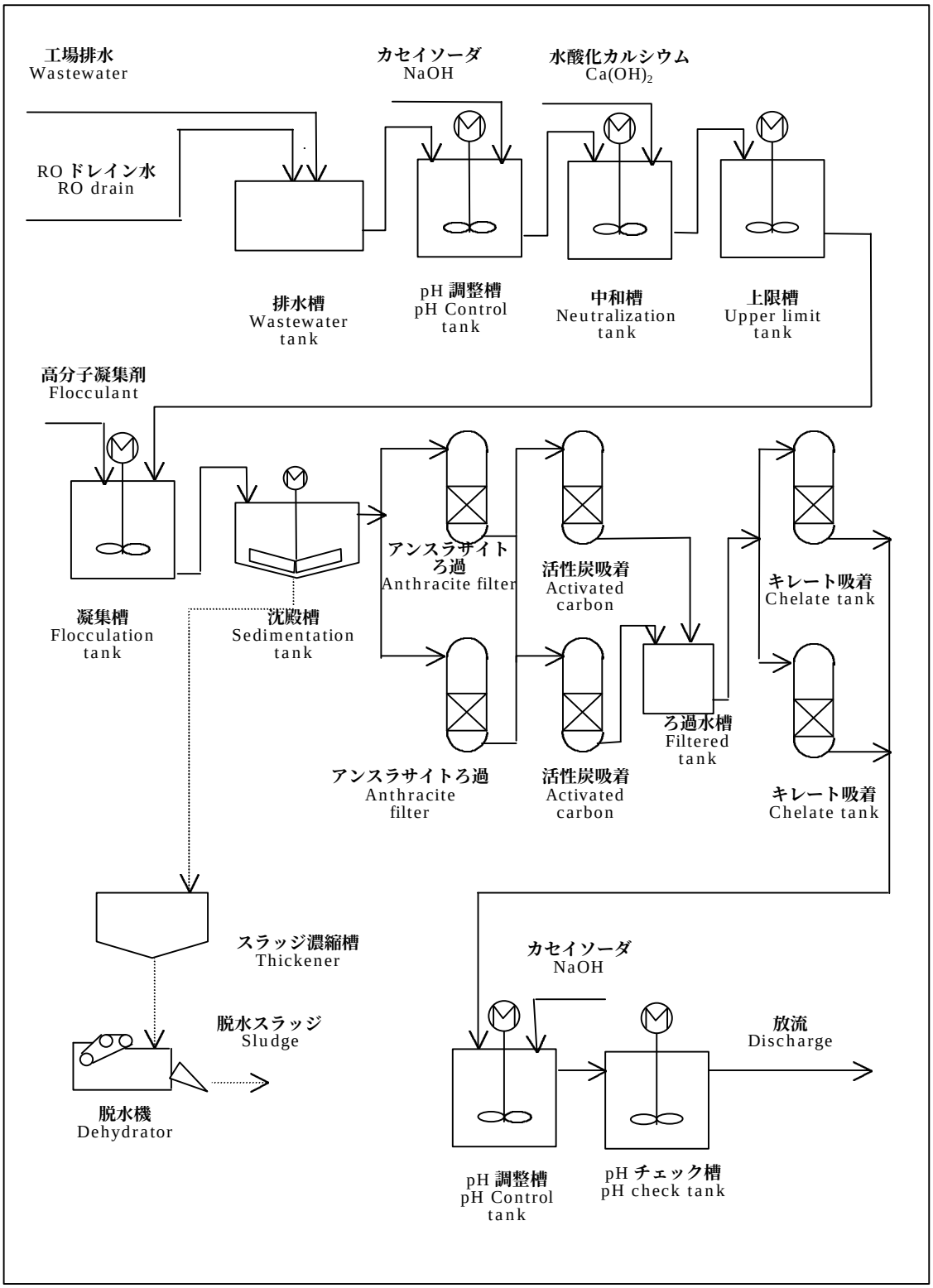
The etching process and reverse osmosis process produce nearly the same amounts of wastewater. The sum of these two streams amounts to about 40 m^3/hour. The wastewater treatment unit consisting of the facilities shown in Figure 2-2-2 has been installed to treat the wastewater to meet the standards to be dischargeable to the river. The wastewater as generated is acidic and therefore is neutralized by adding an alkali to make most of dissolved heavy metals form insoluble hydroxides. A polymer flocculant is then added to the wastewater to coagulate and settle hydroxides in the form of flocs, to be separated from the bulk of water. The upper clear water from the sedimentation tank is passed through the anthracite filter to remove suspended materials and then the activated carbon adsorption bed to remove dissolved organic compounds by adsorption to reduce BOD and COD values. The wastewater is further treated by the chelate tank to remove traces of heavy metals that have passed through the upstream facilities. The treatment by chelating agents is very effective in removing heavy metals but its operation cost is high.

The wastewater now satisfying all the items of the effluent standards by such an advanced treatment is stored in the detention pond in the industrial estate and mixed with wastewater streams from other plants to be discharged to the water channel outside the estate.

b. Solid Waste Treatment

The waste chips of the materials for printed circuit board and sludge generated at the wastewater treatment unit are consigned to General Environmental Conservation Public Company Limited (GENCO) for disposal.

Figure 2-2-2 Flow of the Wastewater Treatment of Company A



Case 2 Example of Coping with Stringent BOD Standard

1) Outline of the Company

Company B
Business line: Manufacture of synthetic thread and fabrics
Number of employees: 780
Start of operation: 1963
Location of the plant: in Nahkon Pathom 40 km to the west of Bangkok
Japanese equity ratio: 48.3%

2) Background

This plant was established in 1963, 36 years ago from now, at the present location near the River Thacin abundant in water, to secure a plentiful supply of water. At that time this plant was the only industrial installation in the midst of an agricultural land. Since then a number of plants, factories and houses have been built in this area, with associated deterioration of the environment. The government has designated this area as the First Area to restrict further construction of plants and factories. The class 4 water quality standards are applied to this area's portion of the River Thacin where the effluent water of the plant is discharged to. The quality standards call for BOD value of 4 ppm or lower.

The plant manufactures threads and fabrics from purchased polyester and rayon raw fibers. The plant consumes a large quantity of water for the dyeing process which produces a large amount of wastewater containing dyes and greases, which increase the BOD value and could contaminate the river water. The standard for BOD set by the government is a stringent one. The plant needed to install a large-scale wastewater treatment unit to clear this standard.

3) Measures Taken by the Company

a) Wastewater treatment

The plant discharges 3,800 m^3/day of waster water. Figure 2-2-3 shows the effluent standards applicable to the plant. The values of Figure 2-2-3 are basically within the limits set by the government of Thailand. The Nakhon Pathom Branch of the MOI, however, has applied the severest value of lower limit to the plant. The standard for BOD here, 20 ppm is much severer than the 160 ppm set by the Water Pollution Control Law of Japan.

Figure 2-2-3 Effluent Standards Set for Company B (mg/liter)

Item	pH	BOD	COD_{cr}	T-N	TDS	SS
Standard	5.5 – 9.0	20	120	100	3000	50

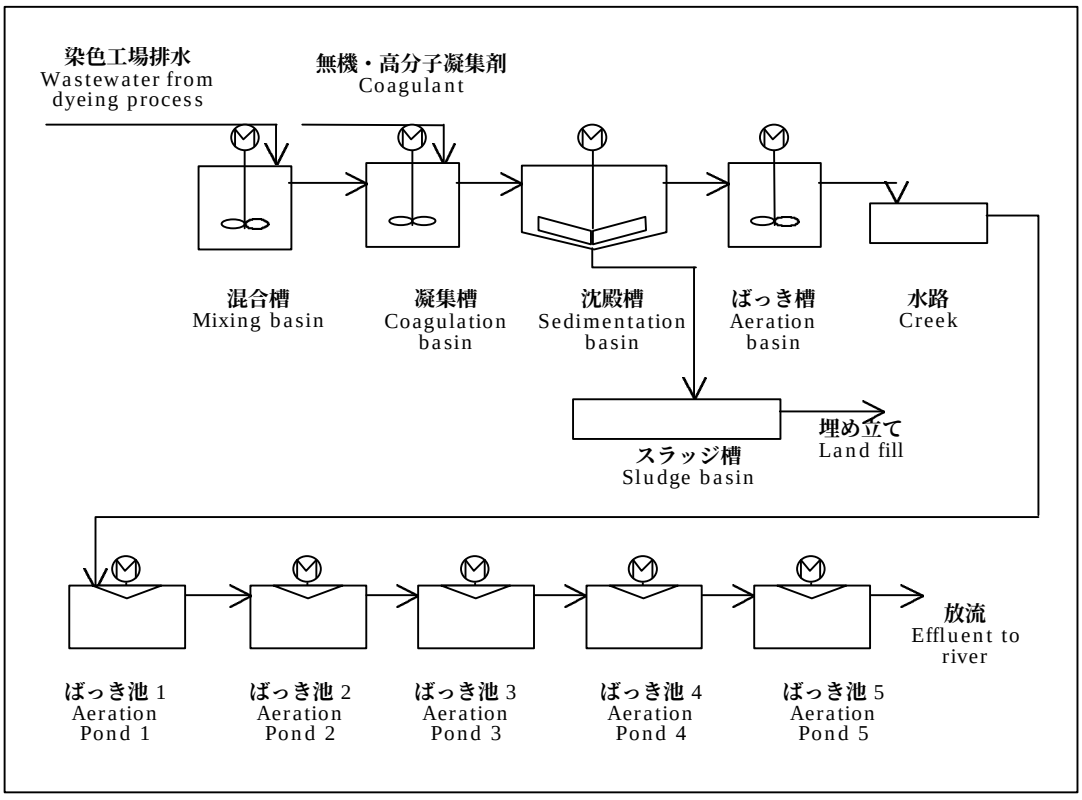
A wastewater treatment unit of the configuration shown in Figure 2-2-4 was built by contracting a Japanese water treatment facility company. A flocculant is added to the wastewater as it enters the unit to have suspended solids settle as floc. Water is then conducted through a channel to the aeration basin equipped with aeration facilities. The aeration basin consists of five ponds with surface areas ranging from 6,000 m^2 to 13,000 m^2. The water flows into these ponds in series taking a total of 13 days. During this course of time the BOD content is reduced from about 100 ppm to 20 ppm or less. Items other than BOD are also reduced to meet the standards.

The total surface area of the aeration ponds amounts to 30,000 m^2 or 25% of the plant area. The aeration ponds, though with a drawback of requiring a vast area, have advantages of being operable at stable conditions throughout the year because of the high temperatures of Thailand and low maintenance cost. The aeration ponds may be considered to be suited to Thailand.

The quality of treated water should be analyzed once in three months by a laboratory authorized by the MOI and the analytical results should be reported to the authority. In the case of this plant, the treated water is analyzed by the chemical laboratory of Chulalongkorn University. The plant also analyzes of its own treated water once a week and posts the results on the wall of the laboratory to help the operators maintain the effluent water quality within the range of standard. The analytical result by the authorized laboratory is in accord with that by the plant. The Thai managerial staffs, who also coordinate with the authorities in charge of environmental conservation, manage the operation and maintenance of the treating unit.

The Thai plant of a Japanese water treating company manufactures the flocculant used by the unit and its price has remained stable irrespective of the depreciation of Baht. The operation cost of wastewater treatment amounts to about 1.4 bahts/m^3, including the price of flocculant, electricity cost and manpower cost but excluding the maintenance cost. With the large amount of wastewater, the treating cost is a heavy financial burden on the plant.

Figure 2-2-4 Flow of Wastewater Treatment of Company B



b. Solid Waste Treatment

The sludge from the wastewater treatment (14,500 kg/month) has the largest volume of all waste categories. The sludge is landfilled in the plant premises. Plastic wastes from packing

materials, used fluorescent light tubes, waste oils and incinerator ash are now consigned to a waste treating agent. The plant has been instructed by the authority to consign disposal of the sludge and these wastes to GENCO, an authorized waste treating agent, from the next year. A small amount of metal scraps are sold to dealers. Waste paper, waste cloths and other general wastes are incinerated in the premises.

c. Exhaust Gas Treatment

Figure 2-2-5 shows the emission standards of the exhaust gas set by the government of Thailand. The exhaust gases from the boilers and incinerators are subject to these standards. The actual contents of the pollutants are much lower than the specified values and therefore the plant does not cause any air pollution problem. The plant is not obliged to report the data to the authority either. Nevertheless, the plant has a laboratory of its own that analyzes the gases several times a year to confirm that the data are below the standards.

Figure 2-2-5 Emission Standards Set for Company B

Item	Particles (heavy fuel oil)	Particles (other fuels)	SO_2	NO_2	CO
Standard	300mg/Nm^3	400 mg/Nm^3	1300 mg/Nm^3	470 mg/Nm^3	870 ppm

d. Establishment of Environmental Management System

The plant is audited and is shown the environmental management policy by the directors of the Japanese parent company once a year. The representatives of six group companies in Thailand periodically meet to exchange information on environmental matters. Company B will be required to obtain ISO14001 certification since one of the group companies in Japan obtained it in 1998.

The Environmental Conservation Committee is held in every three months participated by all executive members and representatives of the employees. The subjects discussed in the committee include quality of treated water and its trend, importance of the issue of environmental conservation, laws and regulations about environmental conservation. The minutes of the meetings are brought to all workplaces to disseminate information to all employees to enhance interest in and to provide motives for environmental conservation, reduction of wastes for example.

This plant is sometimes requested to hold seminars or to hold exhibitions as a model plant for environmental conservation. In such occasions, materials and posters are exhibited also in the plant so that every employee may be able to see them. Newly recruits have a lecture of importance of environmental conservation at the introductory course. Follow-up training is also done to impress them with the importance of environmental conservation.

As a result of these efforts the performance of this plant in environmental management is now highly evaluated. The plant was awarded three times as the best factory in environmental conservation in Nakhon Pathom in 1994, 1995 and 1998. In 1998 also, this plant was awarded by the Ministry of Labor and Social Welfare as the best plant in safety management in the nation for having achieved a record operation without accident.

Case 3 Example of Accommodating Separate Standards by Three Authorities

1) Outline of the Company

Company C
Business line: Manufacture of polyester fibers
Number of employees: 1,000
Start of operation: 1970
Location of the plant: Pathum Thani, about 15 km to the north of Bangkok
Japanese equity ratio: 45%

2) Background

The area surrounding the plant used to be an agricultural land when the plant was built 30 years ago. Since then, a number of plants, factories and houses have been built in the surroundings as the suburbs of Bangkok. As the environmental conditions deteriorated, the government has applied the stricter environmental controls. On the effluent water in particular, three different authorities, namely, the MOI, the Royal Irrigation Department of the Ministry of Agriculture and Cooperatives and the Ministry of Science, Technology and Environment (MOSTE) have set their respective standards separately for each item. This plant is therefore obliged to satisfy the strictest of all standards for each item.

The process of manufacturing polyester generates a large amount of wastewater. The treated wastewater flows through a channel to the paddy fields nearby as irrigation water. Therefore, discharging of polluted water is prohibited. The water treatment unit should be properly operated and the quality of the treated water should be properly controlled.

The Japanese parent company, on its part, laid down the following Global Environmental Conservation Charter in 1992. The parent company has also voluntarily launched a responsible care movement which closely watches the entire operation ranging from R&D, manufacturing, and sales to treatment and disposal of wastes. The parent company calls upon its overseas affiliates to act to realize the principle of the parent company. Company C positively responds to this policy and does its best in its environmental measures.

Global Environmental Conservation Charter of the Japanese Parent Company of Company C

Company C declares the following principles to realize one of its corporate ideologies, "to co-exist with the global environment and to care for nature and life."

(1)Company C always gives priority to environmental conservation and maintenance of safety in its business activity and provides the society with the products and services harmonious with the global environment.
(2)Company C promotes reduction of environmental load through effective utilization of resources and energy and through recycling of its products.
(3)Company C cooperates with the regional communities and international communities in its contribution to global environmental conservation and maintenance of sustainable development of the society through provision of knowledge and technology.

3) Measures Taken by the Company

a. Wastewater Treatment

The plant manufactures polyester raw fibers and threads from the chemicals imported from Japan and neighboring countries. The manufacturing process uses a large quantity of water. The plant takes 250 tons per hour of well water and discharges 200 tons per hour of wastewater.

The generated wastewater contains organic compounds to such an extent that its BOD and COD values are about 200 mg/liter and about 400 mg/liter, respectively. Figure 2-2-6 shows the effluent standards indicated by the MOI, the Irrigation Department and the MOSTE. The local offices of these authorities have requested the company to clear these standards. The plant has set the standards of its own taking the strictest value of each item.

The standard for CODcr, 60 mg/liter, is as strict as half the lower limit of the standard range (from 120 to 400 mg/liter) set by the government of Thailand. The standard for BOD, 20 mg/liter, is very strict compared with 160 mg/liter, the standard of the Water Pollution Control Law of Japan. The standards of the Irrigation Department include specification of electric conductivity, because the effluent water from the plant is used as agricultural water. Too high an electric conductivity indicates too high salt concentration, and shows possibility of salt damage to the agricultural crops.

Figure 2-2-6 Effluent Standards Set for Company C

		Effluent Standards			
Items	Unit	MOI	Irrigation Department	MOSTE	Standards set by the plant
pH	-	5.5 –9.0	6.5 – 8.5	5.5 – 9.0	6 – 8
Temperature	ºC	<40	-	<40	<40
COD_{Cr}	mg/liter	60	-	120	60
BOD	mg/liter	20	20	20	20
SS	mg/liter	150	30	50	30
Oil	mg/liter	5	5	15	5
Free Cl	mg/liter	1.0	-	1.0	1.0
T-N	mg/liter	-	-	100	100
Electric conductivity	µs/cm	-	2000	-	2000
Ethylene glycol	%	-	-	-	0.025

The plant has installed a wastewater treatment unit consisting of the facilities shown in Figure 2-2-7 to clear all these strict standards. The wastewater as received is stored in the reservoir to be homogenized. The water is then passed to the spray-bed pollutant decomposition tower (Trickling tower) where pollutants are bio-decomposed as the water flows down through filling with cultured microorganisms while contacting air. Then suspended particles in the water are settled in the sedimentation tank from which supernatant clear water is sent as treated water to the pond. The role of the pond is to prevent insufficiently treated water, if ever generated, from being discharged to the channel leading to the paddy fields.

The wastewater before treatment contains BOD at about 200 mg/liter. The BOD, then, is reduced to below the standard, 20 mg/liter, while passing through this unit. The values for all other items are also reduced to less than the standard values; therefore, wastewater exceeding any item of the standards will never be discharged under a proper operation management. The sludge separated from the bulk of water in the sedimentation tank is condensed in the thickening tank and dried under direct sunlight in a storage house roofed with a transparent plastic sheet. The swift drying in this storage house prevents disagreeable odor from being generated from the sludge.

The MOI, the Irrigation Department and MOSTE check the analytical results of the wastewater. The analyses for official reporting to these authorities are consigned to a laboratory authorized

by the MOSTE. The plant analyzes the wastewater once a week at its laboratory for operation management of the wastewater treatment unit. The officials of Irrigation Department sometimes come to take samples for their own analysis. Figure 2-2-8 shows the frequencies of analyses. The pH value of the treated water, a firsthand indicator of the water quality, is measured every hour. The amperage is also checked every hour to check the operation conditions of electrical machinery such as pumps and agitators. Any abnormality is taken care of immediately after it is found. The plant laboratory analyzes the untreated wastewater entering and the treated water leaving the wastewater treatment unit at a frequency of once a week for all items to maintain the unit in normal operating conditions.

The plant now uses well water with the license, which will irrevocably expire in two years. However, the plant has been instructed by the Provincial Water Works Authority to use industrial water supplied by the authority. Use of industrial water increases the cost of water several times; however, that plant has no alternative but to switch to use the industrial water.

Figure 2-2-7 Flow of the Wastewater Treatment of Company C

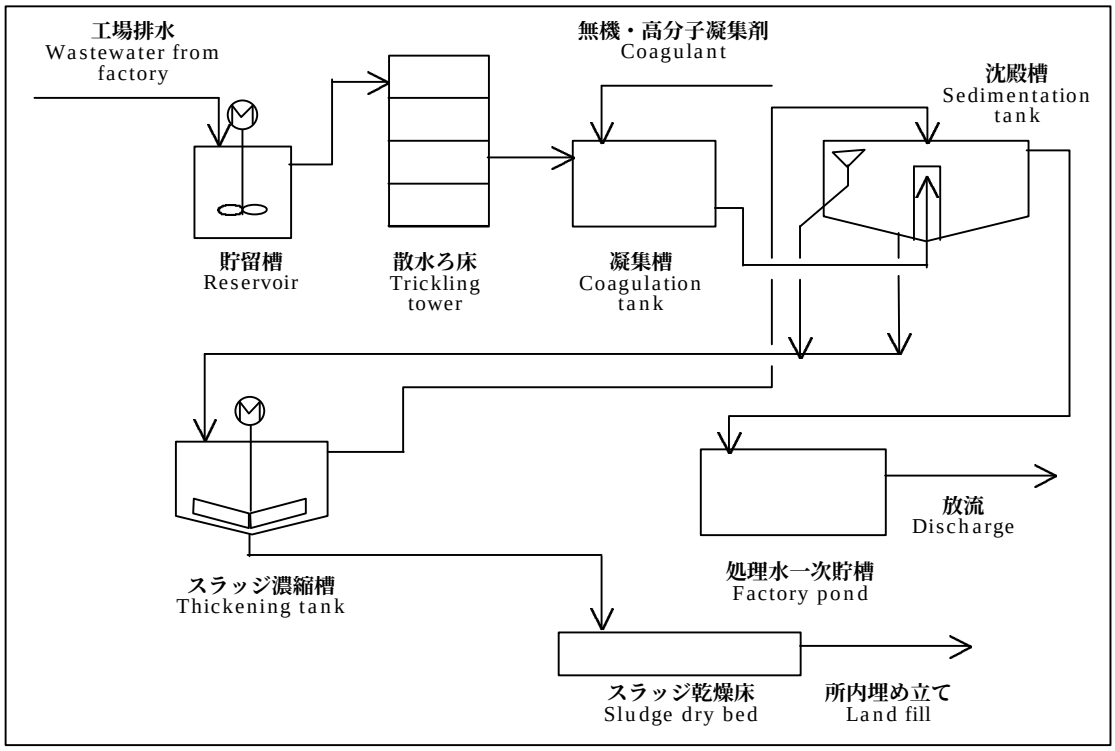


Figure 2-2-8 Frequency of Water Quality Check and Analysis

Authority or measurement provision	Subject of measurement	Frequency
Local pH meter	Wastewater at inlet	Every hour
	Recirculating water	Every hour
	Treated water	Every hour
Local ammeter	Electric power for operation of the wastewater treatment unit	Every hour
Plant laboratory	Wastewater at inlet	Once a week
	Treated water	Once a week
MOSTE	Treated water	Once a month
Irrigation Department	Treated water	Twice a month
MOI	Treated water	Once a month

b. Solid Waste Treatment

The sludge produced from the wastewater treatment unit at a rate of 2,400 tons per month constitutes the bulk of the wastes. The sludge is dried and used in the plant premises as fertilizer, or disposed of by landfilling. The next largest is the faulty fibers amounting to 220 tons per month. These faulty fibers are recycled back to the manufacturing process for reuse. The fused solid polymers before being processed into fibers are incinerated by the incinerator, with a capacity of 400 kg/hour, installed in the plant premises. Such wastes as waste paper, waste cardboard, spent oil, spent ethylene glycol are also incinerated. The kitchen garbage produced at a rate of 20 tons per month is consigned to a local treating agent for landfilling. Metal scraps are sold to dealers. The incineration ash, waste chemicals, those wastes, which may be classified as hazardous substances and the burnable wastes generated in excess of the incinerator capacity are consigned to GENCO.

c. Establishment of Environmental Management System

It is obligatory in Thailand for the designated plants to have environmental management officers. The plant of Company C is the designated one, and has two environmental management officers. These people have studied such professional areas in the universities. Environmental management officers in Thailand may be considered to correspond to the "manager in charge of pollution control" of Japan. The documents submitted to the authorities require their approval with signatures.

The safety committee, consisting of equal numbers of executive members and employees, is held once a month. This committee deals also with issues concerning environmental conservation. The Japanese parent company has already pronounced the Environment, Safety and Healthy (ESH) Policy and overseas affiliates follow suit in their activities to conserve environment, safety and health. Once a year a director of the Japanese parent company presides over the ESH committee and oversees the domestic and overseas plants conducting audit and performance evaluation and setting the next year target. The plant is scheduled to obtain the ISO9002 certification March 1999. The plant is also to obtain the ISO14001 certification following acquisition of the ISO9002 certification.

d. Others

A flood washed away a number of houses in this area two years ago. The plant, which was saved from the damage of flood, accommodated as many as 1,000 people who lost their houses in the plant laboratory and other buildings for about two months, and provided them with food. This was highly appreciated as an act of contribution to the community, and the King and the MOI awarded the plant.

Case 4 Example of Employing Advanced Treatment Including Activated Carbon Treatment

1) Outline of the Company

Company D
Business line: Manufacturing automobiles
Number of employees: 5,500 (as of end of 1997)
Start of operation: 1975 (Old plant), 1997 (New plant)
Location of the plant: Samut Prakan 30 km to the east of Bangkok (old plant) and Chachoengsao (new plant)
Japanese equity ratio: 70%

2) Background

The Japanese parent company has pronounced its global environmental conservation charter as given below. Its overseas affiliates should act basically according to this charter. In other words, the affiliates are required to strictly observe the environmental standards and to positively work for environmental conservation of each country.

The area where the old plant was located is an industrial and commercial area close to Bangkok. A number of large plants and factories have been operated since many years ago in this area. The pollution of river running near the plant has been so worsened that the government applied stringent effluent standards to prevent further pollution. The plant was obliged to install an advanced wastewater treatment unit to clear the standards. The new plant was established in Chachoengsao.

Global Environmental Conservation Charter of the Japanese Parent Company of Company D

Basic policy

1. Positive approach

Recognize that the manufacture of automobiles is deeply related to the earth's environment. Combine the strength of all groups within the Company and cooperate with suppliers and distributors worldwide to develop technologies that are gentle on the earth and serve to promote environmental measures.

2. Thorough implementation of proactive preventive measures

Evaluate the potential environmental impact at every stage in a motor vehicle's life-cycle from product development through design, manufacture, and marketing, to disposal, and take active measures to minimize that impact.

3. Social contribution

In order to realize a better environment, actively participate in diverse endeavors, in addition to those related to automotive considerations, to support environmental protection and cooperative activities within societies and regions as a good corporate citizen.

3) Measures Taken by the Company

a. Wastewater Treatment

The degreasing, chemical treatment and painting processes of steel sheets produce large quantities of wastewater. Figure 2-2-9 shows the effluent standards indicated to this plant by

the MOI. The standards are severer than those of Japan in a number of items. The value of BOD, 20 mg/liter, the value of SS, 50 mg/liter, and those of heavy metals are particularly strict. The plant installed a wastewater treatment unit consisting of the facilities shown in Figure 2-2-10 to clear all these standards. The wastewater treatment unit, with a capacity of 1,200 m^3 per day, collects all wastewater streams and subjects it to neutralization and coagulation sedimentation to remove heavy metals. These processes consist of two parallel trains to ensure steady operation even in the case of one train being in trouble. Thereafter, the wastewater is given biological treatment in the aeration tank to decompose organic substances contributing to BOD. After sludge is removed by sedimentation, the wastewater is sand filtered and subjected to activated carbon adsorption to remove BOD that has not been removed by biological treatment. The activated carbon treatment is necessary to reduce BOD to below the standard although the treatment requires very high running cost.

The plant laboratory analyzes the treated water every week for pH, TDS, SS, COD and BOD. Analysis of heavy metals is consigned to a water treating company of Japanese capital.
The sludge generated by sedimentation with flocculation is concentrated and dehydrated. The dehydrated sludge contains heavy metals and is classified as a hazardous waste. The sludge is consigned to GENCO, an authorized treating agent for disposal.

Figure 2-2-9 Effluent Standards Set for Company D

(mg/liter)

Item	COD	BOD	SS	TDS	Tempe-rature	pH	HCN	H_2S	Oil	Tar
Standard	120	20	50	3000	40℃	5.5-9.0	0.2	1.0	5	ND

Item	Free-Cl	Zn	Cr^{6+}	Cr^{3+}	Hg	Cd	Mn	Pb	Cu	Ni
Standard	1.0	5.0	0.25	0.75	0.005	0.03	5.0	0.2	2.0	1.0

Item	As	Ba	Se	T-N	Formaldehyde	Phenols	Pesticides	Color/odor
Standard	0.25	1.0	0.02	100	1.0	1.0	ND	Not object

b. Establishment of Environmental Management System

The company established the environmental management system in 1994. The vice-president in charge of production management was assigned as a head of the committee. The committee has been dealing with such issues as prevention of water pollution, prevention of air pollution, reduction of wastes, measures for global warming. The committee has several working groups in charge of wastewater treatment, energy, wastes, volatile organic compounds (VOC), and others. Environment Group was established in the Construction and Maintenance Department to coordinate these working groups. With the internal organization for environmental conservation well established as such, the company was able to obtain certification of ISO14001 rather smoothly. The new plant, which started in April 1997, and the old plant successively obtained certification respectively in December 1997 and July 1998 from a British authorized assurance organization.

c. Others

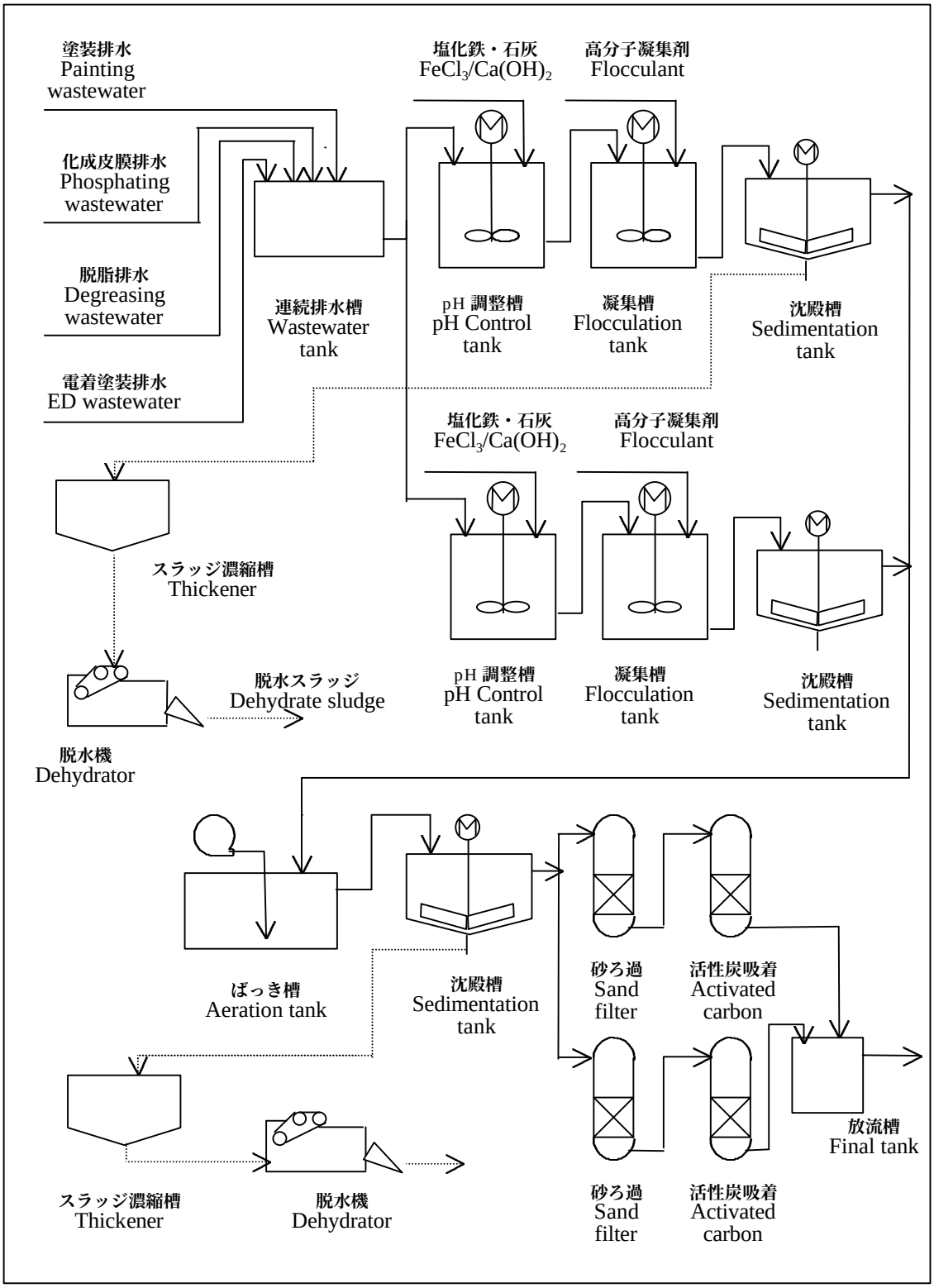
The plant is striving to reduce the emission of VOC that is now at 110 g/m^2 to the Japanese parent company's level of 80 g/m^2. The measures being tested are adoption of a minibell

automatic paining machine, recovery and regeneration of thinner, reduction of flushing time of the spray guns.

The wastes are packaging materials, sludge from the wastewater treatment unit, debris of paints. The sludge and paint debris are consigned to GENCO. The plant is now studying the ways for reducing packaging wastes such as, reducing import of components with bulky package from Japan and increasing local procurement.

New models of product line-up are subject to official inspection. The officials must approve the noxious gas levels of the exhaust gas. The plant offers a gas analyzer in the separate building to the officials in charge for their sample analysis.

Figure 2-2-10 Flow of the Wastewater Treatment of Company D



Case 5 Example of Coping with a Strict Standard for Cyanide

1) Outline of the Company

Company E
Business line: Manufacture of general electric products
Number of employees: 920
Start of operation: 1995
Location of the plant: An industrial estate in Ayuthaya 69 km to the north of Bangkok
Japanese equity ratio: 100%

2) Background

Company E produces a wide variety of products in the same plant premises ranging from desk lamps, wiring equipment, copper-plated laminates, connectors, epoxy sealing by financially independent divisions. Company E is a well-known consumer goods manufacturer and is therefore intent on environmental conservation not to damage corporate image among consumers. Company E has made public its environmental conservation policy. The company assures utmost attention to environmental conservation to protect the beautiful nature of the Ayuthaya ancient city where the company is situated, and its efforts to improve the environmental conditions with full participation of the company, including every employee, in recognition of the corporate social responsibility.

The manufacturing process includes copper and silver electric plating in a bath containing cyanides. The plant pays particular attention to the wastewater from this process. The industrial estate has a central wastewater treatment unit which gives ultimate treatment to the pooled wastewater generated in the industrial estate and discharges the treated water to the public waters. The plants in the industrial estate treat their wastewater to the specified standards before sending it to the central wastewater treatment unit of the industrial estate. The central wastewater treatment unit does not have a facility to treat cyanides; therefore, the plant has to treat cyanides before sending the wastewater to the central wastewater treatment unit. The standard indicated by the office of the industrial estate for the cyanides was much stricter than the Japanese standard. Facilities for advanced treatment and minute operation are required to satisfy this standard.

3) Measures Taken by the Company

a. Wastewater Treatment

Wastewater effluent streams containing heavy metals, cyanides, acids and alkalis are generated from different processes. Figure 2-2-11 shows the effluent standards indicated by the office of the industrial estate. The standard for cyanide (HCN), or 0.2 mg/liter, is one-tenth the Japanese standard of 2.0 mg/liter and is very strict. The standards for heavy metals, chromium (Cr), copper (Cu) and nickel (Ni) for example, are also stricter than the Japanese standards. On the other hand, the standards for COD and BOD are more lenient than the Japanese standards since the standards are defined by assuming the biological treatment for waste is done in the central wastewater treatment unit.

Figure 2-2-11 Effluent Standards Set for Company E

(mg/liter)

Item	COD	BOD	SS	TDS	Tempera-ture	pH	HCN	H_2S	Oil	Tar
Standard	1250	1000	200	2000	45℃	6.0-9.0	0.2	5.0	10.0	10.0
Item	Free-Cl	Zn	Cr	Hg	Cd	Mn	Pb	Cu	Ni	As
Standard	5.0	5.0	0.5	0.005	0.03	5.0	0.2	1.0	0.2	0.25
Item	Ba	Se	F	Free NH_3	Ammonia	Phe-nols	Pesticides	Color/ odor	Formal-dehyde	Deter-gent
Standard	1.0	0.02	5.0	50	50	1.0	ND	ND	1.0	100

The plant has installed a wastewater treatment unit consisting of the facilities shown in Figure 2-2-12. The wastewater with heavy metals is acidic and is neutralized by adding caustic soda as to precipitate heavy metals as hydroxides. The supernatant clear water is sent to the equalization tank. Sodium hypochlorite is added to the CN wastewater while its pH value is adjusted to oxidize and decompose cyanide. Then, the wastewater is sent to the equalization tank. Both acid and alkali wastewater are directly poured into the equalization tank to be mixed with other wastewater streams. The pooled wastewater homogenized in the equalization tank is sent to the reaction tank where ferric chloride and a coagulant are added while its pH value is adjusted to coagulate and settle suspended substances for separation. The supernatant water is filtered with sand, and pH adjusted and discharged as treated water.

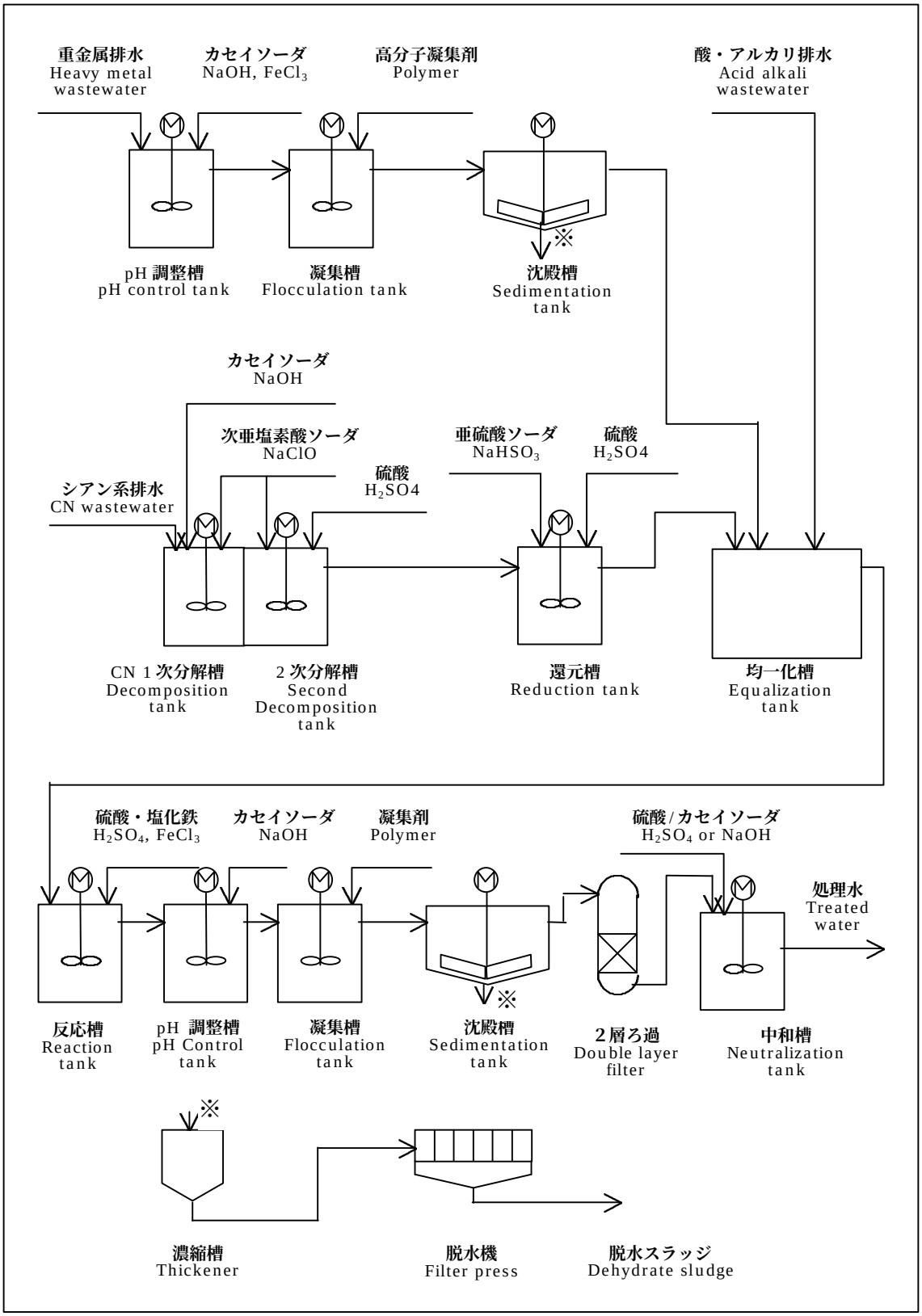
The reactions for oxidation decomposition of cyanide requires minute controls. The decomposition can easily be incomplete if not controlled well enough, and can generate poisonous hydrogen cyanide if the water is made too acidic. The treatment is carried out in two stages of the first decomposition tank and second decomposition tank, the content of the former being maintained alkaline and that of the latter neutral by pH control. The chemicals are added very carefully while watching the reduction-oxidation potentials. After oxidation decomposition is complete, the residual oxidizing agent is decomposed by a reducing agent. Thai staffs control this operation while the Japanese staff is closely instructing them.

The sand filter has double layers of different sizes of sand to remove traces of suspended heavy metals to meet the strict standards.

The wastewater after treatment by the plant is sent to the central wastewater treatment unit of the industrial estate for final treatment. The treatment cost is charged to the plant according to the following equation. Accordingly, it is necessary to reduce both the amount of wastewater and BOD value to reduce the payment of the treating cost.

Treating cost (bahts/month)
= 2.55 x Volume of water (m^3/month) + 6.1 x BOD load (kg/month)

Figure 2-2-12 Flow of the Wastewater Treatment of Company E



b. Treatment of Waste Solvents

The process to produce laminates generates wastewater and waste gas both containing solvents. The reaction between phenol and formalin to form the varnish for laminates produces condensation water that contains unreacted phenol and formalin. This water has a high value of COD and also hazardous and is therefore incinerated by being atomized in the flame of diesel fuel.

In the process of drying laminated resin papers, papers impregnated with varnish, generates waste gas containing formaldehyde. This gas is incinerated as in Japan though there is no effluent gas control in Thailand for formaldehyde. The waste heat of the effluent incinerator gas is effectively utilized for drying laminates.

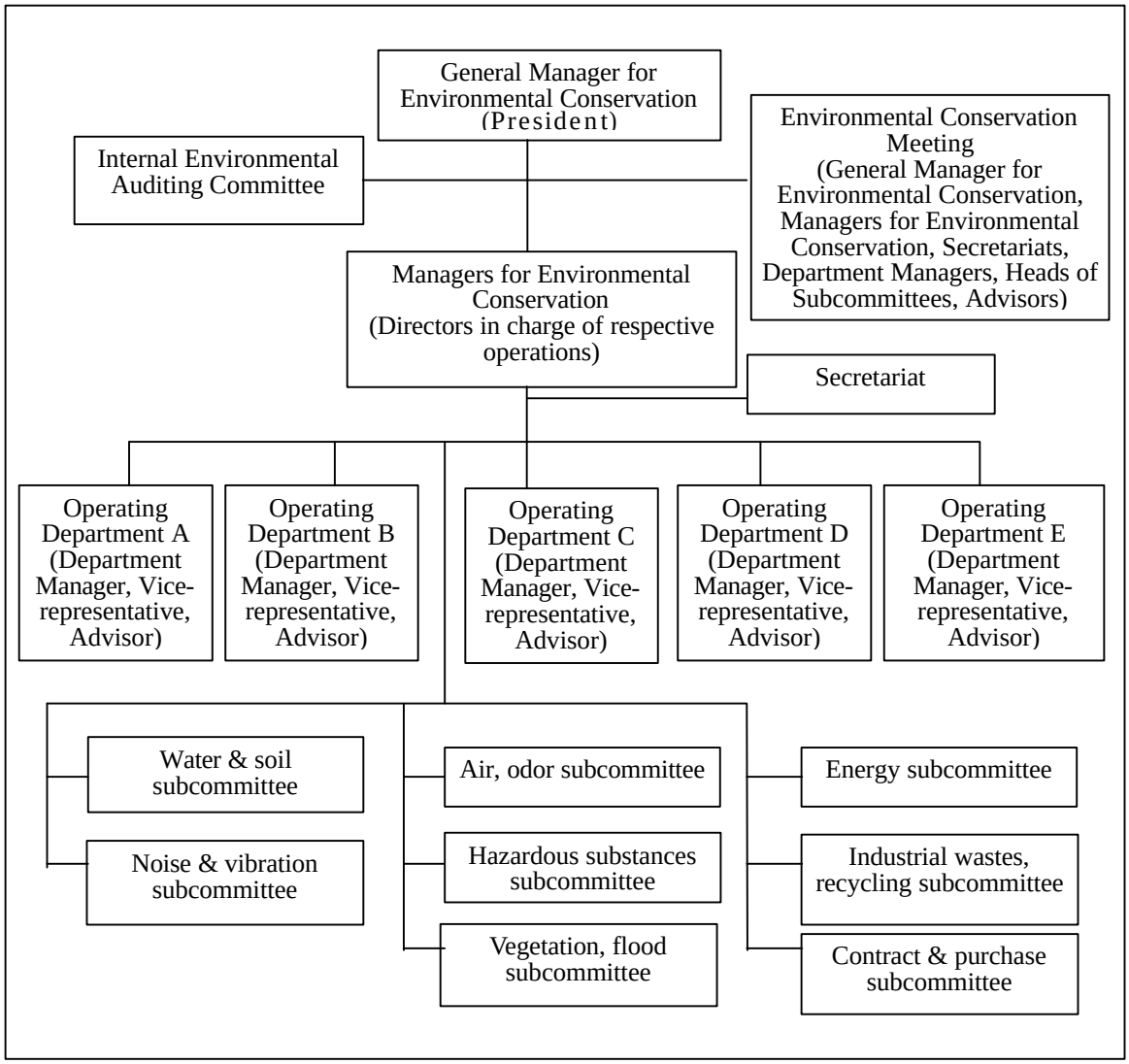
c. Solid Waste Treatment

The fines of laminates produced in the laminates processing, faulty resin paper and spent varnish are consigned to GENCO, a waste disposal agent authorized by the government of Thailand. The fines of laminates are packed in bags. The problem with the fines is dispersion to the surroundings, which must be prevented. The wastes consigned to GENCO, Ltd. amounts to about 20 tons per month. The expense paid to GENCO is rather high. Spent copper foils and faulty laminates containing copper are sold to dealers. The fine cuts of laminates are saleable in Japan; in Thailand however, these have to be handed over to disposal agents because of the lack of technology to reuse them.

d. Establishment of Environmental Management System

The plant is scheduled to obtain certification of ISO14001 in 1999 at the instruction of the Japanese parent company. The organization for promotion of ISO14001 as shown in Figure 2-2-13 has been established. Since the plant has a variety of operations, the department manager, the vice-representative and advisor are held responsible for leading each operating department. Besides, subcommittees are set up to deal with subjects common to all operating departments. The person in charge of the concerned subject of each department participates in the subcommittee. This plant's subcommittees are unique in that they cover a wide range of subjects, including measures for floods. The department deals with the problems particular to a given department and the relevant subcommittees deal with common problems. A local consulting company has been retained to identify problems concerning environmental conservation.

Figure 2-2-13 Organization for Promotion of ISO14001



Section 3
Cases of Establishing an Environmental Management System

The International Organization for Standardization (ISO) issued in September 1996 ISO14001, the international specifications for environmental management for companies and corporations. Acquisition of the ISO14001 certification not only serves as an evidence of being a company of good environmental consideration but also places the company in an advantageous position in international trades. More than 20 Japanese companies in Thailand have obtained the ISO14001 certification. The survey team visited some of these companies and obtained information on their activities through interviews. These companies are trying to manage their own ways in the formulation of environmental management organizations, enlightenment of the employees, identification of environmental problems, selection of certifying organizations. Certain companies, in addition to their own plants, require their suppliers to give environmental consideration to their manufacturing processes. The environmental management activities, enhanced throughout the companies from acquisition of ISO14001 certification, should contribute also to reduction of raw material costs through recycling and saving of electric power consumption through energy savings, in addition to environmental conservation itself, if the activities are maintained high as ever.

Case 6 Example of Obtaining the ISO14001 Certification

1) Outline of the Company

Company F
Business line: Manufacture of peripheral components of computers
Number of employees: 3,500
Start of operation: 1985
Location of the plant: An industrial estate in Pathum Thani 46 km to the north of Bangkok
Japanese equity ratio: 100%

2) Background

The plant manufactures computer interface cables, wire harnesses, flexible cables, wire assemblies for hard discs and other peripheral components. The plant exports 70 % of the products to Europe and the United States and 30 % to Japan. If a company exports 85 % or more of its production, the Board of Investment grants tax exemption for a certain fixed time period. This is one of the reasons for expanding to Thailand.

Some clients in the developed countries require acquisition of ISO14001 certification as a condition for becoming their trade partners, reflecting the enhanced recognition for global environmental conservation. Company F has regarded environmental consideration as one of the most important objectives since inauguration of the company. To comply with the requirements of such clients, furthermore, the company established an ISO14001 committee in 1996 for the purpose of obtaining the ISO14001 certification.

3) Measures Taken by the Company

a. Acquisition of the ISO14001 Certification

The plant discharges very small amounts of substances in the effluent water and effluent gas that may have impacts on the environment. The first objective was to identify the targets that may be cited as the themes of the effort to obtain the ISO14001 certification. The company selected two themes; namely, reduction of waste generation and reduction of electric power consumption. All persons in managerial positions were educated on the environmental management system. Various manuals for environmental management have been prepared. All employees have been trained for thorough execution of these manuals. The company was audited by a British certifying organization in April 1998 and the company was certified in May 1998. The company's activities are chronologically shown below.

October 1996	The president announced the environmental policy. An environment committee was established for acquisition of the ISO14001 certification. The Plant Engineering Department was entrusted with the function of environmental management. A special officer in charge of environmental conservation was appointed to assist the Manager of the Plant Engineering Department.
January 1997	The leaders of the committee received training in a course for environmental auditors. Then they educated and trained all the Thai and Japanese persons in management and supervisory positions.
April 1997	The manuals for environmental conservation are prepared. These manuals

	were combined with the manuals for quality guarantee and operation standard for the ISO9001 certification obtained in 1994.
July 1997	A preliminary environmental report was prepared summarizing all the issues concerning environmental conservation. Information on Thai laws and regulations on environment was collected.
October 1997	Important themes for environmental improvement were selected. The schedule for achieving improvement was planned and executed accordingly. The company held exhibitions to inform all the employee of the above. The concerned officers of the government and the autonomous body and persons of the concerned companies in charge were also invited to those exhibitions.
January 1998	All persons in managerial positions and representatives of all workplaces receive training for internal auditing, then they conducted internal auditing of environmental management.
March 1998	A preliminary auditing was done by a British authorized assurance organization and execution of the official audit was confirmed.
April 1998	The official audit was conducted by the certifying organization.
May 1998	The company was awarded the ISO14001 certification by the British certifying organization.

Through the above process, the internal structure for environmental management has been organized. Now, environment committee meeting is held once a month called by the president. The committee consists of managers of all departments, the environment supervisors and the manager of the Plant Engineering Department. Any activity concerned with environmental conservation is carried out through the company organization with the environment committee playing the central role.

b. Solid Waste Treatment

The processes to manufacture cables and cable assemblies produce wastes consisting of copper wire tips, debris of metals used for terminals and tin dross. About 95% of the waste is sold to a recycling agent and the rest is consigned to an authorized waste treating agent for disposal. The recycling agent has a process to separate copper and plastics from the wastes and reuses them. It was feared in view of the local conditions that the recycling agent might not effectively recycle the waste or might cause pollution in the process of recycling. The environment committee took up improvement of wastes recycling as an important subject in its effort to obtain the ISO14001 certification.

The measures taken to this subject included a study on the regenerative process, analysis of the recycling agent's operation and conversion of the process into a more efficient one.

Not recyclable wastes, such as waste paint and spent activated carbon, can not be sold to the recycling agent and therefore consigned to General Environmental Conservation Public Company Limited (GENCO), a waste treating agent authorized by the government. GENCO disposes of the waste by landfilling.

GENCO cannot handle such wastes as waste paper, sawdust and wood chips, kitchen garbage. Such wastes, constituting a small portion of the total waste, are stored in the premises of the

plant and consigned to a disposal company of the industrial estate for treatment or disposal.

c. Energy Conservation

The plant receives electricity via two oil-cooled transformers, each having a capacity of 3,500 kVA. The plant consumed a monthly average of 1.7 million kWh in 1997. Compared with the monthly average 1.54 million kWh for 1994, the consumption has gradually increased. The tariff was 1.97 Bahts/kWh on the average from April to September 1997. The breakdown of the consumption was as follows.

(1) Operation of the production machines	37%
(2) Air conditioning	23%
(3) Lighting	12%
(4) Air compressors	7%
(5) Others	21%

The plant has had an established energy management system for economizing energy consumption in which small group activities and energy conservation committee have played important roles. These efforts have implemented seven concrete and effective measures which include a change of operation hours of high-electric-load machines, modification of operating hours and set temperatures of air-conditioning, replacement of fluorescent lights to power-saving types.

The power supply and distribution facilities are periodically inspected and maintained by the Plant Engineering Department and electric work companies. The consumption of electric power is recorded. The plant continually endeavors to improve efficiency of electric power consumption by means of the above-mentioned energy management system.

The proposed measures for further conservation of energy include insulation of molds for plastic molding, reduction of idle operation time of machines, prevention of leaks of pneumatic air, turning off of unnecessary lights, recycling after purification of that portion of the exhaust gas from the soldering operation which contributes to improve air-conditioning efficiency, spreading of light-shielding films on window panes. The plant aims to achieve 4 % reduction of electric power consumption by the end of 1998 by implementing all these proposed measures.

The Energy Conservation Enhancement Act requires that from July 1999 plants consuming a large amount of electric power as this one have a person in charge of energy, keep records of energy consumption for five years, formulate plans for energy saving, report all these to the government. The plant will steadily implement all these.

d. Wastewater Treatment

The industrial water is supplied by the Province of Pathum Thani. This plant consumes about 9,000 m3/month. The industrial water is used for cooling of machines and process facilities, cooking, cleaning and sanitary purpose. The wastewater stream from the kitchen and the sanitary wastewater stream, amounting totally to 240 m3/day, are pooled in a wastewater pit of 100 m3. The plant does not produce wastewater of high pollutant concentration.

Nevertheless, the wastewater flow is arranged to facilitate inspection to guard against unlikely emergencies. The wastewater pit is equipped with a gate to block the pit to prevent the content from escaping the pit in case of emergency. The wastewater in the pit is sent to the central wastewater treatment unit of the industrial estate. Figure 2-3-1 shows the effluent standards indicated by the office of the industrial estate. The plant conducts oxidation by agitated aeration in the wastewater pit to satisfy the BOD standard. The plant satisfies all the items of the standards.

Figure 2-3-1 Effluent Standards Set for Company F by the Office of Industrial Estate

Item	COD	BOD	SS	Settleable matter	Temperature	pH	HCN	Sulfur	Oil	SO42-	SO_3^{2-}
mg/liter	600	450	500	1000	45℃	6-9	5	5	100	500	10

Item	Glucose	Free Cl	Tar oil	Detergent	Hg	Cd	Cr	Pb	Ag	Zn	Cu
mg/liter	500	100	50	100	0.01	1.0	1.0	1.0	1.0	5.0	1.0

Item	Ni	As	Ti	Fe	Ba	Se	Al	Heavy metals[1)]	Metals[2)]	Phenols
mg/liter	1.0	1.0	1.0	5.0	1.0	1.0	5.0	16	30	10

1) Sum of two times of zinc (Zn), cadmium (Cd), copper (Cu) and eight times of nickel (Ni)
2) Excluding iron and alkaline earth metals

e. Others

There are ten group companies operating in Thailand. Other group companies also strive to obtain the ISO14001 certification.

Case 7 Example of Obtaining the ISO14001 Certification and Promotes Environmental Management Including Its Business Partners

1) Outline of the Company

Company G (Company L of Case 12)
Business line: Manufacture of motor cycles and general-purpose engines
Number of employees: 2,500
Start of operation: 1992
Location of the plant: An industrial estate in the City of Bangkok
Japanese equity ratio: 83%

2) Background

The Japanese parent company maintains that its plants throughout the world, including the production centers in Japan, Europe and the Unites States, as well as its products should become more pollution free. The parent company has established the target for environmental conservation for the plant shown below called green factory plan on the basis of its own environmental standards, and promotes environmental conservation activities. The activities include acquisition of the ISO14001 certification and extension of activities to its business partners.

All the member of group companies should positively promote measures for environmental conservation, notably the following aspects.
1) Promotion of measures to make the products more pollution free
2) Promotion of measures to make the products safer
3) Promotion of measures to reduce to zero generation of wastes

3) Measures Taken by the Company

a. Acquisition of the ISO14001 Certification

A special project team consisting of eight persons was established in March 1998 specifically for acquisition of the ISO14001 certification. The members are all Thais, and three of them have majored in environment-related subjects in university. The team prepared the basic documents and studied the environmental aspects under the guidance of consultants and led the persons in charge of environmental conservation of the concerned departments and sections in preparation of their manuals. The Japanese professionals occasionally offered some advice. Reduction of wastes, achievement of effluent standards and reduction of effluent water flow were selected as targets of the environmental aspects. As a result of the concerted effort throughout the company, the company passed the audit in November 1998, eight months after the company started working for acquisition of the ISO14001 certification. The certifying organization is the Thai branch of a German certifying organization.

Since acquisition of the ISO14001 certification, Environmental Engineering Group consisting of three exclusively nominated persons has been established which has served as secretariat to promote environmental conservation. The company sometimes conducts internal audits to establish the ISO14001 movement. Three committees (Environment Committee, Energy Committee and Recycle Committee) have been formed which have done excellent jobs under the leadership of Thai leaders of department manager level. The company has provided every

employee with the cards containing basic principles for environmental consideration and manuals.

b. Solid Waste Treatment

Paint waste and kitchen garbage is the main waste generated in the plant. The plant generated 189 tons of waste in 1996 but reduced it by half, or to 43.3 tons for the first half of 1998, equivalent to 87 tons a year. The reduction of waste is attributable greatly to the reduction of paint waste achieved by modification of painting process.

The paint waste is incinerated. A portion of paint waste is sprayed with a killer agent to be made less sticky and dried. The dried paint waste is mixed with incineration ash and pressed into pebble-form solids. These solidified paint waste are used for pavement in the plant. This pavement is permeable to rain water and is expected to give a favorable effect on the environment. The plant is trying a various ways of recycling wastes.

The sludge from the wastewater treatment is consigned to GENCO. and other wastes to a local disposal company.

c. Wastewater Treatment

The process of surface treatment of steel sheets produces a large amount of wastewater. As much as 180 m^3 a day of wastewater is sent to the central wastewater treatment unit of the industrial estate after pH adjustment and heavy metal removal have been done. The central wastewater treatment unit of the industrial estate reduces BOD and COD to the government standards or less and discharges the wastewater to the river. The standards of BOD and COD indicated to the plant by the office of the industrial estate are relatively lenient, because the wastewater is further treated by the central wastewater treatment unit. The plant however has set plant's own standards more stringent than those indicated by the office of the industrial estate and operated the wastewater treatment unit to meet the plant's standards. Figure 2-3-2 compares the standards indicated by the office of the industrial estate and plant's own standards. It is one of the environmental policies of the plant to do everything the plant can do. Those are, irrespective of the standards indicated to the plant, to prepare for future tightening of the standards, to give sufficient environmental consideration for the sake of the people in the community, and to give global environmental consideration. The quality of treated water is analyzed by an authorized laboratory once a month to confirm the quality.

Figure 2-3-2 Comparison of Standards by the Office of the Industrial Estate and Company G's Standards (mg/liter)

Item	Standards by the Office of the Industrial Estate	Plant's standards
BOD	1000	200
COD	400	250
SS	500	100
Pb	1.0	0.2

d. Cooperation with the Business Partners

The company believes that the plant's products should be manufactured with due consideration given to environment at every process. In this standpoint, the company has asked its suppliers for cooperation in environmental conservation. The company has sent questionnaire to all the 106 suppliers to get hold of their environmental management. The company asked them to

implement environmental measures to the extent they can. The plant procures paints that have high pigment concentrations and low solvent content. The company asks the suppliers to treat their wastewater to the Company G's plant standards. The suppliers are classified into the following three classes: companies in which Company G has a stake or affiliates, companies of Japanese equity and companies of local capital. The company naturally asks its affiliates for more cooperation than others.

The extension of cooperation among business partners is being promoted by the initiatives of the Thai group companies, not at the instruction of the Japanese parent company. In Japan, Europe and the United States, environmental management including business partners has been accepted and established, but not sufficiently yet in Thailand. Therefore, Company G exercises its own judgment in the promotion of environmental conservation involving the suppliers. The price reduction and environmental conservation certainly add to the burden on the suppliers. Yet, Company G asks its suppliers at least to apply already established technologies to environmental conservation. Company G plans and promotes measures for environmental conservation together with the suppliers.

Case 8 Example of Obtaining the ISO14001 Certification with Other Group Companies

1) Outline of the Company

Company H
Business line: Manufacture of refrigerator parts
Number of employees: 440
Start of operation: 1988
Location of the plant: An industrial estate in Pathum Thani 50 km to the north of Bangkok
Japanese equity ratio: 100%

2) Background

The Japanese parent company has manifested the following global environmental conservation charter. The parent company requested that all the overseas affiliates should obtain the ISO14001 certification by the end of 1998.

The parent company has 12 affiliates in Thailand. Company H coordinated all group companies' efforts to obtain the ISO14001 certification, because it was considered more economical and efficient in collecting information and training employees if all the group companies worked together.

Company H has more clients of companies of Japanese capital as more Japanese companies advance to Thailand. Company H increasingly needs to exercise its own independent management policy suited to the local conditions. Similarly, initiatives by Thai staff and employees are increasingly needed to exercise measures of environmental conservation suited to the Thai local conditions.

Global Environmental Conservation Charter of Company H's Japanese Parent Company

We, human beings, live in harmony with everything in the Universe, and are entrusted with a noble mission to realize on earth a harmonious prosperity.
Our company fulfills its social responsibilities, while keeping in mind this noble mission given to us, as human beings, and, at the same time, gives full consideration and makes continuous effort to the conservation and improvement of the environment so that the earth may be maintained in a good-balanced conditions.

3) Measures Taken by the Company

a. Acquisition of the ISO14001 certification

At first the group companies separately began preparations for acquisition of the ISO14001 certification and contacted different certifying organizations. Soon the group companies realized that this was an inefficient way to obtain the certification and decided to join forces. The group companies choose one British certifying organization for the whole group. The group companies started preparation in June 1997 and all 12 group companies successfully obtained the certification July 1998. The group companies agreed that the internal audits would be done by each others in the group so that they might all receive objective audits.

Company H obtained the ISO14001 certification early among the companies of the industrial

estate. Company H therefore provides consulting services to other companies in the industrial estate. The companies of the Japanese capital tend to have consultation of Japanese companies. Company H advises that it is better to work with an organization established in Thailand because of the language barrier.

The company at first established a task force consisting of two persons exclusively in charge of environment to prepare for acquisition of the ISO14001 certification, and called a committee of seven managers with this task force as secretariat. The committee now meets once a month.

The manufacturing process of the plant does not discharge highly contaminated wastewater or exhaust gas. Therefore, the plant had difficulty identifying targets in environmental aspects in the stage of preparation of ISO14001 documents. Themes such as reduction of electric power consumption, reduction of wastewater and termination of the use of chlorinated organic compounds were selected after minute studies.

The targets set forth 5 % reduction of electric power consumption and of wastewater discharge in 1998 against the 1997 consumption. All the employees are given cards with these targets and environmental management policy. At the morning meetings, resource saving and energy saving are frequently quoted to enlighten the employees in these subjects. The employees are asked to be conscious of resource saving and energy saving even at home.

As a result of such endeavors, the employees' awareness of environmental conservation was enhanced and they became positive in submitting constructive suggestions. These suggestions include prevention of oil leaking from the machines, recycling of copper tubes and utilization of liquefied nitrogen chilliness for air conditioning. Minute attention to the lights and machines to turn off electricity when lights are not necessary and machines are running idle achieved the targeted reduction of electric power consumption. The target for wastewater reduction was also achieved by increasing the recycling of washing water. Use of chlorinated organic compounds for rinsing precision devices was terminated July 1998. These measures not merely contribute to environmental consideration but also reduce expenses, thereby increasing the profit of the company. The company accordingly promotes environmental conservation measure in the philosophy that good environmental conservation ultimately pays.

c. Others

The Thai society typically has a top-down structure. Thais normally work under the instruction of the superiors and seldom voluntarily propose their ideas. The company promotes various committee activities to break such traditional behaviors and encourage employees' voluntary activities. Kitchen and Canteen Committee, for example, made a suggestion that the burnt deposit of rice on the bottom of the rice cooking pot represented wasting of resource and energy. Responding to this suggestion, the plant installed a gas burner controller to achieve better temperature control.

The plant's wastewater is not highly contaminated; therefore, it is directly sent to the central wastewater treatment unit of the industrial estate. The exhaust gas is only emitted from the soldering process in the plant.

Case 9 Example of Jointly Obtaining the ISO14001 Certification with Division Companies of a Corporate Group

1) Outline of the Company

Company I (Company A of Case 1)
Business line: General electric machinery manufacturing
Number of employees: 2,900
Start of operation: 1996
Location of the plant: In an industrial estate for division companies of the same group in Samut Prakan, 30 km to the east of Bangkok
Japanese equity ratio: 49%

2) Background

The Japanese parent company of Company I has pronounced its environmental policy that the company gives continuous consideration to the environment and make a sincere effort to maintain and improve the environment. The parent company requires that its affiliates, both in Japan and abroad, obtain the ISO14001 certification by the end of March 1998.

Company I used to be a general electric machinery company manufacturing various electric products. Company I had a scope to strengthen its management structure and to expand business in preparation of the ASEAN Free Trade Area (AFTA) scheduled to become effective after 2000. Then, it planned to divide itself by each operating division, formed eight financially independent operating companies and one managing company in 1996 and has completed it August 1998. All these companies are situated in this industrial estate to form a group of companies except one and manage themselves in a financially independent manner.

The managing company coordinates and promotes subjects, like acquisition of the ISO14001 certification, that are common to all member companies of the group.

3) Measures Taken by the Company

a. Acquisition of the ISO14001 Certification

As shown in the following record, the group member companies obtained the certification a year after they started working for acquisition of the certification.

April 1997	Environmental Office was established to coordinate the member companies.
May 1997	Restructuring of the environmental management organizations
July 1997	Start of activities for acquisition of certification
August 1997	Selection of logotype and slogans, holding of ISO14001 exhibitions and seminars
September 1997	Distribution of brochures on environment issues to all the employees and issuance of environment news for educational purpose
October 1997	Start of audio programs on environment and ISO14001 at the employee's cafeteria / Start of preparation for education and necessary document preparation for acquisition of the ISO14001 certification / Education of all employees on ISO14001
November 1997	Exhibition on Energy Conservation was held

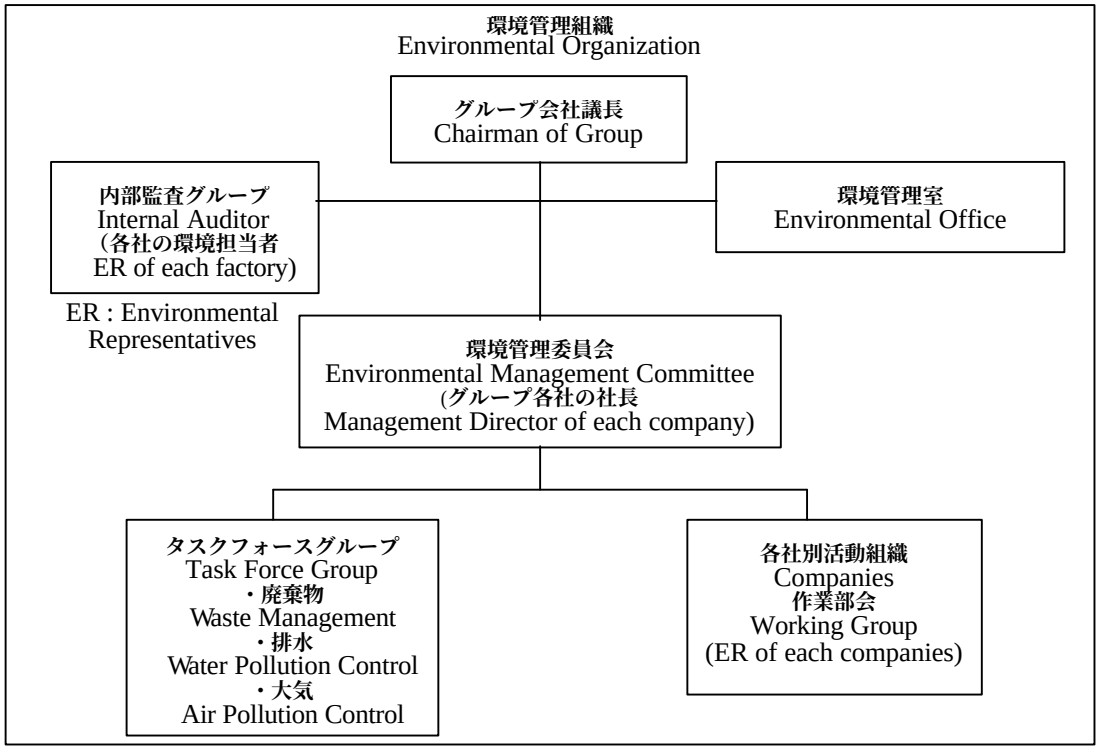
January 1998	Completion of documents for ISO14001 and starting of execution of the ISO14001 activities
February 1998	First internal audit by members of the Association of the Group Companies
June 1998	Audit by the Thai certifying organization
July 1998	Acquisition of certification
December 1997	First surveillance

b. Cooperation with Other Companies

In May 1997, the group companies agreed to reform environmental management organization as shown in Figure 2-3-3 so that the groups companies may be able to deal with environmental problems more rationally. Environmental Management Committee meets once a month to decide on common subjects and exchange information. Implementation of the measures for improvements is consigned to three task force groups. Waste Management Task Force achieved a 25 % reduction of waste treating cost in one year of the group companies by conglomerating the packaging materials of expanded polystyrene through heating, fusing and pressing and letting the dealers to take them. Waste Management Task Force also promoted waste paper recycling. Water Pollution Control Task Force applied right maintenance to the wastewater treatment units that had not functioned well to clear the effluent standards. Air Pollution Control Task Force replaced carbon tetrachloride with pure water for cleaning devices and parts and thus decreased emission of pollutants to the atmosphere and reduced inhalation of organic compounds by improving the paining process.

The cooperative works among the group companies not only facilitated acquisition of the ISO14001 certification and helped solve various problems by drawing upon the combined capabilities of the group companies.

Figure 2-3-3 Environmental Management Organization of Inter-Companies of Company I Group



Case 10 Example of Obtaining the ISO14001 Certification with Little Environmental Impact

1) Outline of the Company

Company J
Business line: Manufacture of printers, hard disc drives, cameras, data-processing devices, precision parts of optical instruments
Number of employees: 9,000
Start of operation: 1988
Location of the plant: In an industrial estate in Pathum Thani, 50 km to the north of Bangkok
Japanese equity ratio: 100%

2) Background

The Japanese parent company has guided all overseas plants in environmental consideration. The parent company has taken care of this company very minutely since inauguration. The parent company decided that Company J should obtain the ISO14001 certification as an evidence of good environmental conservation.

Two years ago the Japanese parent company requested this plant to obtain the ISO14001 certification by the end of March 1999. The plant rallied all forces and prepared for acquisition of the certificate. As a result, the plant successfully obtained certificate in May 1998, about one year earlier than expected. Since the plant obtained certification, some European clients have begun asking whether this plant has obtained ISO14001 certification.

3) Measures Taken by the Company

a. Acquisition of the ISO14001 Certification

Environment Committee, the supreme organization, with the president heading the committee and all department managers of the operating departments being the members, holds a meeting twice a year. Under Environment Committee are Promotion Groups, which have various committees each in charge of particular subject such as waste, chemicals, beautification of the plant, energy. These committees prepared documents for ISO14001 with participation by the representative of each department.

Basic materials and guidance were provided by the Japanese parent company. The company obtained certification from a Thai certifying organization rooted firmly in Thailand, because the company operates in Thailand. The operation of the plant consists mainly of assembling precision devices and parts and therefore does not discharge highly contaminated effluent water or effluent gas. Therefore the company carefully sorted out environmental aspects and devised methods for evaluation in preparation of the audit documents.

Under the motto of “harmony with the environment”, the company established the targets for reduction of electric power consumption, reduction of water consumption and reduction of waste generation as shown in Figure 2-3-4. Other targets include review and improvement of the environmental aspects of the soldering process and thorough maintenance of wastewater pits.

The plant is now reducing electric power consumption by modification of the power distribution system and setting of right voltage and is reducing water consumption by increasing the use of recycled water.

Figure 2-3-4 Targets for Reduction of Environmental Impact of Company J

Item	Target
Electric power consumption	Reduction of electric power consumption per unit sales value by 5 % from the previous year's performance
Water consumption	Same as above
Waste generation	Reduction of waste generation per unit sales value by 10 % from the previous year's performance

b. Wastewater Treatment

The office of the industrial estate provides water from a well in the estate, and this plant receives about 400,000 m^3 a year. The received water is partly purified by reverse osmosis and used for washing precision devises and parts and is partly used for cooling purpose. The spent water from the washing process and used cooling water constitute the wastewater. Since the degree of contamination is very low, the wastewater is sent directly to the central wastewater treatment unit of the industrial estate after pH value is checked.

Effective from 1999, use of well water will be prohibited by the instruction of the Ministry of Industry (MOI). The plant will then have to purchase industrial water from the Provincial Water Works Authority. The cost of water, 8 Bahts/m^3 as of the end of 1998, will increase to 21 Bahts/m^3. The reduction of water consumption will be economically more important and must be implemented also from the viewpoint of cost reduction.

c. Solid Waste Treatment

The packaging materials -- wood frames, expanded polystyrene, and cardboard -- constitute the bulk of wastes. The boxes used by the Thai parts suppliers are designed for repeated use; therefore, the plant sends them back to the suppliers. The plant is now studying the methods for using the boxes coming from Japan as containers for export products to Japan so as to send them back to Japan. Two 8-ton truckloads of expanded polystyrene is generated a day, which is sold to a local agent.

About 250 tons of faulty products are generated per half a year. These are crushed and consigned to a dealer authorized by the MOI for treatment and disposal. The dealer extracts metals and other valuables for reuse, incinerates the combustibles and disposed of incombustibles by landfilling. Since the company receives tax incentive from the Board of Investment specially for manufacturing export products, the company is strictly forbidden to channel to the domestic market even a faulty product. The toner for the printer is harmful for the health if inhaled; therefore, utmost care is exercised for its disposal. The plant sees to it that a disposal company consigned for the treatment rightly disposes of it by visiting the company and watching their work.

Waste oils and hazardous substances such as waste chemicals are consigned to GENCO, an authorized disposal company by the government. Company J pays the cost for treatment and

disposal.

d. Others

This plant has been promoting High Reliability (HR) program since 1991. This program aims to improve the reliability of the company's products involving all employees from manufacturing to product delivery. The program consists of group activities and a suggestion system. Every employee participates in one of the group activities where group members discuss the problem and finds solution to a problem. The leader is selected from the group members, and the group holds a meeting every week. The suggestion system is open to everyone. Anyone who submits a suggestion is responded from plant managers within a week or two. The HR program has been established among the employees and helps encourage them and contributes to enhancing reliability of the company's products.

This program contains issues concerning environment. Accordingly, this movement promotes enhancement of employee's awareness of environmental conservation and encourages their voluntary actions.

Section 4
Cases of Adopting Locally Tailored Environmental Practices

The most of Japanese companies in Thailand have established corporate principle for environmental conservation. Many of their products are well-known consumers' goods; therefore, their good environmental conservation measures are important to enhance their corporate images. These companies attach particular importance to maintaining good relations with the people in their local communities. This prompts them to take thorough measures to odor, wastewater and wastes so that the local people would not have any complaints against them. Some of them open the plant to the local people to let them see the facilities and operation, thereby establishing friendly relationship with the local people. The environmental conservation measures based on mutual acceptance and mutual benefits between the plants and the local people are expected to be very effective.

Case 11 Example of Converting Byproducts into Soil Conditioners to be Returned to Farmland

1) Outline of the Company

Company K Business line: Manufacturing chemical seasonings Number of employees: 320 Start of operation: 1998 Location of the plant: In Kamphaeng Phet about 160 km to the north of Bangkok Japanese equity ratio: 70%

2) Background

Company K is one of the early comers to Thailand. Its No.1 plant in the suburbs of Bangkok has been operating for 37 years. The No.1 plant manufactures chemical seasonings from starch extracted from cassava, a root crop. The company decided to build the new plant to meet the growing demand. The company planned to use spent molasses with starch as raw material. This location was selected because of this area's availability of both starch and molasses. Besides, the No.1 plant has a problem with transportation and distribution of a liquid byproduct of chemical seasonings, which contains organic substances at high concentrations. The No.2 plant reported in this case, being situated in the midst of a stretch of farmland, has an advantage of being able to returning the byproduct to the farmland as organic fertilizer.

3) Measures Taken by the Company

a. Measures for the Byproducts

The plant produces as much as 45,000 tons of byproduct liquor consisting mainly of waste cells of microorganisms. This byproduct contains nitrogen and minerals and is therefore effective as fertilizer. A significant difference has been noticed in growth between the seedlings of sugar canes given this liquor and those not given it. As this information spreads, an increasing number of farmers growing sugar canes in the vicinity of the plant are requesting the plant to spray this liquor on their farms. This liquor is becoming famous also as effective fertilizer to corn and cassava.

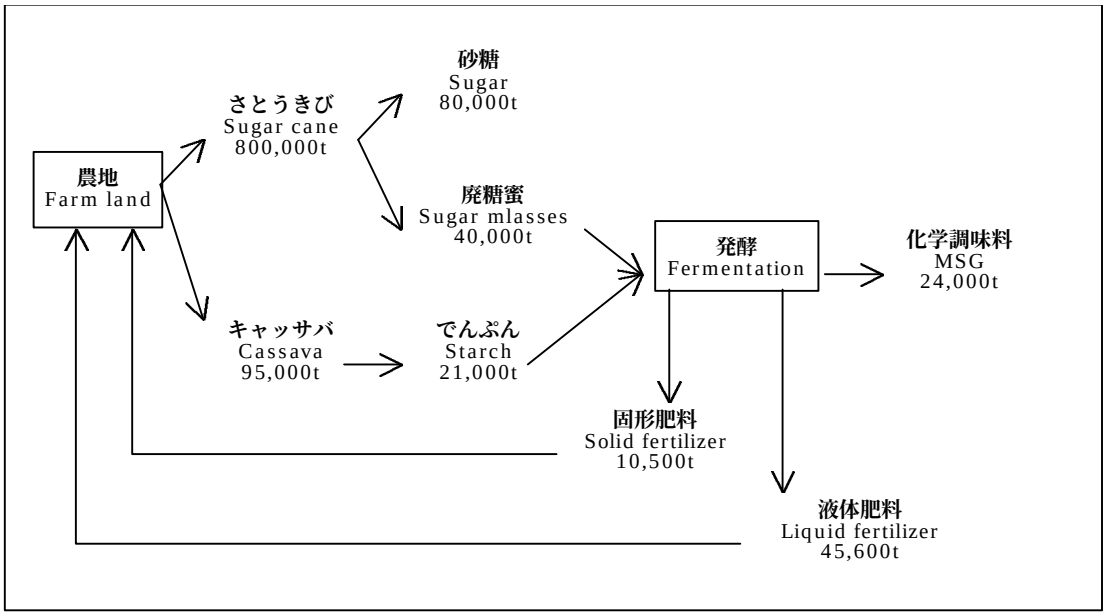
The plant now treats the liquor and sends a tank-truck to spray it on the nearby farmlands. This liquor, a nuisance in the No.1 plant in the suburbs of Bangkok, is effectively utilized as a resource in the agricultural area of the No.2 plant, thereby reducing the transportation cost needed for disposal in the case of the No.1 plant.

This plant also produces as much as 10,500 tons of a solid waste consisting of the waste activated carbon used for decolorization and the excess sludge from the activated sludge process. These solid wastes contains nitrogen and potassium, effective ingredients as fertilizer, and is sold to a fertilizer company, which adds phosphorus to it and sells as a fertilizer for strawberries, litchi trees and longan trees.

Neither the byproduct liquor nor the solid wastes can be officially called fertilizer because of their nitrogen and potassium contents being lower than the standards specified by the Thai law.

The company therefore has to call them soil conditioners. Figure 2-4-1 indicates the routes through which these byproducts are recycled back to the farmland as soil conditioners.

Figure 2-4-1 Byproducts Agricultural Recycling Flow of Company K



b. Wastewater Treatment

The river to which the plant discharges wastewater flows to Bangkok. Therefore, the plant is voluntarily conducting the strict control of wastewater quality. The plant has set the standards for BOD and total Kjeldahl nitrogen (TKN) to be 20 mg/liter maximum and 200 mg/liter maximum, respectively, equivalent to the standards the government of Thailand has set for the effluent water for chemical seasoning plants. The plant has installed a wastewater treating unit consisting of the facilities shown in Figure 2-4-2.

The government prohibits plants or factories from being constructed within one to three kilometers from river banks, the distance depending upon the kind of industries. The manufactures of chemical seasonings are not subject to this restriction. However, the company made a large pond to keep wastewater from the activated sludge process when the plant was built, in compliance with the request which the Ministry of Industry (MOI) made in view of the recent industrial pollution problems.

The wastewater treatment unit receives 1,500 tons per day of water from the processing facilities. The incoming water is adjusted for pH and subjected to biological decomposition in the aeration tank. The water is then sent to the sedimentation tank to be separated from the sludge by sedimentation. The upper clear water is called treated water. The treated water is sent to the pond with a holdup capacity of 20 days. Fish and shrimps inhabit the pond. There is more in environmental conservation effect to the pond than the mere holdup capacity required by the MOI, including good impressions the visitors may have on this plant.

The plant measures COD_{Mn}, TKN and color of the treated water quality every day, items relatively easy to measure, for controlling the operation of the wastewater treatment unit. If

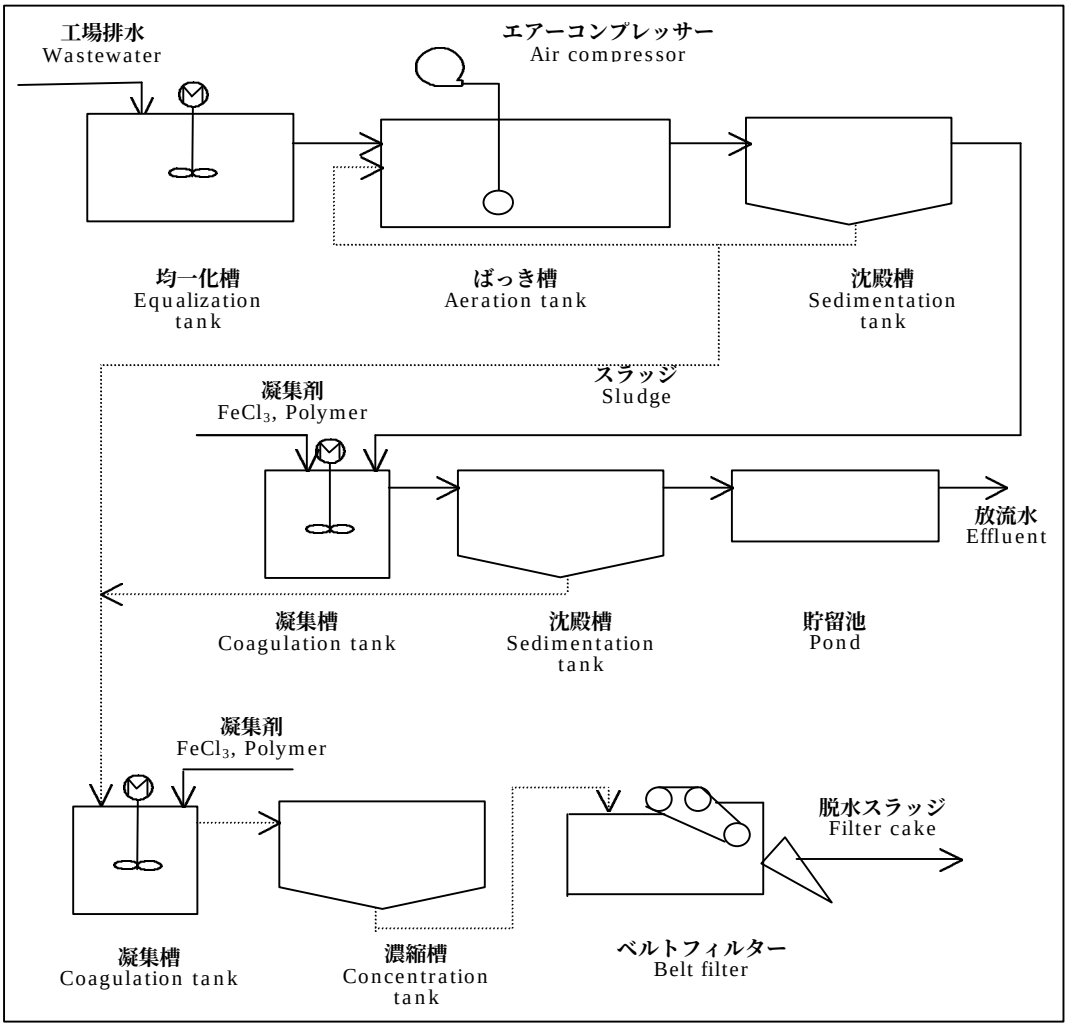
any abnormality is found in these measurements, corrective measures are taken immediately. The treated water is analyzed for BOD and CODcr by the No.1 plant once a week. The analytical results of the main items (BOD, CODcr, pH and T-N) are reported once a month to the officer of the MOI stationed in the Provincial Office.

During the harvest season the farmers burn the leaves of cane sugar on the farmlands. The ash from the burning falls on the pond and raises the pH value of the water. During this season, the pH value of the water from the activated sludge process is so adjusted that pH of the water discharged from the pond may fall within the controlled range, taking into consideration of the effect of the falling ash.

c. Others

Company K has established a fund to extend financial aids to schools and restoration of historical buildings. Company K presents awards to the school athletic meetings, and extends cooperation to the local industrial promotion society in the campaign for safety training and 5S movement (named after the Romanized Japanese terms all starting with S meaning tidying up, cleanup, and others for organized plant environment). The company normally avoids donating money but offers cooperation in activity.

Figure 2-4-2 Flow of Wastewater Treatment of Company K



Case 12 Example of Taking Thorough Measures for Disagreeable Odors as Environmental Consideration to the Community People

1) Outline of the Company

Company L (Company G of Case 7) Business line: Manufacture of motor cycles and general-purpose engines Number of employees: 2,500 Start of operation: 1992 Location of the plant: An industrial estate in the City of Bangkok Japanese equity ratio: 83%

2) Background

The company has been in operation for 34 years since 1965. The company used to have a plant located in another place in the suburbs of Bangkok, which has become too small for the present operation. The company therefore built a new plant in this place in 1992. This industrial estate was managed by the Industrial Estate Authority of Thailand (IEAT), a joint public-private company; therefore, the company considered that procedures for applications and granting of permission would proceed smoothly in this industrial estate. The industrial estate is conveniently located for transportation of the parts and products and for supply of labor. These were the reasons for selecting this industrial estate as location of the new plant.

This plant is located in the outermost side of the industrial estate and is adjacent to a residential area across the fence. The plant would receive complaints from the residents about any odor if the plant might emit. The plant's products are reputed in Thailand; therefore, the plant aims to maintain a good impression of the products all the more by taking thorough environmental conservation measures, thereby reducing occurrence of odor claims to zero.

3) Measures Taken by the Company

a. Odor Prevention

The odor is generated in the processes of spraying paints and subsequent drying. Since 1993, the plant has consecutively taken the following measures.

(1) Installation of an exhaust gas scrubbing chamber
(2) Replace the spray guns with low-pressure ones
(3) Increase of the height of stack to 40 meters and installation of a filter unit in stack
(4) Increase of pigment concentrations and reduction of solvent concentration
(5) Adoption of micro bells to improve transfer efficiency of the gun

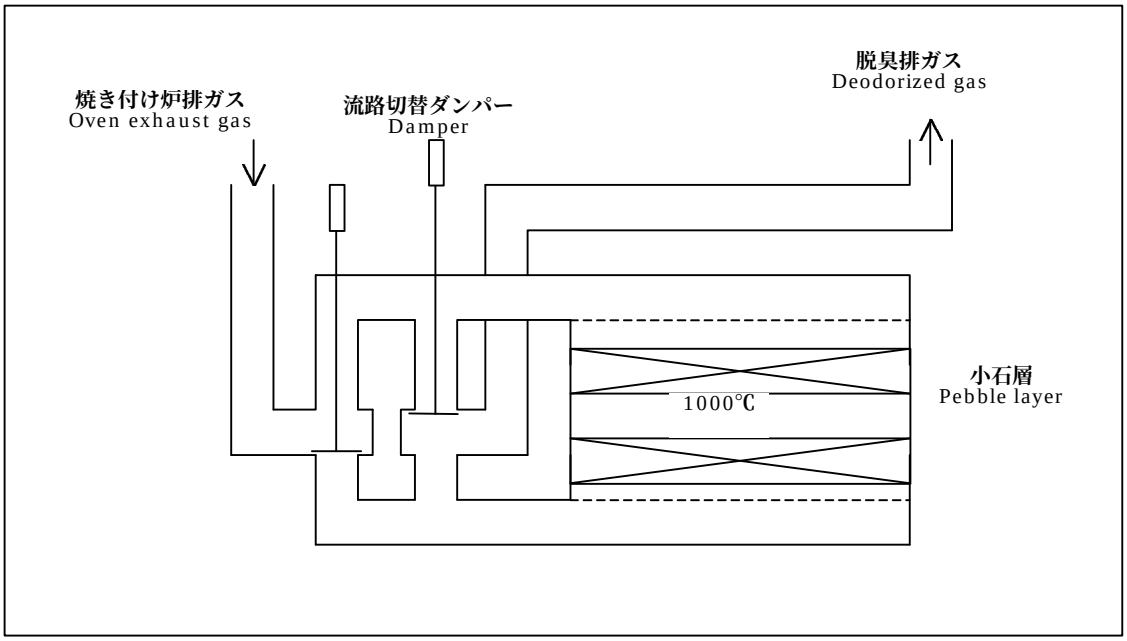
These measures resulted in a reduction of xylene content in the air from 200 ppm, the standard, to 45 ppm. However, this did not provide a complete solution of the odor problem because the odor caused complaints if it was felt even for a short period of time.

The plant took an additional measure by installing a facility to decompose the odorants effluent from the oven for baking process of the paint. This facility, as shown in Figure 2-4-3, allows the exhaust gas to flow alternately upward and downward through pebble layers heated to 1,000ºC to oxidize and decompose the odorants. The gas is flown at first downward. When the lower pebble layers become hot by heat of combustion, the flow is reversed from downward

to upward to perfect oxidation decomposition. The switching of the flow is done by intermittent damper operations to ensure continuous decomposition of the odorants. Gas is burned to heat the unit when the facility is started up. Through these measures the concentration of xylene has been reduced to 25 ppm, a level low enough not to be perceived by human sense. The plant analyzes the odorants to confirm the decomposition. The company also periodically sends the gas sample to the parent company in Japan for gas chromatographic analysis.

The above measures have resolved the problem of complaints. Nevertheless, the employees conduct monitoring of odor in the surrounding of the plant when the plant is in operation and the plant takes corrective measures if odor is ever detected before the plant receives complaints.

Figure 2-4-3 Flow of the Odorants Combustion System of Company L



Case 13 Example of an Industrial Estate Where the Community People are Allowed to Watch Environmental Conservation Measures

1) Outline of the Company

Company M Business line: Development, sales in lots and management of an industrial estate Number of employees: 200 Start of operation: 1990 Location of the plant: Ayuthaya 69 km to the north of Bangkok Japanese equity ratio: Not disclosed

2) Background

The US-educated general manager of this industrial estate has a keen interest in environmental conservation. Of the 92 tenants of this industrial estate, companies of Japanese capital represent the majority, or 62 to be exact. Ten of these companies of Japanese capital have already obtained the ISO14001 certification. These companies lead the entire industrial estate in the environmental conservation activities. In the City of Ayuthaya where the industrial estate is situated, restoration of the historical relics has been underway. The awareness of the local people for environmental conservation is very high. Under such circumstances, environmental measures open to the community are required. The industrial estate monitors not only effluent waters and wastes from the plants but also the quality of air surrounding the industrial estate, thus the industrial estate gives utmost consideration to environmental conservation. The results of the monitoring are disclosed to the people of the community. The company considers good relationship with the community people very important.

3) Measures Taken by the Company

a. Wastewater Treatment

The industrial estate takes water from 16 deep wells and supplies it as industrial water to the plants and factories in the estate. The wastewater generated by the plants and factories are fist treated by them to the specified quality and then collected in the central wastewater treatment unit of the industrial estate where water is given final treatment to be discharged to the channel outside the industrial estate. The maximum capacity of the central wastewater treatment unit is 15,000 m^3 a day.

Figure 2-4-4 shows the effluent standards set for the plants and factories in the estate. The standards presume biological treatment by the central wastewater treatment unit and are therefore relatively lenient for COD and BOD. The plants are individually required to satisfy the strict specifications for heavy metals, which are not amenable to biological treatment. The industrial estate takes samples of water from each plant and factory twice a month, and has them analyzed by a laboratory authorized by the government at the tenant's expense. A warning is issued to the tenant not complying with the standards of the industrial estate. If the tenant does not correct the quality of wastewater to comply with the standards, the supply of industrial water may be suspended. The Japanese companies take an immediate measurement for any problems they may cause after they are warned.

Figure 2-4-4 Effluent Standards Company M Has Set for the Tenant Plants and Factories

(mg/liter)

Item	COD	BOD	SS	TDS	Tempe-rature	pH	HCN	H_2S	Oil	Tar
Standard	1250	1000	200	2000	45℃	6.0-9.0	0.2	5.0	10.0	10.0
Item	Free-Cl	Zn	Cr	Hg	Cd	Mn	Pb	Cu	Ni	As
Standard	5.0	5.0	0.5	0.005	0.03	5.0	0.2	1.0	0.2	0.25
Item	Ba	Se	F	Free NH_3	Ammo-nia	Phenols	Pestici-des	Color/ odor	Formal-dehyde	Deter-gent
Standard	1.0	0.02	5.0	50	50	1.0	ND	ND	1.0	100

The central wastewater treatment unit of the industrial estate must comply with the effluent standards set by the government for all items. For this purpose, the industrial estate installed a central wastewater treatment unit shown in Figure 2-4-5. The central wastewater treatment unit receives wastewater streams from the plants and factories in the equalization tank. Then the treatment unit neutralizes the wastewater and subjects it to biological treatment to decompose the pollutants. The formed sludge is separated by settling in the sedimentation tank. The upper clear water is discharged as treated water after chlorine disinfection. The sludge is concentrated by the thickener followed by dewatering by filter press. The dewatered sludge was disposed of by landfilling.

The environmental impact assessment prepared at the time of industrial estate construction set the items for routine checking and standards as shown in Figure 2-4-6. The company consigns once a month analysis for these items to a laboratory authorized by the MOI. The past records indicate that BOD of the water received ranges from 60 to 300 mg/liter and that of the discharged water ranges from 9 to 47 mg/liter which satisfies the standard for BOD. The company summarizes the results of these analyses and reports to the Ministry of Science, Technology and Environment (MOSTE) every six months.

Formerly, the company had to analyze the treated water for all the 30 items of the effluent standards set by the government. The rule was revised afterward, and now only 11 items shown in the figure should be analyzed for ordinary testing.

Figure 2-4-5 Flow of the Central Wastewater Treatment of Company M

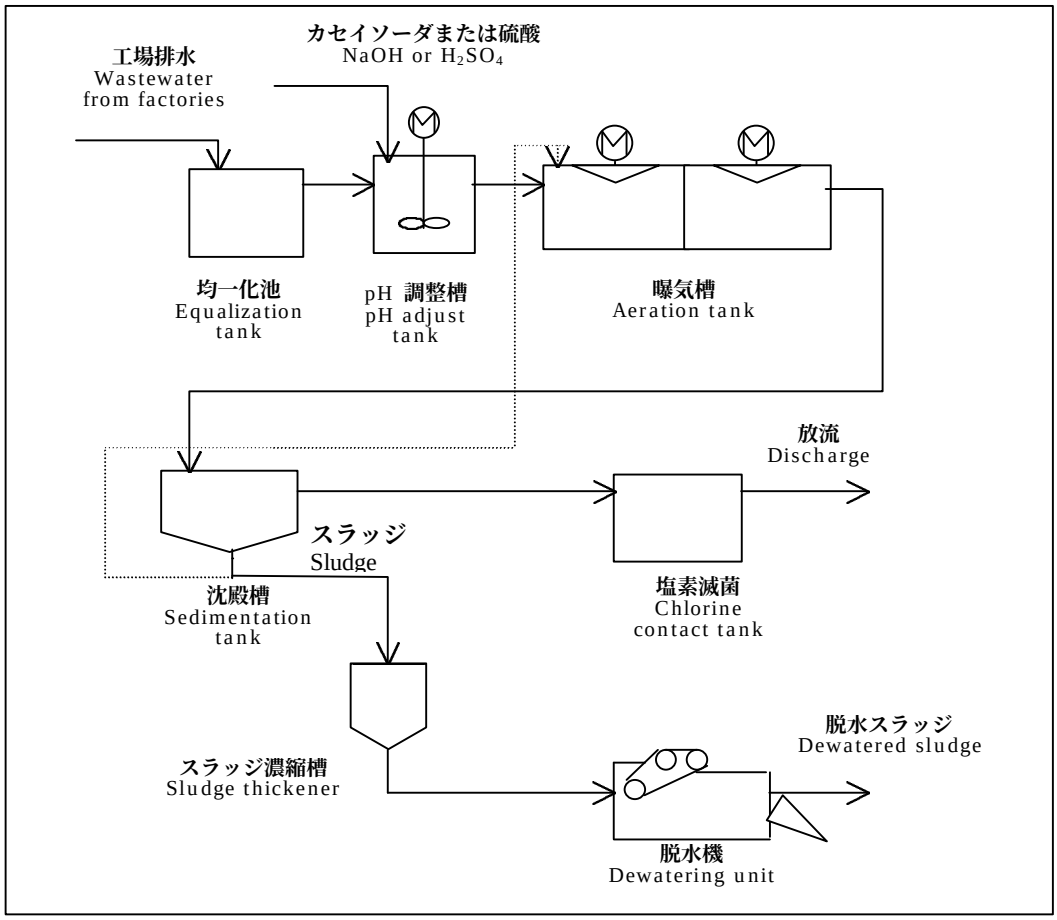


Figure 2-4-6 Effluent Standards Set for Company M

(mg/liter)

Item	pH	BOD	COD	SS	DS	Oil
Standard	5.5-9.0	60	400	150	5000	5
Item	Zn	Cr	Cu	Pb	Ni	—
Standard	5	0.5	2	0.2	1.0	—

b. Solid Waste Treatment

The industrial estate collects about 7 to 8 tons of general wastes such as kitchen garbage and waste paper from the plants, and incinerates the waste in the incinerator inside the estate with a capacity of 5 tons per day. Cost of 45 Bahts per drum is chargeable to the tenants. The company calls a disposal company to sell them such salable wastes as recyclable paper and metals and incinerates the remaining wastes by a five-tons-a-day incinerator in the premises of the industrial estate. The incinerator ash is landfilled.

Each plant and factory individually consign a treatment and disposal of hazardous wastes to a disposal company authorized by the government. On the other hand, the industrial estate collects record on the treatment and disposal of hazardous wastes from each tenant, and compiles them to report to the MOSTE in every six months.

c. Measures Taken for Air Pollution and Noise

One of the environmental policies of this industrial estate is to prevent air pollution and to contain noises. The company monitors air quality and noise at one point in the premises and at three points outside the premises. Figure 2-4-7 shows environmental standards for this area and the monitoring results. The figure indicates that the monitored quality of air both inside and outside the premises satisfies the standards by big margins, indicating that the plants and factories in this industrial estate do not cause air pollution. The maximum noise levels measured outside the premises are close to the standards; this is presumably attributable to the location of the industrial estate being close to a trunk road.

Figure 2-4-7 Environmental Standards for Air and Noise and Company M's Measurements

		Locations and measured values			
Item	Standards	Outside 1	Outside 2	Outside 3	Inside
TSP	0.33 mg/m^3 24 hr	0.025 - 0.085	0.24 - 0.13	0.032 - 0.072	0.025 - 0.095
PM 10	0.12 mg/m^3 24 hr	0.013 - 0.051	0.019 - 0.083	0.022 - 0.052	0.016 - 0.041
SO_2	0.30 mg/m^3 24 hr	Less than0.001	Less than0.001	Less than0.001	less than 0.001
NO_2	0.32 mg/m^3 1 hr	0.006 - 0.12	Less than0.001	Less than0.001	0.006 - 0.025
CO	34.4 mg/m^3 1 hr	1.75 - 3.25	2.50 - 3.00	2.25 - 3.25	2.75 - 3.75
Noise	70dB 24 hr	6.46 - 68.0	57.4 - 62.3	-	-

d. Others

The company submits an environmental impact assessment (EIA) report in every six months to the MOSTE. The report contains amount of water discharged, treated water quality, treatment and disposal of wastes, results of monitoring of air quality and noise level, discharges of hazardous wastes from individual plants and factories. The report volume is as thick as several centimeters.

The company discloses to the local residents the environment-related facilities and their operation conditions upon request by the residents. They come to the plant several times a year. They appreciate that the water discharged from the estate is cleaner than the water in the channels in the local community.

Section 5
Other Examples of Innovative Environmental Practices

The Japanese companies in Thailand encounter various challenges in their efforts for environmental conservation. Some companies have set up strict self-imposed effluent standards in anticipation of the official standards becoming tighter in future. Others have modified their manufacturing process itself so that they do not generate wastewater or hazardous wastes. There are still others conducting effective treatment of their wastewater linked with the central wastewater treatment units of the industrial estates. Each activity effectively reduced their environmental impacts in its own way.

Case 14 Example of Working Closely with the Central Wastewater Treating Unit of the Industrial Estate

1) Outline of the Company

Company N Business line: Manufacture of polyester fibers Number of employees: 450 Start of operation: 1993 Location of the plant: Ayuthaya 20 km to the north of Bangkok Japanese equity ratio: 75%

2) Background

In 1993 when the company was looking for an industrial estate for locating a plant, they knew that different environmental measures were required for different places in Thailand. In convenient places near Bangkok, construction of a plant was not allowed within 1 km from riverbanks and strict effluent standards were regulated. Requiring a large quantity of water, the polyester fiber plant is desirably located in a place where water is sufficiently available. Places far apart from Bangkok have more generous effluent standards but are inconvenient for transportation of raw materials and products.

The company therefore chose this industrial estate as the plant site, being located not far from the City of Bangkok and having utility supply, industrial water in particular, and central wastewater treatment unit. This industrial estate is managed by a public-private joint corporation participated by the Industrial Estate Authority of Thailand (IEAT) and private firms.

Company N manufactures polyester staples and filaments from the chemicals imported from Japan and the Middle East, generating a large quantity of wastewater highly containing BOD contents. The company has adopted a useful system that both its own wastewater treatment process and the central wastewater treatment unit in the estate compensate each other effectively to meet the strict effluent water standards set by the government of Thailand.

3) Measures Taken by the Company

a. Wastewater Treatment

The plant produces wastewater at a rate of about 40 m^3 per hour. Figure 2-5-1 shows the standards for the water acceptable to the central wastewater treatment unit of the industrial estate. At the beginning, the plant used to send its wastewater to the central unit without treatment, then the wastewater sometimes failed to meet the BOD standard. Therefore, in 1996, the plant made a pond equipped with an aeration facility. The purposes of the pond were emergency holdup, equalization of the quality of wastewater, and reduction of BOD by aeration. The aeration pond had a capacity of 1,000 m^3 and a surface area of 600m^2 and holdup capacity of one day. Since this aeration pond was made, the plant's wastewater has never failed to meet the standards of the industrial estate. The office of the industrial estate checks every month the quality of the sample of effluent water streams from each tenant. This plant contracts out analysis of the treated water to the supplier of the water treating chemicals every week. The both tests at the estate and at the plant show same results.

The central wastewater treatment unit collects wastewater streams from the tenants and gives the water activated sludge treatment to reduce BOD to 60 ppm or less and discharges it. If a tenant sends wastewater exceeding the standards to the central wastewater treatment unit, the tenant is given a penalty by the rule of this industrial estate. Figure 2-5-2 shows price of industrial water supplied to the tenant. The water prices are decided based on the BOD content of the wastewater of each tenant. If the BOD content of the wastewater exceeds 500 mg/liter, the price of the industrial water increases threefold. In a case of the plant receiving 1.5 times as much water as wastewater it discharges, it is economically effective to hold down the BOD content to less than 500 mg/liter.

Figure 2-5-1 Effluent Standards Set for Company N by the Industrial Estate

(mg/liter)

Item	pH	BOD	SS	Temperature ℃
Standard	5.5 to 9.0	500	50	45

Figure 2-5-2 Water Price Set for Company N by the Industrial Estate

BOD of wastewater (mg/liter)	Water price (Bahts/m^3)
200 max.	4.5
200 to 300	5.5
300 to 500	6.4
500 or more	18.2

b. Solid Waste Treatment

The off-specification fibers produced from the manufacturing processes are thoroughly recycled as raw material. However, those stained or stiffened in a lump end up being a waste. The plastic materials for packaging and cardboard become wastes. Easily combustible wastes amounting to from 100 to 200 kg a day are incinerated in the incinerator inside the plant. The wastes amounting 12 tons a month that are not easily combustible and general wastes like kitchen garbage, are burned by the incinerator of the industrial estate. The hazardous wastes specified by ordinances are consigned to General Environmental Conservation Public Company Limited (GENCO) for treatment and disposal at a price of 3.6 Bahts per kg. The plant generates hazardous wastes at a rate of about two tons a month. The restriction on the waste is becoming ever stricter. When a waste is brought out of the industrial estate, the guard checks the destinations of transportation.

c. Exhaust Gas Treatment

The standards set by the government are applied to the plants in the industrial estate. This plant operates two 500 kW diesel-powered generators on a low-sulfur diesel fuel; therefore, they do not cause any problem. This plant consigns analysis of exhaust gas to an authorized laboratory once in six months. The company reports the results of analysis to the Ministry of Industry (MOI) through the IEAT.

d. Others

The Power and Utility Section is in charge of wastewater treatment and water supply. The Personnel Section, also in charge of general affairs, is in charge of waste management because

of this work requiring frequent meetings and negotiations with the outside organizations. The manger of the Personnel Department closely keeps in touch with the Provincial and District offices of the IEAT. Through such contacts with outside organizations the company is able to obtain direct information on such themes as revisions of laws and regulations about environmental conservation. The Bangkok Japanese Chamber of Commerce also provides various pieces of information.

The safety committee consisting of 15 members in executive positions and representatives of workplaces meets once a month to discuss the means of giving due environmental consideration and thorough execution of operation standards in the execution of the 5S movement. This was named after the Romanized Japanese terms all starting with S meaning tidying up, cleanup, and others for organized plant environment. Performances of such endeavors were highly evaluated and the Ministry of Public Health awarded the company for the activities of safety, environmental conservation and sanitation.

The company will soon need to obtain certification for ISO14000 series, because this certification is inevitable when exporting products to the United States and European countries.

Case 15 Example of Setting Strict Company Standards in Anticipation for Tightening of Official Standards

1) Outline of the Company

Company O
Business line: Manufacture of polyester raw materials
Number of employees: 136
Start of operation: 1999 (planned)
Location of the plant: An industrial estate in Rayong about 160 km to the southeast of Bangkok
Japanese equity ratio: 50%

2) Background

Company O's Japanese parent company has an excellent manufacturing process of polyester. Now it has become more difficult to build a plant in Japan for various reasons. The parent company has decided to build a most advanced plant in Thailand, which has an advantage of good raw material supply and a good market. The design of the new plant was reflected on the future aspect of environmental conservation including measures against the global warming.

The local partner also fully understands corporate social responsibility and has announced the corporate principle to the group companies. The corporate principle states, among others, that the group companies should take pride in environmental conservation. A booklet containing this corporate principle is distributed to all employees to enhance their awareness in environmental conservation.

The location is close to a chemical complex producing a variety of chemical derivatives from the natural gas produced close to this area. Raw materials such as Para-xylene are supplied from the complex.

3) Measures Taken by the Company

a. Wastewater Treatment

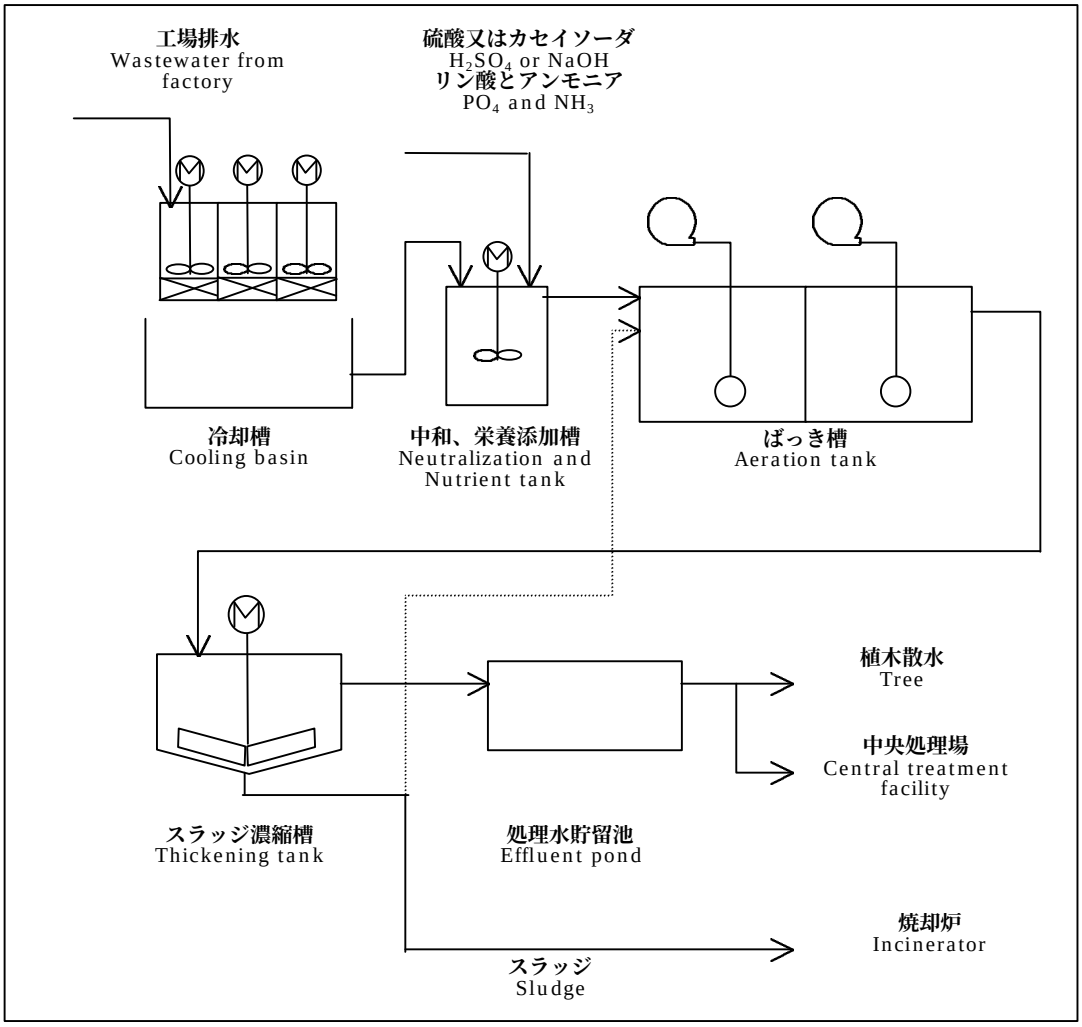
The company prepared an environmental assessment report on the construction of the plant with the cooperation of a local consulting company. The company first obtained approval on the environmental assessment report from the Ministry of Science, Technology and Environment (MOSTE) and then submitted the environmental impact assessment report, together with other documents, to the MOI and obtained permission for operation of the plant. The MOSTE and the MOI indicated effluent water standards; however, the company has set up its own company's standards, stricter than the official one in certain items, in anticipation of future tightening of the standards. Figure 2-5-3 compares the official standards and the company's standards. The company's standards specify more stringent values for pH and suspended solids (SS). The company considers it important that the treated water always satisfy the stricter standards for these items. The company has installed the wastewater treatment unit consisting of the facilities shown in Figure 2-5-4.

Figure 2-5-3 Comparison of Official and Company O's Standards for Wastewater

(mg/liter)

Item	Official standards	Company's standards
pH	5.5 – 9.0	6.0 – 8.0
TDS	3000	3000
SS	50	30
Oil	5	5
BOD	20	20
COD	120	120

Figure 2-5-4 Flow of Wastewater Treatment of Company O



The hot wastewater streams from the manufacturing processes are received in the cooling basin where the water is cooled. The pH values of the wastewater are adjusted and nutrients are added in preparation for biological treatment. Organic compounds in the wastewater are decomposed by the action of microorganisms in the two aeration tanks arranged in series to ensure reduction of BOD. The water is then sent to the thickening tank to settle the sludge of

micro-biological flocs. The supernatant clear water is sent to the effluent pond for holdup as treated water which is sent to the central wastewater treatment unit of the industrial estate, with a portion of water used for spraying on trees. The purpose of the effluent pond is to hold the treated water so that the treated water not meeting the standards, if ever produced, may not be allowed to flow out of the plant. A part of the sludge is recycled from the thickening tank to the aeration tanks and the rest is taken out for incineration.

The plant is charged with the treating fee of the central wastewater treatment unit according to the following unique formula.

Treating fee (Bahts/month)
= 2.55 x effluent water volume (m^3/month) + 6 x BOD load (kg/month)

This equation consists of two elements, one proportional to the effluent water volume and the other proportional to the BOD load. Reduction of either element leads to reduction of the treating fee.

b. Solid Waste Treatment

The waste consists mainly of the solid wastes produced from the manufacturing processes, sludge from wastewater treatment and waste paper from the office. These wastes are burned in incinerator with a capacity of 43 tons/day in the premises. The MOSTE and the MOI have set the standards for the effluent gas from incinerator. The company has set more stringent company's standards in anticipation of tightening of the official standards in future. Figure 2-5-5 compares these two standards.

The company's standards specify more stringent values for TSP (total suspended particulates) and NOx (nitrogen oxides) than the official standards. The design of the stack incorporates a cyclone and a dust collector to attain the standard for TSP and injection of urea into the cyclone to reduce NOx. In addition, a secondary combustion chamber is installed at the outlet of the stack to decompose the excess urea.

Figure 2-5-5 Comparison Official and Company O's Standards for Exhaust Gas from Incinerator

Item	Official standards	Company's standards
TSP (mg/Nm^3)	400	300
SO_2 (ppm)	30	
NOx (ppm)	250	155
Transparency (%) [1)]	20	
HCl (ppm)	136	
Dioxins (ng/Nm^3)	30	

Note 1) The method of the U. S. Environmental Protection Agency is used for measurement.

c. Measures Taken for Noise

The MOI has issued an ordinance on the noise level and tolerable exposure time of workers as shown in Figure 2-5-6.

Figure 2-5-6 Noise Level and Exposure Time

Tolerable exposure time per day	Noise level (db(A))
Less than 7 hours	Over 91
Over 7 hours & less than 8 hours	Below 90
Over 8 hours	Below 80
No exposure	Over 140

d. Environmental Monitoring

The environmental assessment calls for environmental monitoring. The company plans to conduct environmental monitoring more frequently than required by the assessment. Figure 2-5-7 shows the schedule of the environmental monitoring.

Figure 2-5-7 Schedule of Environmental Monitoring of Company O

Item	Location of measurements	Frequency required by the environmental assessment		Company O's own standards	
		Frequency	Measuring organization	Frequency	Measuring method
Wastewater	Outlet of the effluent pond	Once a month	Authorized laboratory	Every minute Once a month	Automatic measurement Manual analysis
Exhaust gas	Stack	Once a month	Authorized laboratory	Every minute	Automatic measurement
Air	Surroundings of the plant	Once a month	Authorized laboratory	-	-
Noise	Plant border Compressor	Once in every six months Four times a year	Authorized laboratory Authorized laboratory	- -	- -

An automatic pH meter was installed at the outlet of the effluent pond to continuously record pH. If an abnormality is found, measures will be taken immediately. Automatic measuring instruments continuously monitor SO_2 and NOx contents of the combustion effluent gas to maintain the operation in normal conditions.

e. Others

The company's business is regarded as one of the fashion industry because the company manufactures a raw material for fibers. Therefore, if the plant is not kept clean, the company will not be able to give a good public impression. The company therefore stresses the importance of sorting-out, tidying-up and cleanup. The plant executes a big cleanup campaign twice a year. The Thai people are well disciplined and cooperative to the company's policy.

The company makes financial contributions to the temple and the activities of community. The Thai have very strong feelings of attachment to their temples. This helps the company to maintain a strong tie with the community.

Case 16 Example of a Salt Manufacturing Process with Minimum Environmental Impact

1) Outline of the Company

Company P Business line: Manufacture of table salt and industrial salt Number of employees: 87 Start of operation: 1989 Location of the plant: Nakhon Ratchasima 300 km to the northeast of Bangkok Japanese equity ratio: 20%

2) Background

In the northeastern part of Thailand, there is a high-quality rock salt formation with purity as high as 98%. There has been salt manufacturing industry in this area since long time ago. Traditionally, nearly saturated brine was pumped up from underground to be poured to salt pans where salt crystals were formed by solar evaporation of water. Such a method of manufacturing salt involves the following environmental problems.

- In the process of concentration of the brine, a portion of mother liquor is discarded to remove undesired impurities. If this mother liquor is discharged to rivers, it would cause damages on the agriculture which uses the river water for irrigation.

- The salt water could unintentionally spill over to give damages to the nearby farms and paddy fields in case of a heavy rain.

- Fresh water is pumped down to the salt formation to be recovered as a rich brine. Since they do not have technology to control degree of dissolution of rock salt, they could excessively dissolve the rock salt to form too big an underground cavity. Naturally, the cavity could collapse and create a cave-in on the ground.

- When the climate is abnormal, they burn firewood to heat the brine to concentrate it by forced evaporation without using salt pans. This requires a large amount of firewood and could lead to forest destruction.

This company used to apply the above method of manufacturing salt; however, the company found it difficult to meet the growing demand for industrial salt as the Thai economic has been growing. The company has decided to construct a plant equipped with a modern salt manufacturing technology, which is environmental-friendly and is not affected by the climatic conditions.

3) Measures Taken by the Company

Since Japan does not have a technology to produce salt from rock salt, the technology was introduced from Europe. Figure 2-5-8 shows the flow of the overall manufacturing process. The plant has expanded four times since 1989 to reach the present capacity of one million tons a year. The pipe wells reaching to the rock salt formation about 200m deep inject water to dissolve the rock salt to form concentrated brine, which is pumped to the ground by other pipes.

To the brine thus brought to the ground are added chemicals for refining to precipitate such impurities as magnesium chloride and calcium chloride in the form of water-insoluble solid compounds. The solid compounds are removed and the remaining refined liquor is condensed by evaporation of water. As the liquor is concentrated, slurry containing crystalline salt is precipitated. The precipitated slurry is dehydrated by centrifuge to obtain the industrial salt. This industrial salt contains moisture at about 2%. Further drying of the industrial salt produces table salt of 99.9 % purity.

The removed solid consists mainly of calcium sulfate and magnesium hydroxide. These are insoluble in water and not harmful to human bodies. The solid waste is generated at a rate of 20 kg per ton of refined salt. The waste is landfilled in a pit, 100m long 50m wide and 3m deep, in a clay formation.

The steam generated from brine evaporation is reheated through adiabatic compression by a compressor as shown in Figure 2-5-9 to be used for heating the brine. The condensate generated from the steam after heating the brine is pumped underground to dissolve the rock salt. This plant does not burn fuel to generate heat but uses heat of compression generated by electric-power driven compressors. Accordingly, this plant does not cause air pollution.

Figure 2-5-8 Flow of the Overall Manufacturing Process of Company P

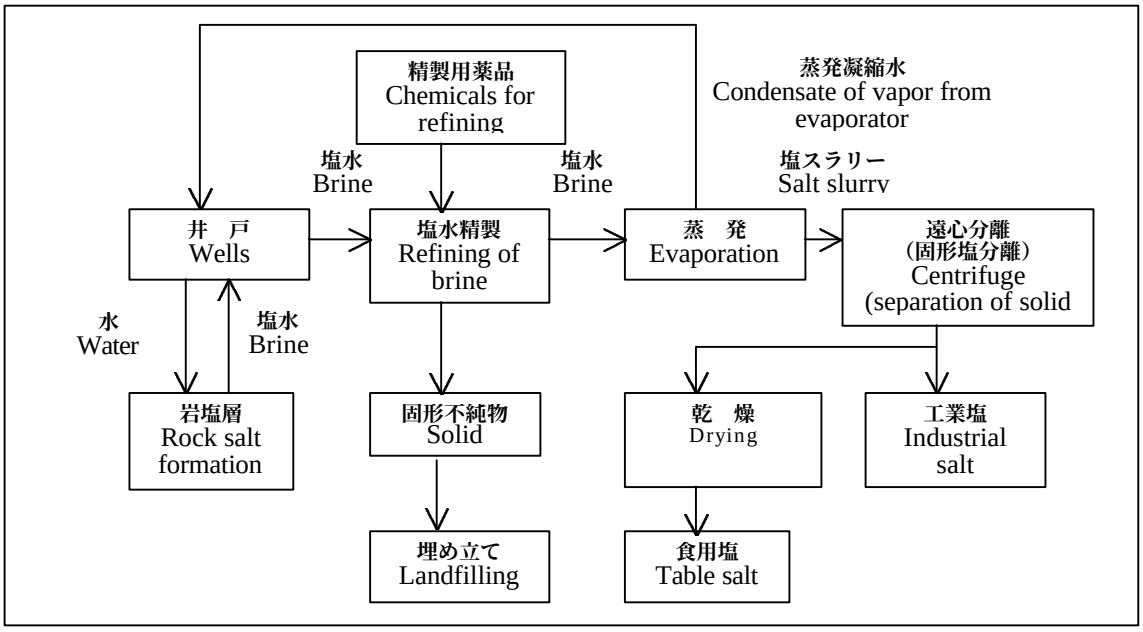
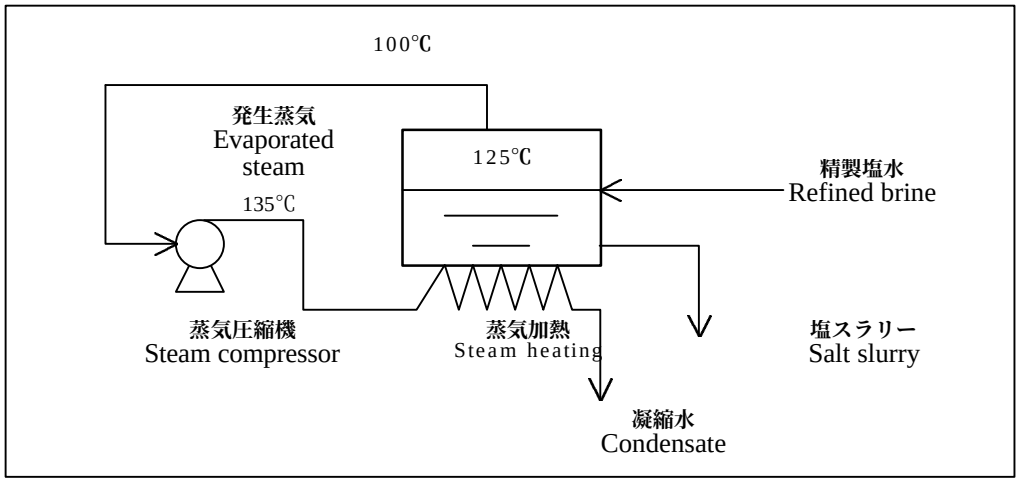


Figure 2-5-9 Process to Evaporate Brine of Company P



Cavities are created in the rock formation where rock salt has been dissolved. If a cavity becomes too large, it could cause a collapse to create a cave-in on the ground. The size of the cavity is measured by an ultrasonic instrument while the brine is pumped up. The pumping is terminated when the diameter of the cavity reaches 80 meters, the maximum tolerable size for not causing collapse.

The water used for dissolving salt is reused and therefore this plant does not discharge wastewater. The plant receives 30 m^3 per hour of river water as a whole including kitchen and sanitary uses. The used river water is filled in the underground cavities and is not discharged. The company plans to plant trees on the land where there was a pit used for disposing of the solid waste, and develop a recreation park there to demonstrate that the solid waste does not have adverse environmental impacts.

The company reports once a year the locations and sizes of the underground cavities to the Department of Mineral Resources of the MOI. The company also reports once a month the analytical results of the solid waste to be buried and water to be used for sealing the cavities to the MOSTE.

The company operates the plant without discharging the mother liquor containing the impurities to the agricultural land, without burning firewood that could cause forest destruction, and without causing collapse on the ground. Such operation of the company has been highly evaluated as non-pollution plant operation. In 1994 the plant was selected by the MOI as a model plant and was awarded a citation of the Prime Minister.