Chapter 1
Overviews of Environmental Issues and Environmental Conservation Measures in Singapore

This chapter is divided into seven sections and provides basic information necessary for Japanese companies to implement appropriate environmental measures in Singapore.

Section 1 gives an outline of Singapore and a short history of the relationship between Singapore and Japan as well as the activities of Japanese companies in the country. Section 2 introduces current environmental issues facing Singapore. Section 3 gives an outline of Singapore's environmental policies, legislation, and the structure of governmental organizations for environmental administration.

Sections 4 through 6 introduce the structure and content of environmental laws and regulations in the areas of water pollution, air pollution, and industrial wastes, which are key environmental challenges for Singapore and also constitute indispensable factors to be taken into account when Japanese companies are implementing environmental measures. Section 7 provides information on noise and soil contamination control measures, and the regulation on Legionella bacteria in circulating water of cooling towers.

The Environmental Pollution Control Act (implemented in 1999 and last amended in 2000) is the basis for the environmental policy of Singapore. Appendix 1 carries its full text. Appendices 2 through 5 contain necessary portions of four pieces of environmental legislation deeply relevant to Japanese companies operating in Singapore.

Section 1
Singapore and Japanese Companies

1. Close relationship between Japan and Singapore centering on economic areas

Singapore, a Small Island Country the Size of Lake Biwa

The Republic of Singapore (hereinafter, Singapore) consists of a main island situated at the southern tip of the Malay Peninsula, extending 42 km from north to south and 23 km from east to west, and more than 60 islands. Its land area is expanding annually through reclamation of land from the sea, and as of 2001 stood at 682.3 km^2 (compared to 639.1 km^2 in 1991). The population is 4.13 million, including foreigners residing in the country for one or more years, and the ethnic composition is Chinese 76.7%, Malay 13.9%, Indian 7.9% and others 1.5%. Located 137 km from the equator, the country has a tropical maritime climate under the effect of monsoons. The climate is generally hot and humid with the average daytime temperature ranging between 24 to 32℃ and the average relative humidity of 80% throughout the year. There is no clear dividing line between the dry and rainy seasons, but the rainy season lasts approximately from November to February, when it is relatively cool and a little more bearable.

The designated national language is Malay, but as the diverse ethnic composition suggests, Chinese, Malay and Tamil are also used as official languages. Since English remains the main medium for business and public administration, the teaching of English is emphasized, and more than half of the Singaporean speak fluent English.

Since the independence from the Federation of Malaysia in 1965, Singapore has adopted a constitutional republic system of government. The parliament is unicameral with its member's term of office of five years. The People's Action Party (PAP), formed by the former Prime Minister Lee Kuan Yew, now has 82 out of a total of 84 seats, serving as a ruling party. Hence, the political situation of the country is very stable.

Since 1819, when Thomas Stamford Raffles of the British East India Company landed in Singapore, the country had been under colonial rule by the United Kingdom for a long period of time, except for three years and half during the Second World War, when the country was a colony of Japan. In 1959, when Lee Kuan Yew took office as prime minister, Singapore acquired autonomy from the United Kingdom and became a self-governing state. Thereafter, when the Federation of Malaysia was formed in 1963, Singapore joined it as one of the self-governing states. When friction subsequently developed between Malaysia that gave preferential treatment to the Malaysian and Chinese-dominated Singapore, Singapore declared independence from the Federation on August 9, 1965 as the Republic of Singapore.

Singapore - The First Country With Which Japan Concluded a FTA

On November 30, 2002, a bilateral free trade agreement (FTA) between Japan and Singapore (officially referred to as the Japan-Singapore Economic Agreement for a New Age Partnership) went into effect. The fact that Singapore became the first country with which Japan signed a FTA indicates a close relationship between the two countries, especially in economic areas. This bilateral agreement is comprehensive arrangements for bilateral cooperation in various fields including not only liberalization of trade and investment and their promotion but also financing, information and communications technology, and human resources development in order to further strengthening the cooperation between the two countries in economic activities. Specifically, it calls for, among others, the abolition of customs duties on items accounting for more than 98% (in terms of value as of 2000) of the trade between the two countries; the computerization of trade documents; mutual recognition of occupational skills, including certifications issued in the counterpart country; more active exchanges of people; the liberalization of service trade in a broader range of sectors; the creation of an investment climate that enables investors of both countries to invest mutually more easily (including lifting the control on overseas remittance of funds); the sharing of various types of information, including that on patent examination. This FTA is expected to make the economic relationship between the two countries closer and help vitalize the two economies.

Business Activities of Japanese Companies Contributing to the Economic Development of Singapore

A noteworthy factor behind the establishment of the close economic relationship between the two countries was the business activities of many Japanese companies that started in the 1960s and became full-blown from the late 1970s to the late 1980s. Particularly in the 1970s, as Japanese assembly manufacturers shifted their manufacturing operations into Singapore in quick succession, their suppliers of materials and parts and logistics-related firms followed suit. Besides the manufacturing sector, various other sectors, including trade, distribution, and commerce, also expanded their business activities in Singapore. These Japanese companies are considered to have made a great contribution to the development of Singapore into an industrially advanced country in the Asian region along with Japan and South Korea.

Singapore is geographically located in a core in the Asian region, and is equipped with advanced infrastructures necessary for business operations, including telecommunications, financial services, and physical distribution. The country also offers various tax benefits to investors. For these reasons, many Japanese companies, as well as multinationals in Europe and the United States, have formed local corporations in Singapore that function as regional headquarters. Most of the Japanese companies operate manufacturing or sales bases alone in other Southeast Asian countries. In contrast, most of the Japanese companies in Singapore are performing the functions of regional headquarters in the Southeast Asian region in varying degrees. Many of them are also playing a role of a model for doing businesses in overseas countries, including approaches to environmental measures.

High Economic Growth of Singapore Through Active Foreign Capital Introduction

The GDP of Singapore, standing at 2.15 million Singaporean dollars in 1960, reached 156 billion Singaporean dollars in 2002, a remarkable 70-fold increase in 40 years. With the GDP per capita reaching 37,400 Singaporean dollars (29,000 US dollars), the country achieved a high economic growth prominent in the Southeast Asian region. The country was suffering from trade deficits and unemployment rates of over 30% at the time of its independence in 1965, and yet achieved such a miraculous growth that is enough to qualify it to join the club of industrially advanced countries. This achievement owes a lot to the economic growth policy vigorously pursued under the leadership of Lee Kuan Yew and the administrative capability of the current prime minister, Goh Chok Tong, who succeed Lee Kuan Yew in 1990.

Under the economic policy, two main pillars of which are the principle of free trade, and the active foreign capital introduction (industrialization based on the introduction of foreign capital), the country opened its domestic market to the world without adopting restrictive trade policies in order to establish itself as an hub of trade ports, and actively invited foreign firms to set up their plants in the country. The national government set up the Economic Development Board (EDB), under which industrial estates were formed one after the other, while social infrastructures such as electricity, city gas, industrial water, and communications were built to ensure smooth operation of seaports, airports, and industrial plants thus attracted.

At the same time, the government endeavored to develop a financial market for promoting more brisk economic activities. In part because Malaysia and Indonesia gave the cold shoulder to people of Chinese origin, Singapore has attracted huge amounts of overseas Chinese capital and come to play a role of a financial center in Asia.

Singapore thus continued to maintain a high GDP growth, average rates of which in real terms were 9.4% in the 1970s, 7.4% in the 1980s, and 7 to 8% even in the 1990s.

Electronics and Chemical Sectors Supporting Singapore's Economy

In 1998, however, Singapore's growth rate in real GDP fell to a negative figure under the influence of decelerated economy within the region due to the Asian currency crisis of 1997. Thereafter, however, the recovery of the Asian economy, worldwide increase in demand for electronic products, and restored domestic consumption helped the country to resume high growth rates: 6.9% in 1999 and 10.3% in 2000.

The manufacturing industry has continued to have the largest influence on Singapore's economic growth. Currently, the electronics and chemical sectors constitute the backbone of the manufacturing industry in Singapore. As of 2002, the electronics sector accounted for 32.3% of the total value added in the manufacturing industry, and the chemical sector 23.8%. These two sectors’ combined share of over 50% in the manufacturing industry indicates their importance. In addition, these sectors accounted for 75% of the total investment made by the manufacturing industry in 2002. Against this backdrop, almost all of the Japanese companies recently started businesses in Singapore belong to either of these two sectors. The Jurong Island chemical complex area hosts many industrial plants established by leading chemical manufacturers of Japan.

The growth rate in real GDP for 2002 was 2.2%, and its 2003 forecast ranges from 0.5 to 2.5%.

Singapore Aiming at Industrial Restructuring and Enhanced Functions as an Asian Hub Spot

Facing tough international competition with China and other countries, the Singaporean government has recently been introducing a series of new industrial policies for the 21st century, including those aiming at industrial restructuring.

In June 1998, the government of Singapore announced a new basic industrial policy entitled “Industry 21 Program.” This Program aims at turning the country into a place where technology- and information-intensive industries are concentrated and making it an Asian hub by helping businesses to enhance their functions as regional headquarters. Specifically, the Program focuses on six areas: (1) strengthening the foundation of the technology- and information-intensive industries, (2) developing world-class local enterprises, (3) pursuing technological innovation, (4) realizing an international business hub (strategic core), (5) inviting regional headquarters into the country, and (6) developing and accumulating human resources.

In January 1999, the Program’s targets for each industry and each industrial sector were also announced. Nine fields (electronics, petrochemical, life science, engineering, educational services, medical services, physical distribution, information, telecommunications and media, and regional headquarters services) were defined as strategic industries, accompanied by their respective visions and 2010 targets.

In addition, the Singaporean government has come out with the policy of developing industries related with life science (pharmaceuticals, medical equipment, agricultural biotechnology) as priority industrial sectors of the 21st century.

Furthermore, in connection with another plan to be pursued in parallel with the restructuring of the manufacturing industry, that is, to turn the country into an Asian business hub, the government has announced a program named “International Business Hub 2000.” This program is applicable to multiple fields such as regional headquarters operations, financial services, physical distribution, transportation, information and communications, electronic trading, international products trading, international conferences and trade shows, and cultural events and art festivals. The program aims at inviting multinational service enterprises to locate their regional headquarters in the country and building advanced, high-quality infrastructures. In support of the program, the Economic Development Board (EDB) uses its certification system for regional headquarters (RHQ) to offer tax and other benefits to certified firms according to the types of their regional headquarters operations. Three types of RHQ are designated: operational headquarters (OHQ), business headquarters (BHQ), and manufacturing headquarters (MHQ), and their respective requirements for certification and possible incentives are defined.

2. Large-scale entry of Japanese companies, mainly manufacturers, into Vietnam, beginning in 1994

A Large Share of Japanese Investment in Singapore

One of the reasons why Singapore, despite its small land area, small population, and limited natural resources, achieved the economic development prominent in the Asian region is the active introduction of funds and technology from Japan, Europe, and North America. In particular, Japanese companies, mainly those in the manufacturing industry, have played an important role through direct investment in the country, which began in earnest in the late 1970s. In addition, through technology transfer, they also supported Singapore's economic growth when the country was still in the developing stage.

The amount of direct investment by Japanese companies in the manufacturing industry of Singapore was 1,513 million S dollars (approximately 105.9 billion yen) in 2003 according to the Economic Development

Board (EDB) of Singapore.

The largest direct investor in the manufacturing industry of Singapore is the United States, followed by the EU. Japan is the third largest. The amount of direct investment from Japan, after peaking at 20.32 million S dollars in 1997, continued to decline, and it was surpassed by that of the EU in 2000, falling to the third place, due to the stagnation of the Japanese economy and other factors. However, the signing of the FTA between Japan and Singapore, earlier mentioned, is expected to contribute to increasing trade between the two countries. It will also help expand mutual investment between the two countries thanks to deregulation in the service sector such as transportation and physical distribution, so that the direct investment by Japanese firms will no doubt begin to rise again.

In terms of trade value, Japan is an important trade partner of Singapore along with Malaysia and the United States. In 2001, Japan was the fifth largest destination of export from Singapore (7.7% in share), and the third largest origin of import to the country (13.9% in share). Exports to Japan totaled 16.7 billion S dollars and imports from Japan 28.8 billion S dollars, resulting in a trade imbalance with Japan of 12.1 billion S dollars. Anyway, Japan accounts for very large shares in Singapore's international trade values.

Against these marked economic interchanges, Japanese residents living in Singapore as of 2002 numbered approximately 20,000, the majority of which were personnel of Japanese companies and their families. This figure is the second largest in the Southeast Asian region after about 22,000 Japanese residents in Thailand.

Drastic Change in Business Lines of Japanese Companies Operating in Singapore

Japanese companies that have hitherto worked as an engine for promoting the close economic relationship between the two countries totals 763, including representative offices in non-manufacturing sectors, according to the number of members of the Japanese Chamber of Commerce & Industry, Singapore. By line of business, about half of them (52%) are in the manufacturing sector, and the rest are in transportation and service (20%), international trade (13%), finance and insurance (7%), construction (6%). The number of Japanese companies incorporated in Singapore started to increase sharply in the first half of the 1970s and peaked at 173 in the later half of the 1980s. But in the 1990s, they started to decrease gradually. In fact, the number of members of the Chamber, after reaching a high of 833 in 1998, is decreasing, probably because Japanese companies, especially those in the manufacturing sector, are diversifying their operations into neighboring countries such as Malaysia, Thailand, and Indonesia. The shift of new business operations to China would be another reason. However, the number of member companies in Singapore is still the largest in the Southeast Asian region along with the corresponding one in Thailand, indicating brisk business activities of Japanese companies in Singapore.

Representative Japanese manufacturing companies operating in Singapore used to be assemblers of electrical appliances and audio-visual equipment, but because of their operations being relocated to neighboring countries of low labor costs, this position is now taken over by chemical and electronics businesses as mentioned earlier. This remarkable change has occurred in the past ten years or so. A factor especially contributing to the change occurred in 1995 when the Singaporean government, through the Jurong Town Corporation, a government affiliated industrial estate developer, began to claim land from the sea off the Jurong Island in an effort to accumulate petrochemical complexes in the Island and make it a large-scale petrochemical base in the Southeast Asian region. The Jurong Town Corporation actively invited related enterprises to locate themselves in the Island. In response, leading Japanese chemical manufacturers shifted their operations to the Island, and there are many of their plants located there, which started operations in the latter half of the 1990s.

JETRO conducts an annual survey of operations of Japanese manufacturers located in the Asian region. According to the 2001 survey conducted between November and December 2001, 135 Japanese manufacturers operating in Singapore responded. Their lines of business break down into electrical and electronic parts (23.0%), chemical and petrochemical products (17.8%), foodstuffs and processed agricultural and marine products (8.9%), metal products (7.4%), electrical machinery (7.4%), and plastic products (6.7%). The high share of electrical and electronic parts is similar to that in other Southeast Asian countries. Features of Singapore include a relatively high share of chemical and petrochemical products and the absence of fibers, apparel, other textile goods, cars and motorcycles, reflecting the fact that labor costs in Singapore are too high for labor-intensive industries.

Future Development of Singapore

One fact often cited as the reason for Japanese companies to start businesses in Singapore is its highly developed social infrastructures that make up for rises in manufacturing costs, including wages. In the Asia-Pacific region, however, China (Shanghai and Beijing), Thailand, and Malaysia are rushing to improve the tax systems and infrastructures in order to follow the Singaporean pattern of economic development. These moves on other Asian countries will without doubt place Singapore in a difficult position for it to be selected as a new location of Japanese and other foreign companies. Nevertheless, according to surveys by international think tanks, Singapore ranks fifth in the world in terms of industrial competitiveness (a result announced by IMD, the International Institute for Management Development) and overtook Hong Kong to become the country offering the best business environment in the Asia-Pacific region (Country Forecast announced by EIU, the Economist Intelligence Unit). Doubtless, Singapore is an attractive place to invest in by international standards. The companies interviewed during this on-site survey also cited well-developed infrastructures, quality labor (high levels of technical skills, proficiency in English), the stability of the national government, the flexibility of the administration (bureaucracy) to meet the needs of the private sector as reasons for having selected Singapore as the place to invest in. In the future, Japanese companies will be required to conduct business activities fulfilling the expected functions of the technology- or knowledge-intensive enterprise or an international business hub, in line with the "Industry 21," the new basic industrial policy of the Singaporean government as mentioned earlier. On the other hand, in order to meet the competition with the expanding Chinese market, the Singaporean government will be required to further develop infrastructures in terms of both hardware and software while making the most of its advantages; the central location in the Asian region, and the existence of a huge market where 2.8 billion consumers live within the distance accessible in less than seven hours.

Section 2
Current Environmental Issues in Singapore

1. Successful simultaneous pursuit of economic development and environmental protection in Singapore

Singapore Maintaining Good Living Environment

Singapore has achieved high economic growth through the free trade policy and active introduction of foreign capital while successfully maintaining a favorable living environment. A recent annual report issued by the Ministry of the Environment (ENV) and the National Environment Agency (NEA), the latter being responsible for enforcing environmental legislation under the Ministry, state at its beginning as follows. "Singapore has succeeded in simultaneous pursuit of economic development and environment protection, providing people with a favorable living environment and a high-quality public health by the world's standards." This is a statement that praises oneself on its success in environmental management. Considering the fact that neighboring countries in the Southeast Asian region are suffering from serious environmental pollution caused by economic growth, Singapore is unique in this region in that it is developing the economy while maintaining a favorable living environment.

One reason for this success in environmental management is that Singapore has carried out various environmental policies proactively since the initial stage of rapid economic growth and industrialization. The country's environmental management policy consists of three strategies: pollution prevention, law enforcement, and environmental monitoring. Specifically, the pollution prevention measures include industrial location based on land utilization programs and the building and improvement of environmental infrastructures, including sewer systems and waste disposal facilities. The law enforcement measures include the improvement of environmental administrative organizations, tightening of environmental legislative control and the application of such tightened control to regulate industrial facilities and other sources of environmental pollution. The environmental monitoring measures include the establishment and operation of monitoring systems for air, water, and other environmental qualities. Singapore has implemented these measures in the past 30 years or so. The results of these measures are effectively combined into a comprehensive environmental approach, and this enables Singapore to maintain a favorable living environment.

New Approaches Toward Sustainable Society

Singapore's economic development has increased per capita national income and made mass-production, mass-consumption, and mass-generation of wastes common aspects of the people's lifestyles. These lifestyles, which reflect material affluence, are highly likely to impose environmental risks on Singapore, a small island country with few natural resources. In an effort to avoid these risks, the Singaporean government has started to take a next environmental management step to realize a sustainable society. To this end, the “Singapore Green Plan” was first formulated in 1992, which incorporated various strategies for realizing a sustainable society. The current version of the Green Plan, with 2002 as the target year, calls for further reduction of environmental loads from industry through the utilization of green technology and the development and promotion of environmental technology. The Plan aims at preserving the natural resources by measures such as (1) fresh water generation by desalination of seawater and reclamation of water from sewage with the latest technology, (2) promotion of reduction and recycling of wastes, and (3) the raising of energy efficiencies. Efforts have already been initiated toward these goals. At the same time, the government requires business enterprises to establish management systems that incorporate environmental consideration, and the general public to raise their environmental awareness. In order to help them with these efforts, various incentive programs are being implemented.

Unlike other countries in the Southeast Asian region, Singapore is equipped with necessary funds, technology, and administrative capacity and will continue to maintain a favorable living environment and improve its quality. However, the success so far achieved in environmental management was largely dependent on the strong initiative of the government. In contrast, for example, most of the general public has no practice of separating domestic garbage. Many challenges still remain to be met toward realizing a sustainable society.

The subsequent sections introduce three main environmental problems in Singapore - water pollution, air pollution, and wastes - as they now stand, and present an outline of the measures being taken against those problems.

2. Water pollution

Excellent Water Environment in Each Water Body

Singapore has been a country short of water resources, meeting half of its water demand by purchasing water from neighboring Malaysia, and is much interested in water environment. For this reason, preservation of water quality is given high priority in environmental administration, and active efforts are being made to build sewage facilities as well to implement effective wastewater control.

In order to monitor the water environment in Singapore, bodies of water are divided into three: the water catchment area, where there are rivers and ponds that are used as supply sources of drinking water; the non-water catchment area; and the coastal waters. Many water quality monitoring points are installed at these bodies of water to measure dissolved oxygen (DO), biochemical oxygen demand (BOD), total suspended solids (TSS) and the like at regular intervals. The 2001 evaluation of water quality against the water quality control targets in Singapore (for example, 10 mg/liter or less for BOD) produced very good results. 92% of the water samples taken from the water catchment area and 94% of those from the non-water catchment area met the BOD target. The results of measurement on DO, TSS and other items were similar. Seawater from the coastal waters, evaluated in terms of coliform groups, also gave a good result: over 90% of the samples met the target.

Building of Public Sewer systems Contributing to Maintaining Good Water Quality

The largest reason for the maintenance of good water quality is the progress made in the construction of public sewer systems. In Singapore, wastewater, both domestic and industrial, is treated basically in public sewer systems. There are now six sewage treatment plants. Sewage conduits extend over approximately 2,800 km. 489 million m^3 of sewage was treated in 2000. With expansion and improvement of the public sewer systems, and progress in laying sewage conduits, the amount of sewage treated is increasing annually. It increased by as much as 43% in the ten-year period from 1991. For further improvement of public sewer systems, a plan was drawn up to build a new sewage treatment plant in each of the eastern and western parts of the Singapore Island. Construction work of the deep tunnel sewer system, a new sewage conduit network for connecting with the new treatment plants, is already underway.

Industrial wastewater accounts for a large part of the loads contributing to water pollution, and is under thorough control by the Pollution Control Department (PC) of NEA. Industrial plants that may discharge acidic wastewater giving adverse effects on sewage facilities are obligated to install a pH meter at the exit of wastewater and a wastewater shutoff device interlocked with the meter. Plants located in an area where no public sewer system is available are placed under more stringent wastewater control than those discharging wastewater into public sewer systems.

3. Air pollution

Air Quality Management Also Remaining Good

Major sources of air pollutants in Singapore are stationary ones such as industrial plants, and mobile ones such as cars, but like water quality, air quality is also well under control.

In Singapore, a total of 17 air pollution monitoring stations are installed in the general living environment like residential areas and along roads, and air quality is constantly monitored. The 2001 results of measurements by these stations indicate that the concentrations of major air pollutants such as sulfur dioxide (SO_2), nitrogen dioxide (NO_2), and particulate matter (PM10) in the general living environment are well below the air environmental standards of the United States Environmental Protection Agency, which are also applied in Singapore. For example, the average annual value of SO_2 is 22 μ g/m^3 compared to the American standard of 80 μ g/m^3, and that of PM10, 20 μ g/m^2 against 50 μ g/m^2.

In order to control lead contained in exhaust gas from cars, measures for reducing it were implemented step by step beginning in 1983. In July 1998, a total ban on leaded gasoline was imposed. Thanks of the effect of this ban, the average annual concentration of lead for 2001 was very low at 0.1 μ g/m^3 both in the general living environment and along the roads.

The Pollutant Standards Index (PSI), developed by the U.S. Environmental Protection Agency and used by Singapore for the evaluation of air pollution, indicates "GOOD" for 305 days, 83% of the 365 days in 2001.

Unique Air Pollution Control Measures Proving Effective

Singapore has a detailed land utilization program and a unique policy of industrial location under this program. Firms in lines of business that may give large air pollution loads as well as large-scale industrial plants are ordered to locate in the industrial estates at the western edge of the Singapore Island or in the offshore reclaimed land areas to avoid adverse effects on the air quality in residential areas.

Thorough implementation of air pollution control measures at individual plants and obligated use of fuels of small environmental loads are also very effective at stationary sources of air pollutants. Another source of air pollutants, exhaust gas from cars, is dealt with by implementing stringent exhaust gas control on individual cars, modeled after the EU's exhaust gas control. In addition, this pollution source is indirectly dealt with by limiting the total number of cars through limited issuance of the Certificate of Entitlement (COE), a unique car purchase certificate system of Singapore, and also by limiting car traffic through the introduction of a road pricing scheme.

4. Waste

Annually Increasing Wastes

With greater industrial activity and rising national income, the volume of wastes generated in Singapore is annually increasing. Figures compiled by NEA indicate that the total volume of solid wastes generated in 2001 was 5,035,415 tons, of which 44.4% or 2,233,232 tons were recycled in some way. Remaining 2,802,183 tons are disposed of mainly by incineration. 42% of the 2.802,183 tons were industrial wastes, and remaining 58% were domestic wastes including those from commercial establishments.

Most of Wastes Disposed of by Incineration

In Singapore, wastes are disposed of mainly by incineration considering its small land area and economic cost. Four incineration plants, including the up-to-date Tuas South Incinerating Plant, are in operation. An additional one is being planned. At present, about 91% of the wastes incapable of recycling are disposed of by incineration. Final landfill disposal had been conducted at the Lorong Halus site. But since this site became full, a new offshore disposal site (Pulau Semakau Final Landfill Disposal Site) was constructed by means of reclaiming land from the sea between the islands of Pulau Semakau and Pulau Sakeng off the southwestern coast of the Singapore Island. In April 2000, the new site started to accept wastes incapable of incineration and incinerator ash generated at the four incineration plants. These waste treatment and disposal facilities have a treatment capacity exceeding annual 2.80 million tons of wastes generated in the country, and are capable of treating and disposing of all of this volume.

NEA operates and manages these treatment and disposal facilities. Private enterprises licensed by the Singaporean government collect wastes for delivery to these facilities.

In order to reduce, reuse and recycle wastes, the Singaporean government is implementing various incentive programs. In addition, it has begun to direct its efforts to the development of so-called Reverse Logistics industry that recycles wastes back to useful materials. The Singapore Green Plan, mentioned earlier, lists targets to be achieved by around 2012, which include (1) to raise the recycling rate from the present 44% to 60%, (2) to extend the usable years of the final landfill site at Pulau Semakau, now expected to be about 30 years, to 50 years, and (3) to delay the implementation of construction plans for incinerating plants.

Private Sector Responsible for Treating Hazardous Industrial Wastes

Issues related to hazardous industrial wastes can have a great effect on the activity of Japanese companies.

Laws and regulations of Singapore stipulate 26 categories of hazardous industrial wastes. Private enterprises licensed by the Singaporean government are responsible for the collection, transportation, treatment, and disposal of these hazardous industrial wastes. About 120 enterprises have acquired some form of business license for the treatment of hazardous industrial wastes. Some of them are engaged in transportation only, while there are several companies that perform all the operations up to final disposal under contract. All of the licensed enterprises have the capacity to handle hazardous industrial wastes as stipulated by applicable laws and regulations. Under normal circumstances, therefore, hazardous industrial wastes can be disposed of by contracting with these licensed enterprises.

According to data compiled by the government, the licensed enterprises collected and disposed of about 121,500 tons of hazardous industrial wastes in 2000.

Section 3
Environmental Policies and Legislation in Singapore

1. Singapore's environmental policies, and laws and regulations

(1) Development of environmental policies and their features

Land Utilization Program Playing an Important Role in Environmental Control

The rapid economic development and industrialization in the past 30 years or so have enabled Singapore to become one of the world's most advanced countries in economic terms. While doing so, the country was successful in maintaining a favorable living environment known as the "garden city." The successful simultaneous pursuit of economic development and environment protection is attributable to the fact that the country's environmental management policy has ingeniously combined the following three elements indispensable for environmental protection from the early stage of economic development: establishment of pollution prevention measures, enforcement of environmental laws and regulations, and environmental monitoring.

It goes without saying that the simultaneous pursuit has owed much to the enforcement of environmental laws and regulations, including the implementation of highly effective environmental rules as mentioned later, and the efficiency of environmental administrative organizations. The establishment of environmental monitoring systems has also played an important part. But the greatest role has been played by the national land utilization program, which was formulated considering environmental protection and implemented as part of the establishment of pollution prevention measures. This land utilization program zones the national land according to the purpose of utilization and has played the role of preventively eliminating adverse environmental effects of new development projects. The program requires new individual factory construction to undergo environmental investigation in advance. Based on the information thus obtained, locations of factories are thoroughly controlled. This mechanism incorporated in the program has been extremely effective for environmental protection. In addition, the proactive approach to the development of environmental infrastructures indispensable for preventing environmental pollution, including sewage and waste treatment plants, has been very useful in the maintenance of a good living environment.

The land utilization program is supervised by the Ministry of National Development (MND). The first master plan was formulated in the 1950s. The program, reviewed at regular intervals thereafter, precisely zones the national land into nature reserve, green zone, residential area, industrial area, and others according to the purpose of utilization. In each zone, it is prohibited to locate facilities other than those for the purpose specified for that zone. For the industrial area, a detailed location plan is drawn up for each factory according to its line of business, the degree of environmental loading, and the possibility of environmental pollution as determined through a prior environmental investigation. Factories with similar characteristics are located in a specified area. Thus, factories are included in the total picture of national land use, and are constructed in a manner that ensures environmental harmony with neighboring areas. In this way, even if a factory caused environmental pollution, the environmental effect would be limited.

When building a factory in Singapore, a parcel of national land must usually be borrowed from the Jurong Town Corporation (JTC, a government affiliated industrial estate development organization), the Housing and Development Board (HDB), or other agencies. Upon application for a building permit with one of these organizations, an investigation is conducted for possible environmental effects caused by locating the factory at a specific site. This environmental investigation is conducted under the guidance of the National Environment Agency (NEA). Based on the result of the investigation, the location of the factory is determined. For example, assembly or processing factories of small environmental loads are located in an industrial area near a residential area. Industries of large environmental loads such as oil refining and chemical plants are located in a place remote from a residential area, or in some cases, in an island off the mainland such as the Jurong Island. In this process, careful consideration is given to the characteristics of the line of business of a factory in question. For example, foodstuff and asphalt factories are not located next to each other.

Green Plan Giving Future Vision of the Environment

By effectively using these schemes, Singapore had almost completed implementing basic pollution control measures by the late 1980s. But in order to initiate new approaches to environmental problems for securing sustainable development, the country formulated the “Singapore Green Plan 2002” in 1992. This Plan was triggered by the Earth Summit held by the UN Environmental Development Council in Rio De Janeiro, Brazil. Although it is not a piece of legislation, the Plan was intended to be the basis for environmental action programs to be implemented by Singapore for further improved environmental quality and sustainable development within the next ten years. The Plan gives numerical targets for each area of concern, including the protection of natural resources and the development of environmental technology, to show a future vision of the environment in the country. In 2002, the “Singapore Green Plan 2012” was formulated setting forth targets for the next ten years. The Plan presents a blueprint for environmental policy with 2012 as the target year. It includes numerical targets such as (1) to raise the recycling rate for all wastes from 44% to 60%, (2) to convert 25% of power plant fuels to natural gas, (3) to meet 25% of water demand by desalination and recycling of wastewater, and (4) to introduce advanced environmental technology for the environmental management of industry. In order to achieve these targets, various programs and incentive measures are currently being implemented.

Flexible Environmental Control Considering Effects on Industrial Activity

While implementing the above-mentioned very effective environmental control, Singapore, with economic development as an important national policy, is also taking flexible environmental measures that relax environmental control within certain frameworks, in order to prevent environmental control from stagnating industrial activity. For example, wastewater that does not meet the standard is supposed to require the installation of a wastewater treatment facility. However, for non-hazardous, organically polluted wastewater up to 4,000 mg/liter in biochemical oxygen demand (BOD) concentration, the standard may be exceeded by paying a surcharge according to the concentration exceeding the control limit. A similar economic solution is applied to wastewater exceeding the control limit for total suspended solids (TSS).

Moreover, in order to shorten the period required for the environmental investigation commenced on application for a building permit, it is made possible to obtain a permit to proceed to the design stage in about two weeks if there are no particular problems. The implementation of such environmental policy giving full consideration the effects on the industrial activity as well as those on the environment is a distinguishing feature of Singapore's environmental administration.

Another example of flexible approaches is that, when revising environmental legislation and wastewater standards, the authorities concerned frequently consult with the industry involved from the drafting stage. With the consent of the industry, the authorities proceed with the revision. This also indicates that Singapore attaches importance to the industrial activity in implementing its environmental policy.

Sophisticated Environmental Measures Implemented in Parallel With Economic Development

Singapore has succeeded in maintaining a good environment while steadily achieving environmental management goals and developing economically. This is a feature totally unlike in other Southeast Asian countries, where the priority is placed on economic development and environmental measures tend to be taken belatedly. Singapore has been successful in implementing sophisticated environmental policies. Various environmental measures as mentioned above have been taken in parallel with economic development from its early stage. Singapore's environment administration will continue to implement very effective environment control. At the same time, as described in the Singapore Green Plan 2012, the development and introduction of latest environmental technologies, including the green technology, is listed as one of the priority goals.

Since the latter half of the 1990s, the Singaporean government has been requesting private enterprises to establish environmental management systems such as those certified by ISO 14001, and extending assistance toward this end. This indicates that the government is shifting away from the old industrial environmental policy that aimed at achieving environmental protection through the administrative control to the new policy that intends to realize a sustainable society through voluntary, high-quality environmental action on the part of private enterprises.

(2) Singapore's Environmental Administrative Organization

Start of NEA in July 2002 for Prompt Response to Environment Problems

In Singapore, the Pollution Prevention Agency was formed in 1969, and the Ministry of the Environment (ENV) was established in 1972 for the purpose of providing a clean living environment and high-quality public health. For about 30 years since then, ENV has been in charge of actual operations of environmental policy and environmental control. In July 2002, the National Environment Agency (NEA) was split off from ENV for more stringent environmental control and more effective, prompt environmental management. Taking over part of the responsibility of ENV, NEA is now in charge of daily environmental control over air, water, and other pollution, public health, and waste treatment and disposal.

NEA was formed by merging the Environmental Policy and Management Division and the Public Health Division of ENV, and the Meteorological Division of the Ministry of Transpiration. NEA's operating budget is basically financed by subsidies from ENV and in this sense, it is subordinate to ENV. But NEA is a comparatively independent administrative organization in that it may distribute and execute its budget at its discretion. For this reason, national environmental administration has become more flexible than before when internal organizations of ENV were in charge and the budget was executed within the national framework. NEA is thus more capable of promptly responding to emergencies such as environmental accidents. Since the split-off of NEA, ENV has been in charge of making decisions on national environmental policies, including the formulation of the Green Plan as a national environmental program, and legislation and rules for environmental protection.

The scope of work of NEA is very broad, and includes the monitoring of the general living environment; implementation of various environmental control; management of environmental pollution control measures in the execution of development projects and construction of factories; operation and control of waste treatment facilities (incinerating facilities, landfill sites) and issuance of related permits; control of food sanitation; environmental cooperation with neighboring countries; and weather forecasting added as a new job. NEA consists of seven sub-organizations such as the Environmental Protection Division and the Environmental Public Health Division. NEA's present workforce totals about 3,000, including site workers of waste treatment facilities.

PCD in Charge of Actual Environmental Control

Of various sub-organizations of NEA, the Pollution Control Department (PCD), under the Environmental Protection Division, is influential in implementing industrial environmental measures. With about 130 personnel, PCD is basically the successor to the internal organization with the same name formed in ENV in 1986. Entire staff members of the previous organization were taken over by PCD, along with its scope of work, when NEA was set up. PCD's main jobs include actually implementing environmental control over stationary sources of pollutants, like factories, with regard to air and water pollution, hazardous industrial wastes and the like, and issuing related permits; and environmental assessment of new development projects and factory construction plans. For these jobs, the Inspectorate Unit and the Central Building Plan Unit are established in PCD.

The Inspectorate Unit conducts an on-site inspection of factories for waste gas, wastewater and other wastes discharged from them at regular and irregular intervals, and warns against or points out any violation or problem, instructing the factory in question to take appropriate action. It is also in charge of issuing a business license to firms engaged in collection and transportation of hazardous industrial wastes.

The Central Building Plan Unit investigates the degree of environmental loading of a planned factory and the content of its environmental measures upon application for a building permit for the factory, and determines whether or not to approve the environmental aspects of the construction plan.

The Engineering Service Department, under the Environmental Protection Division, is also in charge of the treatment, disposal, etc. of wastes and is closely related to industrial environmental measures. Its jobs include operation and management of four incinerating facilities for domestic wastes, like the latest Tuas South

Incinerating Facility, and waste treatment and disposal plants, like the final landfill site at Pulau Semakau, constructed off the southwestern coast of the Singapore Island; and issuance of business permits to collectors of domestic wastes. Incidentally, neither NEA nor PCD has their own regional offices or branch offices because of the small national land. Their personnel in the central office, grouped according to geographical areas, visit the factory in question for an on-site inspection or other work.

Figure 1-3-1 Organizational Structure of the National Environment Agency

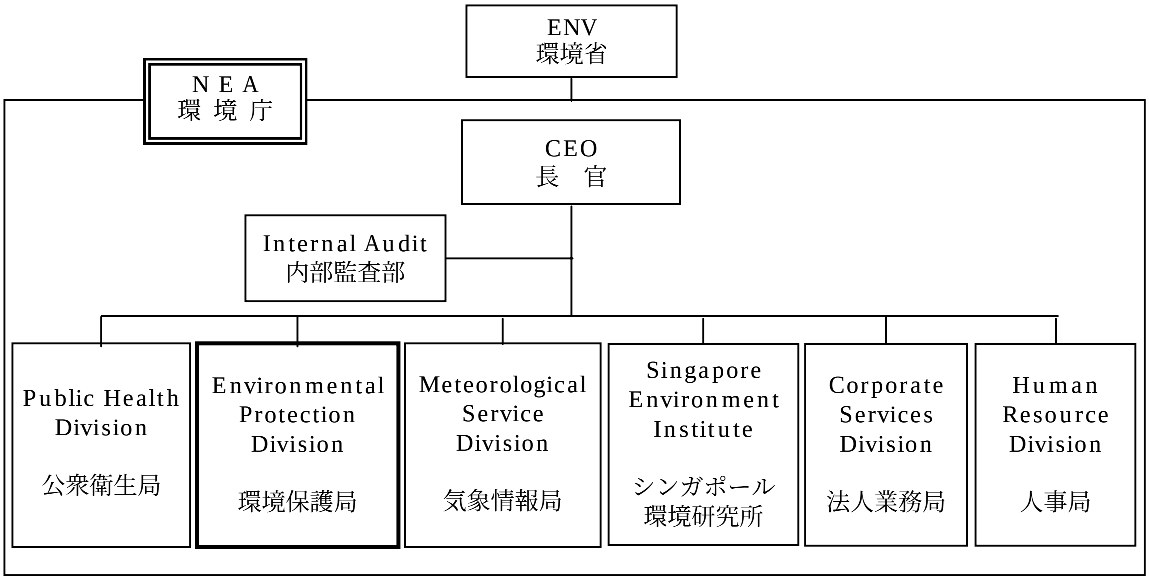


Figure 1-3-2 Organizational Structure of Environmental Protection Division

<u>Environmental Procedure for Factory Construction Through JTC, Etc.</u>

Other government agencies are also involved in environmental policy. In cooperation with the National Environment Agency (NEA), the Economic Development Board (EDB) introduces information on environmental control of Singapore to foreign investors. The Jurong Town Corporation (JTC) and the Housing and Development Board (HDB), both in charge of creating and operating industrial estates, serve as the point of contact through which the environmental aspects of the procedures for application for a building permit for a factory are performed. The Ministry of National Development (MND) and its subordinate organization, the Urban Redevelopment Authority, formulate long-term land utilization programs and their detailed regional plans. The Public Utilities Board (PUB), under the Ministry of the Environment, is in charge of environmental infrastructures, such as public sewer systems and water supply facilities. The Ministry of Manpower holds jurisdiction over working environment control within factories. The Singapore Standards, Productivity and Innovation Board (SPRING), under the Ministry of Trade and Industry (MTI), provides private enterprises with various incentive programs for establishing environmental management systems.

Thus, in Singapore, NEA, operating mainly through the Pollution Control Department under it, plays the leading role in implementing environmental measures, in cooperation with other government organizations. NEA's administrative ability is so high that Singapore has become the only country in Asia, except for Japan and South Korea, that can ensure effective environmental control comparable to those of Europe and the United States.

(3) Environmental Legislative Control Over Industrial Pollution in Singapore

<u>Environmental Pollution Control Act at the Center of Environmental Legislative Control</u>

Singapore's system of legislation, based on that of its former colonial master country, the United Kingdom, consists basically of two main pillars; acts, formulated in each field as required, and their accompanying regulations, although detailed rules may be issued in the form of orders or notifications. Likewise, the subsystem of environmental legislation is rationally composed of acts and regulations under them. Although there is the Green Plan as mentioned earlier, Singapore has no basic environmental legislation incorporating ideals and overall policy for dealing with environmental problems, like the Basic Environmental Law in Japan or similarly positioned legislation that exists in other Southeast Asian countries.

Environmental control over industrial pollution is basically executed by applying the Environmental Pollution Control Act (EPCA), the Environmental Public Health Act (EPHA), and a number of regulations under them. Of these control measures, those over environmental problems, including air pollution, water pollution, wastes, and noise, are mostly executed by applying regulations based on EPCA. But attention also needs to be paid to the control executed by applying the Sewer and Drainage Act, the Sewerage and Drainage (Trade Effluent) Regulations under the Act, and the Environmental Public Health (Toxic Industrial Waste) Regulations under EPHA.

There is no legislation for environmental impact assessment in Singapore because the master plan for land utilization is drawn up and development work is performed under land utilization programs formulated based on the plan considering environmental balance.

There are no environmental standard indicating desirable levels in the general living environment. For example, in order to evaluate air quality in the general living area, standards of the World Health Organization (WHO) and the US Environmental Protection Agency are applied.

Table 1-3-1 Environmental Legal Documents

Legal Documents on Environmental Pollution Control
Environmental Pollution Control Act (Chapter 94A) (Revised Edition 2000)
Rg 4 Environmental Pollution Control (Hazardous Substances) Regulations
Rg 5 Environmental Pollution Control (Trade Effluent) Regulations
Rg 8 Environmental Pollution Control (Air Impurities) Regulations
Environmental Public Health Act (Chapter 95) (Revised Edition 1999)
Rg 11 Environmental Public Health (Toxic Industrial Waste) Regulations
Sewerage and Drainage Act (Chapter 294) (Revised Edition 2001)
Rg 5 Sewerage and Drainage (Trade Effluent) Regulations

Implementation of EPCA Unifying Environmental Legislation

The Environmental Pollution Control Act (EPCA), the mainstay of environmental control, was enacted in April 1999 to unify environmental legislation established in individual environmental fields in the 1970s, including the Clean Air Act, the Water Pollution Control and Drainage Act, and the Poison Act. EPCA is primarily intended to implement control over air pollution, water pollution, noise, and hazardous chemical substances, and carries penal provisions, and provisions for the issuance of various permits, and scopes of authority of environmental government agencies. Under EPCA, supplemental regulations were established stipulating specific standard control values and the like. There are nine regulations that are deeply related to industrial pollution controls. They include the Environmental Pollution Control (Air Impurities) Regulations, the Environmental Pollution Control (Trade Effluent) Regulations, the Environmental Pollution Control (Hazardous Substances) Regulations, and the Environmental Pollution Control (Boundary Noise Limits for Factory Premises) Regulations.

EPCA also has provisions for so-called “Scheduled Premises” in connection with air pollution prevention. Facilities in fourteen lines of business are designated as scheduled premises, which include cement and asphalt plants of large environmental loads. In order to build such facilities, NEA's permit is required in addition to going through other ordinary environmental procedures. The permit is issued based on detailed information on environmental measures to be taken. In connection with soil pollution, which has recently become an issue in Japan, EPCA also includes one statement that "if a tract of land is polluted or is likely to be polluted, the Minister may formulate a regulation for controlling such pollution." At present, there is no specific regulation that controls soil pollution. But the Code of Practice on Pollution Control, to be described later, carries a requirement for controlling soil pollution in anticipation of future regulations on the matter.

After the implementation of EPCA in 1999, the Environmental Pollution Control (Air Impurities) Regulations were revised in 2001. At present, the Environmental Pollution Control (Trade Effluent) Regulations, which contain standards for wastewater discharged to the environment other than public sewer systems, is under revision.

Sewerage and Drainage Act and Subsequent Drainage Regulations Also Playing Important Roles

Other than the Environmental Pollution Control Act (EPCA), the Sewerage and Drainage Act and the Sewerage and Drainage (Trade Effluent) Regulations under the Act are the most important legislation for industrial pollution control. They give acceptance standards, etc. for wastewater discharged into public sewer systems as mentioned earlier. Public sewer systems are extensively installed all over the country so that almost all industrial wastewater is discharged into public sewer systems. Therefore, in practice, almost all industrial wastewater is controlled by applying the Sewerage and Drainage Act and the Regulations under the Act.

Hazardous industrial wastes are controlled by applying the Environmental Public Health (Toxic Industrial Waste) Regulations formulated under the Environmental Health Control Act (EPHA). This is because wastes and their collection and disposal had long been controlled under the Public Health Act, and hazardous industrial wastes alone remained to be regulated within the framework of the Environmental Health Control Act (EPHA) even after the enactment of EPCA.

While these Acts and Regulations are not under jurisdiction of the Ministry of the Environment (ENV), actual work based on them is conducted by the Pollution Control Department (PCD) of ENV, and the important role played by it in Singapore cannot be ignored.

Control on Legionella bacteria in cooling towers is regarded as an environmental control unique to Singapore. This control has been implemented based on EPHA since 2001, and intends to prevent the multiplication of Legionella bacteria in circulating water of cooling towers commonly used in various factories for air conditioning or in manufacturing processes. Factories are obligated to establish structural and maintenance standards for cooling towers and to measure circulating water of cooling tower for Legionella bacteria at regular intervals. Many of the Japanese companies visited during this survey have complied with this obligation.

Statements in the Code of Practice on Pollution Control That Need Careful Consideration

For the convenience of users of legislation, reference materials named Code of Practice are published in Singapore. These materials summarize and explain various pieces of legislation relevant to a certain field. Its environmental version is the Code of Practice on Pollution Control. These materials are prepared to help the reader to get a better understanding of regulative measures spanning several acts and regulations, and as such they are by no means either an act or regulation itself. It should be noted, however, that certain statements in the Code of Practice may in effect become virtual regulations, obligating factories to comply with such statements as guidelines.

The Code of Practice on Pollution Control explains pollution prevention requirements as well as various pieces of legislation relating to environmental permits and approvals. With regard to wastewater control, for example, it explains various regulations related to wastewater spanning the Environmental Pollution Control Act (EPCA) and the Sewerage and Drainage Act, and makes them easily understandable. But as mentioned above, some of the statements in the Code are applied as virtual regulations.

For example, a PH meter is installed at many factories immediately upstream of the wastewater exit for constant water quality monitoring. However, the obligation to install a PH meter is mentioned only in the Code of Practice on Pollution Control. For soil pollution, on which there exist no legislative regulations, the Code of Practice on Pollution Control has an independent section on soil pollution control where investigation and restoration procedures for soil pollution are described.

(4) Environmental Procedures Required of Companies Starting Businesses in Singapore

Prompt Processing of Environmental Procedures

To go through environmental procedures is necessary when factories or other facilities are to be constructed in Singapore. This section explains the flow of environmental procedures on a representative case in which a factory is going to be constructed on a tract of land borrowed through the Jurong Town Corporation (JTC), the most common government affiliated organization for building and operating industrial estates.

The environmental procedures start with entering basic environmental information in the application form for the construction of a factory, for submission to JTC. Pieces of information required include the manufacturing process of the planned factory, raw materials to be used, and the types and amounts of environmental pollutants and wastes that may be generated. Upon receipt of it, JTC forwards the application form to relevant administrative agencies. The Pollution Control Department (PCD) of the National Environment Agency (NEA) conducts an investigation on the environmental aspects of the construction plan in question on the basis of the information provided in the form. If the information so provided proves to be insufficient, PCD may require the applicant to provide additional information. Based on the results of the environmental investigation, PCD determines in view of the environmental aspects of the plan whether or not to permit the construction of the factory in Singapore. No permit is issued to a planned factory that (1) may discharge a large amount of wastes, (2) may use or discharge a large amount of water, a valuable resource for Singapore, or (3) may discharge harmful wastes incapable of treatment in Singapore.

Once the permission to locate the planned factory in Singapore is given, an examination is conducted to determine the specific location of the factory considering the line of business, the degree of expected environmental loading and other conditions. Normally, light industries with little environmental loads such as software development and assembly of electrical machinery, are located in industrial estates near residential areas; general industries of medium environmental loading such as electric plating in industrial estates away from residential areas; and heavy and chemical industries in places far away from residential areas or in a reclaimed land off the coast.

At the design stage of the planned factory, PCD presents the applicant with various requirements on the environmental aspects of the construction plan, including the installation of pollution control systems, their treatment capacity, and applicable emission and discharge standards. At the same time, if hazardous wastes may be discharged, or hazardous chemical substances may be used, PCD requires the applicant to acquire a necessary permit for their storage and transportation. If PCD decides that the applicant can built a factory meeting PCD's requirements, PCD asks the applicant to submit a detailed design and construction plan of the factory to check the compliance with PCD's requirements and conditions on the environment aspects. Once approval is given on the environmental aspects by PCD and then on the non-environmental aspects by other relevant government agencies, the applicant is given a building permit for the planned factory.

On completion of the factory, PCD verifies that environmental control equipment and the like are installed as required by PCD, and then issue an operating permit to the applicant. After the start of operation of the factory, PCD conducts an on-site inspection of the factory to check the environmental control equipment and confirm its operating conditions, etc.

The same procedures as described above apply also when the application is made through a government agency other than JTC, namely, the Housing and Development Board (HDB) or the Urban Redevelopment Authority (URA). PCD investigates and determines the environmental aspects of the application in these cases as well. These procedures are processed as promptly as possible. It normally takes about two weeks from the submission of the application to the start of factory construction.

Pollution Control Study Required of Large Factories

Before constructing a large-scale factory, it may be required to conduct a pollution control study or a quantitative risk assessment of chemical substances to be used there, taking more time in the environmental procedures.

In the case of the scheduled promises under the Environmental Pollution Control Act (EPCA) mentioned earlier, the applicant also needs to provide the Ministry of the Environment (NEA) with detailed information such as the manufacturing process, the pollution control equipment to be installed, and the control methods for hazardous chemical substances, and needs to obtain an environmental permit from the Chief Executive Officer (CEO) of NEA.

Section 4
Water Pollution Management

1. Water problems and water pollution management in Singapore

Maintenance of Good Water Quality in Need for Water Supply

The implementation of effective industrial wastewater control, careful water quality monitoring, and progress in building public sewer systems are contributing to maintaining a good water quality in public bodies of water, like rivers and reservoirs, in Singapore, a country with limited land area, where water resources are valuable and of strong concern of the people. Half of the water supplies in Singapore are taken in from reservoirs scattered around the country and several rivers. The remaining half depends on raw water purchased from neighboring Malaysia. With the expiration of part of the long-term water purchase agreement with Malaysia in 2011, negotiations about water price between the two countries are currently encountering difficulties, making it a matter of urgency for Singapore to secure water resources without relying on Malaysia.

Therefore, considering increased water demand attributable to economic development and increased population, the Singaporean government is working on the development of additional water resources toward realizing self-sufficient water supply. Measures to be undertaken include the construction of additional reservoirs and new rainwater storage facilities, introduction of the latest technology for seawater desalination, and recycling of wastewater. As part of these endeavors, in February 2003, the government started to mix tap water with recycled water known as the “NEWater”, water obtained through membrane treatment of processed sewage. Under these circumstances, the maintenance of a good water quality in public bodies of water, including reservoirs as existing valuable water sources, is becoming increasingly important.

Building of Public Sewer Systems as a Main Measure for Controlling Water Pollution

Water quality control in Singapore are mainly based on two measures: (1) the prevention of pollution through building public sewer systems and (2) the strict enforcement of regulations for making industrial wastewater comply with the applicable wastewater standard. Of the two, the building of public sewer systems has become a particularly important. In Singapore, industrial and domestic wastewater basically needs to be discharged into public sewer systems. Aiming at a 100% diffusion rate, their building is well underway. As of 2000, six treatment plants and sewage conduits extending over approximately 2,800 km were completed, where 489 million m^3 of sewage was treated annually. The amount of treated sewage represented a 1.4-fold increase compared to 10 years ago (1991). At present, work is underway to enlarge or remodel existing treatment plants. At the same time, in order to consolidate existing sewage treatment facilities and build more advanced public sewer systems, the deep tunnel public sewer system is being constructed.

In order to avoid the risk of water pollution, restrictions are imposed on the use or storage of large quantities of chemical substances in a water catchment area, where reservoirs or other water resources are located.

A large number of sampling points are installed along reservoirs, rivers, watercourses, and seas to monitor water quality. At sampling points in a water catchment area, dissolved oxygen (DO), biochemical oxygen demand (BOD), total suspended solids (TSS), etc., are measured at regular intervals. Thus, a system for monitoring water for abnormalities is well established.

Two Sets of Regulations Indicating Wastewater Standards

In the Singaporean legislation relating to water pollution control, there are two sets of regulations. One is the Environmental Pollution Control (Trade Effluent) Regulations, under The Environmental Pollution Control Act (EPCA). The other is the Sewerage and Drainage (Trade Effluent) Regulations, under the Sewerage and Drainage Act.

These two sets of regulations contain wastewater standards that give large effects on the activities of Japanese companies. Of these two, the Environmental Pollution Control (Trade Effluent) Regulations (under the Environmental Pollution Control Act) are applied where wastewater is discharged into watercourses and the like other than public sewer systems. The Sewerage and Drainage (Trade Effluent) Regulations (under the Sewerage and Drainage Act) are applied where wastewater is discharged into public sewer systems. The

Environmental Pollution Control (Trade Effluent) Regulations (under the Environmental Pollution Control Act) contain two levels of wastewater standards. One is for discharging into general watercourses. The other is for discharging into controlled watercourses, from which tap water is taken in. One of these wastewater standards is thus applied to factories depending on where their wastewater is discharged, requiring factories to treat their wastewater to below the applicable control limit before discharging. This in turn requires them to install wastewater pre-treatment equipment within their premises.

Wastewater standards become more stringent when wastewater is discharged into (1) public sewer systems, (2) general watercourses, to which the Environmental Pollution Control (Trade Effluent) Regulations (under the Environmental Pollution Control Act) are applied, and (3) controlled watercourses, to which the Environmental Pollution Control (Trade Effluent) Regulations (the Environmental Pollution Control Act) are applied, in this order. As mentioned earlier, Singapore has a well-developed network of public sewer systems and almost all factories of Japanese companies are located in industrial estates connected with public sewer systems. For this reason, the Sewerage Drainage (Trade Effluent) Regulations (the Sewerage and Drainage Act), containing the most lax wastewater standard among the three, are usually applied to the factories of Japanese companies.

Waste Water Control Under Jurisdiction of the Pollution Control Department (PCD)

In order to ensure that wastewater standards are complied with, the government regulator, or the Pollution Control Department (PCD) of the National Environment Agency (NEA), requires factories to submit reports on water quality measurements at regular intervals, and also conduct an on-site inspection of factories frequently. For factories that may discharge acidic wastewater, or those that are large in scale of operation, it is mandatory to install a pH meter just upstream of the wastewater exit for constant pH monitoring of wastewater. They are also required of installing a device capable of cutting off wastewater discharge when any abnormality is detected. All these steps taken by PCD help ensure the effectiveness of wastewater control.

It should be noted, however, that there is no clear legislative specification as to which of the maximum 36 items covered by the wastewater standards are applicable to a specific factory, or what is the frequency of submission of reports on water quality measurements. Also, the need to install a pH meter is not stipulated anywhere in regulations. All these matters seem to be determined by PCD at its discretion on the basis of the result of the environmental investigation conducted upon application for a building permit.

At present, the work is underway to revise the wastewater standards stipulated under the Environmental Pollution Control (Trade Effluent) Regulations (under the Environmental Pollution Control Act), which are applied when wastewater is discharged into general watercourses or controlled watercourses where tap water intake is.

2. Wastewater control over factories

Different Wastewater Standards Depending On Where It Is Discharged

Table 1-4-1 compares wastewater standards applied to industrial wastewater in Singapore with the uniform wastewater standards applied nationwide in Japan. This table puts together three different sets of wastewater standards applied in Singapore according to where wastewater is discharged, for comparison with Japanese ones. These values are stipulated in the Environmental Pollution Control (Trade Effluent) Regulations, under the Environmental Pollution Control Act, and the Sewerage and Drainage (Trade Effluent) Regulations, under the Sewerage and Drainage Act. These values are upper limits allowable in wastewater. The number of control items differs according to where wastewater is discharged; 36 items for discharging into controlled watercourses from which tap water is taken in, 35 items for general watercourses, and 31 items for public sewer systems.

As used in the regulations, general watercourses refer to those that flow into the sea; controlled watercourses are those used to take in raw water for drinking; and public sewer systems are those into which wastewater is directly discharged. Most of the control items agree with Japanese ones, but include items that are not included in Japan such as chlorine (free), nickel, and tin. Conversely, although not listed in this table, Japanese wastewater standards include more than ten control items that are not included in Singapore such as organo-chloric compounds. One of the three sets of wastewater standards is applied according to where wastewater is discharged. About 80% of the factories of Japanese companies visited during this survey are subjected to the wastewater standards applied to wastewater discharged into public sewer systems. Part of the factories, namely those facing the sea, are subjected to the wastewater standards applied to wastewater discharged into general watercourses. None of them is subjected to those for wastewater discharged into controlled watercourses.

Table 1-4-1 Industrial effluent standards in Singapore and Japan 1)

(Unit: mg/liter where not otherwise indicated)

No	Items	Singapore			Japan3)
		Types of watercourse for wastewater			
		Public Sewer	General watercourse	Controlled Watercourse2)	
1	Temperature (℃)	45	45	45	-
2	Colour/ (Lovibond Units)	-	7	7	-
3	pH Value/pH	6 - 9	6 - 9	6 – 9	5.8 - 8.6 (Other than sea) 5.0 - 9.0 (Sea)
4	BOD_5 (20℃)	400	50	20	160 (Daily average:120)
5	COD (Cr method)	600	100	60	160 (Permanganate method) (Daily average:120)
6	Total Suspended Solids	400	50	30	200 (Daily average:150)
7	Total Dissolved Solids	3,000	2,000	1,000	-
8	Chloride (as chloride ion)	1,000	600	400	-
9	Sulphate (as SO_4)	1,000	500	200	-
10	Sulphide (as sulphur)	1	0.2	0.2	
11	Cyanide (as CN)	2	0.1	0.1	1.0
12	Detergents (linear alkylate sulphonate as methylene blue active substances)	30	15	5	-
13	Grease & Oil Grease & Oil (Hydrocarbon) Grease & Oil (Non-hydrocarbon)	- 60 100	10 - -	5 - -	5
14	Arsenic	5	1	0.05	0.1
15	Barium	10	5	5	-
16	Tin	10	10	5	-
17	Iron (as Fe)	50	20	1	10
18	Beryllium	5	0.5	0.5	-
19	Boron	5	5	0.5	10(Other than sea 230(Sea)
20	Manganese	10	5	0.5	10
21	Phenolic Compounds (expressed as phenol)	0.5	0.2	Nil.	5
22	*Cadmium	1	0.1	0.01	0.1
23	*Chromium (Ⅵ & Ⅲ)	5	1	0.05	Ⅵ: 0.5 Total 2.0
24	*Copper	5	0.1	0.1	3
25	*Lead	5	0.1	0.1	0.1

26	*Mercury	0.5	0.05	0.001	0.005
27	*Nickel	10	1	0.1	-
28	*Selenium	10	0.5	0.01	-
29	*Silver	5	0.1	0.1	-
30	*Zinc	10	1	0.5	5
31	Metals marked with * in total	10	1	0.5	-
32	Chlorine（Free）	-	1	1	-
33	Phosphates (as PO_4)	-	5	2	16 (as P)
34	Calcium (as Ca)	-	200	150	-
35	Magnesium (as Mg)	-	200	150	-
36	Nitrate (as NO_3)	-	-	20	100 4)

1) Environmental Pollution Control (Trade Effluent) Regulations, 2001
Analysing methods are defined in accordance with Standard Methods for the Examination of Water and Wastewater, USA.
2) Controlled watercourse means the watercourse within the area of water-intake.
3) Excerpt from the Directive of the Prime Minister's Office for setting effluent standards (1993 Directive No. 54 Table 1, 1993 Directive No. 40 Table 2)
4) (NH_3-N×0.4 + NO_2-N + NO_3-N) ≦ 100 mg/liter

Stringent pH Value Control in Wastewater

Factories discharging wastewater are obligated to control the quality of wastewater by measuring at regular intervals and report the result to the Pollution Control Department (PCD). The items to be measured are designated by PCD according to the manufacturing process of the factory in question, the types and quantities of chemicals used, the amount of wastewater discharged, and others. For the factories visited during this survey, the measuring items range from 9 to 36, the maximum number that may be designated by PCD. The frequency of reporting is also varied from factory to factory, ranging from once a month to once several months. Some small-to-medium-sized factories that discharge only a small amount of wastewater are not required to report at all.

The control limit of pH is 6 to 9 regardless of where wastewater is discharged, but very stringent pH value control is being carried out. Many of the factories visited during this survey are made to install a pH meter and an automatic shutoff valve interlocked with the meter just upstream of the wastewater exit of the factory. PCD explains that this requirement is for preventing acidic wastewater with a substandard pH value from promoting corrosion of the sewer pipe and piercing through it, which results in wastewater leakage and soil contamination. This mechanism is such that when the pH meter senses an abnormal value, the shutoff valve automatically stops the flow of wastewater. The pH meter is sealed by PCD so that other than personnel of PCD may take out the recording chart from the meter. It should be noted, however, that all the factories are not necessarily obligated to install a pH meter and an automatic shutoff valve. PCD determines whether or not they need to be installed on the basis of the types of chemicals used by the factory in question, the characteristics and quantity of wastewater discharged, etc. Some old factories are equipped with a manual shutoff device.

Unique Arrangements under which Paying Trade Effluent Tariff enables the Company to Exceed Wastewater Standards for Public Sewer System

Specific standards for wastewater discharged into public sewer systems, into which Japanese companies commonly discharge their wastewater, are discussed below. Since the wastewater standards for discharging into public sewer systems in Singapore is relatively lax, it is meaningless to compare them with the uniform wastewater standards in Japan that are applied to discharging into public waters. Therefore, control items specified in Singapore but not in Japan are discussed below, pointing out problems with them.

The wastewater standards of Singapore set the control limit for Total Dissolved Solids at 3,000 mg/liter for wastewater discharged into public sewer systems. However, when acidic or alkaline wastewater commonly discharged from factories is neutralized, the salt concentration necessarily increases, and hence the dissolved solid concentration as well, which easily exceeds 3,000 mg/liter. The salt thus formed is sodium chloride (NaCl), sodium sulfate (Na_2SO_4), or other similar substances. These substances are contained in seawater at a level of some 35,000 mg/liter in total and are not hazardous at all. Some of the factories visited during this survey are not meeting this control limit, but by explaining to PCD the reason why these substances are generated and the fact that they are not hazardous, they are allowed to continue operating. During this survey, we questioned responsible personnel of the National Environment Agency (NEA) about this matter. Already being aware of the unreasonableness of this control limit, they responded that they are going to revise it. For a similar reason, the control limits of 1,000 mg/liter for chloride ion and 1,000 mg/liter for sulphate ion are unreasonable.

A unique feature of the wastewater standards for discharging into public sewer systems is the fact that the control limits for biochemical oxygen demand (BOD) and total suspended solids (TSS) may be exceeded by paying a charge called Trade Effluent Tariff. Table 1-4-2 shows the concentration in wastewater discharged and the corresponding amount of trade effluent tariff to be paid.

Table 1-4-2 Outline of the concentration of wastewater discharged into public sewer systems and the amount of trade effluent tariff

Concentration（mg/liter）	Trade effluent tariff (S dollars/m^3)	
	BOD	TSS
400 – 600	0.21	0.15
601 – 800	0.42	0.3
In between, the trade effluent tariff gradually increases with every increase of 200 mg/liter.		
3,801 – 4,000	3.78	2.7

For example, even when the BOD concentration in wastewater discharged into public sewer systems exceeds the designated control limit of 400 mg/liter, the factory in question can discharge it by paying only 0.21 S dollars per m^3 of wastewater if the BOD concentration is less than 600 mg/liter. This trade effluent tariff scheme is applicable up to 4,000 mg/liter. It is not allowed to exceed this limit under any circumstances. In other words, wastewater exceeding this limit must be treated for reducing the concentration to a level below the limit. The BOD concentration in wastewater from factories may vary in an amplitude greater than 200 mg/liter from day to day. To make the matter more difficult, it takes five days to measure BOD. Therefore, it is difficult to precisely track the variation in the wastewater quality. In practice, it appears that total oxygen demand (TOD) values automatically obtained by a TOD meter are converted to BOD values for controlling BOD. None of the factories of the Japanese companies visited during this survey are using this tariff scheme, and no details are known as to what kind of control is being conducted. Responsible personnel of NEA explained that, while wastewater pre-treatment equipment shall be installed in principle, the tariff scheme is an economic solution that allows factories to discharge wastewater exceeding a control limit into public sewer systems if they pay a trade effluent tariff according to the concentration level. The NEA personnel added that the amount of the trade effluent tariff is based on extra costs incurred for treating such wastewater discharged. A similar trade effluent tariff scheme is also in effect for TSS.

Very Stringent Wastewater Standards for General Watercourses on Some Control Items

Next, wastewater standards for discharging into general watercourses are compared with the uniform standards of Japan, since the purposes of these standards are almost the same in both countries. Generally, the control limits in Singapore are almost at the same levels as those in Japan, but some of the values in Singapore seem to be too stringent and almost unreasonable. Some control items used in Singapore are not adopted in Japan.

The control limit of Chemical Oxygen Demand (COD) is set at 100 mg/liter, more stringent than Japan's 160 mg/liter. This limit is more stringent than it appears because different measurement methods are specified in both countries. In Japan, oxidation reaction with potassium permanganate is used to find the amount of oxygen required for oxidation (COD_{Mn}), while in Singapore, oxidation reaction with potassium dichromate is used for the same purpose (COD_{Cr}). Since potassium dichromate is more oxidative, the Singaporean method gives a higher analysis value for the same sample. Though varying from sample to sample, the COD_{Cr}-based value is about 2.5 times the COD_{Mn}-based value. This means that the Japanese control limit of 160 mg/liter is equivalent to about 400 mg/liter as determined by the Singaporean method. As a result, wastewater treatment equipment meeting Japan's COD control limit would not work in Singapore if it were brought into the country without modification.

The combined control limit for heavy metals indicated by asterisk at the head of each name in Table 1-4-1 is very stringent at 1 mg/liter. Zinc is included in these heavy metals. It is an amphoteric metal that dissolves not only in an acidic solution but also in a strong alkaline solution. Because of this property, wastewater treatment equipment must be operated while controlling the pH within a very narrow range in order to treat zinc as water-insoluble hydroxide and decrease its concentration to below 1 mg/liter.

Wastewater Standards Determined in a European and American Manner

Countries in Europe and North America set their wastewater standards at concentration levels that can be achieved by the Best Available Technology (BAT). In contrast, Japan first sets environmental standards for the general environment and then, taking into consideration the diluting effect and natural purification, determines the control limits that can meet the environmental standards. For example, in Japan, degradation by microorganisms in nature is taken into consideration before the control limit for total nitrogen is set at 120 mg/liter. In contrast, many Western countries set the corresponding control limit at about 10 mg/liter that can be achieved by using oxidation treatment or other technology.

Singapore sets a stringent control limit of 1 mg/liter for free chlorine in its wastewater standards for general and controlled watercourses, following the examples of Western countries, where chlorine, a very harmful substance, is subjected to stringent control. In Japan, where there are no signs of environmental pollution caused by chlorine, the element is neither an item of control nor that of monitoring. Japanese people, accustomed to the odor of chlorine used to sterilize tap water and swimming-pool water, are puzzled by such stringent limits. As long as Singapore controls wastewater on the basis of the Western thinking, Japanese companies operating in the country must basically meet such limits.

Section 5
Air Pollution Management

1. Air pollution management in Singapore

Control Measures for Pollution Sources Producing Effects

As well as for water pollutant control, Singapore has succeeded in controlling air pollutants. All the concentrations of main air pollutants, such as sulfur dioxide (SO_2), nitrogen oxides (NOx), ozone (O_3), and particulate matter (PM10), are below the corresponding long-term targets of the World Health Organization (WHO) and the control limits of the Air Environmental Standards of the United States Environmental Protection Agency (USEPA). The 2001 evaluation according to the Pollutant Standards Index (PSI), developed by USEPA, gave a "Good" rating to 83%, and an "Average" rating to 17%.

Singapore's air pollution control measures are based on two basic principles: (1) to minimize the generation of air pollutants at their sources, and (2) to minimize the effect of any air pollution arising from industrial location. Possible sources of air pollutants in Singapore include stationary sources, like factories and power plants, and mobile sources, like cars and outdoor incineration of wastes. Measures against the stationary sources include the designation of the site of a plant according to a detailed land utilization program, thorough implementation of air pollution control, and compulsory use of fuels of small environmental loads. Measures against car exhaust gas include control on individual cars and the limitation of total traffic of cars. To verify the effect of these measures against car exhaust gas, air pollution monitoring stations equipped with telemeters are installed at seventeen locations for constant monitoring of air quality in the general environment.

Measures Against Stationary Sources Implemented under the Environmental Pollution Control (Air Impurities) Regulations, Etc.

Specific control measures over stationary sources of air pollutants, like factories, are implemented in accordance with the Environmental Pollution Control Act (EPCA) and the Environmental Pollution Control (Air Impurities) Regulations under the Act. The Regulations contain, among others, emission standards for 23 air pollutants. The predecessor of the Regulations is the Clean Air (Standards) Regulation, in effect since 1978, which was revised as a supplement to EPCA in 2000 when EPCA took effect, to become the Regulations.

These pieces of legislation prohibit factories to emit black smokes (soot and dust) and make it mandatory for them to limit air pollutants below the emission standards. For compliance with these emission standards, factories are required to install, operate, and manage air pollution control equipment in an appropriate manner and to check their exhaust gas at regular intervals. In addition, factories with equipment of a certain size or larger (2,300 kg/hour or more in generated steam in the case of boiler heating equipment) are obligated to make a constant measurement of soot and dust by installing a smoke density meter.

To ensure the implementation of these air pollution measures, the Pollution Control Department (PCD) of the National Environment Agency (NEA) conducts an on-site inspection of factories at regular intervals. Upon receipt of a complaint or the like about air pollution, a surprise on-site inspection is conducted. On the basis of the results of these inspections, the analysis facility of the Ministry of the Environment determines where the factory is in violation of the relevant legislation. In 2001, 28,432 factories were subjected to regular inspections and at 627 factories, the inspectors measured exhaust gas, or soot and dust, or analyzed fuels used.

Obligation to Use Fuels of Low Environmental Loads Playing a Great Role

In reducing the emission of sulfur dioxide, the policy of obligating factories and the like to use fuels of small environmental loads has become a major pillar of the country's air pollution control.

Specifically, factories located in industrial estates are obligated to use fuel oils with a sulfur content of less than 1%. Factories located in the industrial estates of the Jurong Island or the Tuas district, where refineries, chemical plants and other facilities of large environment loads are concentrated, must use clean fuels such as natural gas. Factories near residential areas must use city gas or diesel fuel with a sulfur content of 0.05% or less. Thus fuels to be used are designated in detail.

Industrial facilities of large environmental loads that fall under the category of Scheduled Premises in accordance with the Environmental Pollution Control Act (EPCA) are required to implement more stringent environmental measures. These facilities must obtain environmental permits from the CEO of the National Environment Agency (NEA) prior to the operation of their facilities. An environmental permit generally contains many conditions attached to it such as the installation and operation of pollution control equipment, measurement and recording of waste gas emissions, and use of particular kinds of fuels. They are obligated to meet these conditions.

Control on Car Traffic Volume Producing an Indirect Effect

Another large source of air pollutants is car exhaust gas. Measures for controlling exhaust gas on individual cars have been strengthened in stages. Car owners are required to check exhaust gas from their cars at regular intervals. In January 2001, when the car exhaust gas control was strengthened, the EU's car exhaust gas standards (for gasoline-powered cars, for example, the standards of EC Directive 96/69/EEC) started to be applied to new gasoline- or diesel-powered cars. In July 1998, a total ban on the use of leaded gasoline was imposed. In order to reduce the exhaust gas from diesel cars, starting in March 1999, the permissible sulfur content of diesel fuel was lowered from 0.3 to 0.05 weight percent.

Unique indirect contributors to mitigating air pollution by cars in Singapore are the limitation of the total number of cars owned, and the restriction of traffic volume of cars through the road pricing scheme, under which cars entering urban districts are required to pay a fee.

Originally started as a measure to reduce traffic-jam, these two policies are contributing to air pollution control as well, through reducing the number of traveling cars and thus the amount of car exhaust gas generated. In order to control the total number of cars owned, the issuance of a Certificate of Entitlement (COE) that is necessary for car registration is limited to regulate the number of registered cars in Singapore. This scheme was started in 1990. COE prices are determined by bidding and very high. As a result, the total amount of expenses and various taxes associated with purchasing a new car is several times higher in Singapore than in Japan. Thus, this scheme has an effect of restraining the growth in the number of cars owned.

The road pricing scheme is also known as the Electronic Road Pricing (ERP) system. Cars in Singapore are usually equipped with an on-board device into which a prepaid card is inserted, and each time such car passes through an urban district where ERP is in place, a specified amount of fee is electronically withdrawn from the card.

Outdoor incineration of wastes is prohibited in accordance with the Environmental Pollution Control (Prohibition on the Use of Open Fires) Order under any circumstances.

As of 2001, 17 air pollution monitoring stations were installed across Singapore, of which 14 stations are for monitoring air quality in the general living environment and 3 stations for monitoring air quality along roads. All of them use a telemeter to send measured data to the Strategic Planning and Research Department (SPRD) of the National Environment Agency (NEA).

2. Waste gas emission control on factories

Emission Standards Approximately at the Same Level as in Japan

As mentioned earlier, air pollution control on factories is implemented in accordance with the Environmental Pollution Control Act (EPCA) and the Environmental Pollution Control (Air Impurities) Regulations under the Act. Promulgated in 2000 by revising its predecessor, the Clean Air (Standards) Regulations, the current Environmental Pollution Control (Air Impurities) Regulations were implemented in January 2001. The waste gas emission standards are as listed in Table 1-5-1. The standards started to be applied on new facilities on January 2001. Existing facilities were granted a grace period of 3 years.

The Environmental Pollution Control (Air Impurities) Regulations have more control items than the Japanese

Air Pollution Control Law. Comparison between the same control items indicates that the control limits are almost at the same levels, except for some items. Discussions below focus on the control items not included in the Japanese standards and those on which more stringent standards are imposed than in Japan. Also, actual measures taken by the Japanese companies visited during this survey are introduced.

For benzene, the control limit is set at 5 mg/Nm^3, which is extremely stringent compared with the Japanese limit ranging from 100 to 1,500 mg/Nm^3. To meet this limit, chemical factories handling benzene are taking various measures to prevent its leak. For carbon monoxide (CO), the control limit is set at 625 mg/Nm^3. No such limit is stipulated in Japan, where only a guideline value for ensuring complete combustion at waste incinerators is specified as a part of the measures to reduce dioxins from these facilities. In the factories visited during this survey where CO is necessarily contained in their waste gas emission, combustion equipment for CO is installed at the exit of the smokestack.

Some Difficult Cases in Dioxins Control

For dioxins, the control limit is set at 0.1 ng-TEQ/Nm^3 for all facilities that started operation in January 2001 or later. This limit is also extremely stringent compared with the Japanese control limit ranging from 0.1 to 5 ng/Nm^3 depending on the type and size of the facility. The emissions of dioxins vary according to the type and size of the facility such as an electric furnace or aluminum melting furnace. It would not be easy to meet the control limit of 0.1 ng-TEQ/Nm^3 without fail. Some administrative measures to relax the control limit for dioxins will be desired, especially for a small facility, which is limited in emissions and of small environmental loads.

For nitrogen oxides (NOx), the control limit is set at 700 mg/Nm^3 (about 330 ppm) for all factories, which is very stringent for some factories compared with the Japanese limit ranging from 120 to 1640 mg/Nm^3. To meet this limit, the diesel engine generator, for example, must be equipped with catalytic denitrification equipment or the like, and this is not a realistic solution for small factories. Fortunately, however, because of the stable power supply in Singapore, there are almost no factories visited during this survey where on-site power generation is required.

Particulate Matter Control Through Emission Allowance Trading

For particulate matter, the control limit of 100 mg/Nm^3 is applied under a unique administrative scheme not available in Japan. When there are more than one source of this matter within the same premises, the limit is deemed met so long as the combined amount of particulate matter generated, divided by the number of sources, is not in excess of 100 mg/Nm^3, provided, however, that the amount from the largest source does not exceed 200 mg/Nm^3. This scheme is a kind of emission allowance trading based on the same concept known as the "bubble" policy in the United States. Under this scheme, the factory may use equipment capable of removing dust at high cost only to keep dust concentration just below 200 mg/Nm^3 while using equipment capable of removing dust at low cost to remove a large quantity of dust. In this way, the factory can keep the total dust-removing cost low. Thus, the environmental control cost is reduced by taking advantage of this scheme.

For particulate matter, factories with boiler heating equipment larger than a certain size are also obligated to make a constant measurement of smoke by installing a smoke density meter to monitor the generation of black smoke (soot and dust). For equipment generating 2,300 kg/hour or more of steam, smoke must constantly be monitored to ensure that it passes the Ringelmann No.1 standard. One of the factories visited during this survey has a monitoring television set to visually monitor the smoke from the smokestack 24 hours a day from the control room.

Possible to Meet Sulfur Oxide Control Limit by Using Fuels of Small Environmental Loads

For sulfur oxide, the emission control limit is set at 100 mg/Nm^3 in terms of sulfur trioxide (SO_3), unlike in Japan, where it is set in terms of sulfur dioxide (SO_2). In Singapore, two types of fuel oil are commercially available: one that is desulfurized to a sulfur content of 1% or less, the other to 0.05% or less. The former is used by factories or the like located in industrial estates, on condition that flue gas desulfurization equipment is installed. General factories near residential districts are obligated to use the latter, which can meet the control limit of 100 mg/Nm^3 when combusted. Natural gas, liquefied petroleum gas, and other fuels of small environmental loads are also becoming widely used in the country, and it is not difficult to meet the emission control limit by using one of these fuels.

Table 1-5-1 Effluent Standard for Industrial Plants

Substance \ Country	Singapore 1)		Japan 2)
(a) Ammonia and ammonium compounds	Any trade, industry or process	76mg/Nm^3 expressed as ammonia	-
(b) Antimony and its compounds	Any trade, industry or process	5mg/Nm^3 expressed as antimony	-
(c) Arsenic and its compounds	Any trade, industry or process	1mg/Nm^3 expressed as arsenic	-
(d) Benzene	Any trade, industry or process	5mg/Nm^3	100 - 1,500 mg/Nm^3 3)
(e) Cadmium and its compounds	Any trade, industry or process	3mg/Nm^3 expressed as cadmium	1.0mg/Nm^3
(f) Carbon monoxide	Any trade, industry, process or fuel burning equipment	625mg/Nm^3	-
(g) Chlorine	Any trade, industry or process	32mg/Nm^3	30mg/Nm^3
(h) Copper and its compounds	Any trade, industry or process	5mg/Nm^3 expressed as copper	-
(i) Dioxins and furans	Any waste incinerator	(i) 1.0ng TEQ/Nm^3 for waste incinerators commissioned before 1st Jan 2001 (ii) 0.1ng TEQ/Nm^3 for waste incinerators commissioned on or after 1st Jan 2001	0.1 - 5ng TEQ/Nm^3 3)
(j) Ethylene oxide	Any trade, industry or process	5mg/Nm^3	-
(k) Fluorine, hydrofluoric acid or inorganic fluorine compounds	Any trade, industry or process	50mg/Nm^3 expressed as hydrofluoric acid	1.0 - 10 mg/Nm^3 3)
(l) Formaldehyde	Any trade, industry or process	20mg/Nm^3	-
(m) Hydrogen chloride	Any trade, industry or process	200mg/Nm^3	80,700 mg/Nm^3 3)
(n) Hydrogen sulphide	Any trade, industry or process	7.6mg/Nm^3	-
(o) Lead and its compounds	Any trade, industry or process	5mg/Nm^3 expressed as lead	10 - 30mg/Nm^3 3)
(p) Mercury and its compounds	Any trade, industry or process	3mg/Nm^3 expressed as mercury	-
(q) Oxides of nitrogen	Any trade, industry, process or fuel burning equipment	700mg/Nm^3 expressed as nitrogen dioxide	120 - 1640 mg/Nm^3 3)
(r) Particulate substances including smoke, soot, dust, ash, fly-ash, cinders, cement, lime, alumina, grit and other solid particles of any kind	Any trade, industry, process, fuel burning equipment or industrial plant (except for any cold blast foundry cupolas)	(i) 100mg/Nm^3 ;or (ii) where there is more than one flue, duct or chimney in any scheduled premises, the total mass of the particulate emissions	30 - 250 mg/Nm^3 3)

		from all of such flue, duct or chimney divided by the total volume of such emissions shall not exceed 100mg/Nm^3 and the particulate emissions from each of such flue, duct or chimney shall not exceed 200mg/Nm^3 at any point in time (iii) Ringelmann No.1 or equivalent opacity (Not to exceed more than 5 minutes in any period of one hour)	
(s) Styrene monomer	Any trade, industry or process	100mg/Nm^3	-
(t) Sulphur dioxide (non-combustion sources)	Any trade, industry or process	500mg/Nm^3	
(u) Sulphur trioxide and other acid gases	The manufacture of sulphuric acid	500mg/Nm^3 expressed as sulphur trioxide. Effluent gases shall be free from persistent mist.	-
(v) Sulphur trioxide or sulphuric acid mist	Any trade, industry or process, other than any combustion process and any plant involving the manufacture of sulphuric acid	100mg/Nm^3 expressed as sulphur trioxide	Sulphur dioxide ・K value regulation[4)] ・Fuel concentration regulation ・Total emission regulation
(w) Vinyl chloride monomer	Any trade, industry or process	20mg/Nm^3	-

1) The Environmental Pollution Control (Air Impurities) Regulations,
Code of Practice on Pollution Control (2000 Edition) (with amendments in Feb 2001 and Jun 2002)
2) Excerpt from Air Pollution Control Law
3) depending upon type and scale of a facility
4) q = K x 10 - 3He2 q : permitted SO_2 Nm^3/hr
K-value (= 1.17 at Tokyo area) He: correct height of outlet (m)
He2 = Ho + 0.65 (Hm + Ht) Ho: height of outlet (m)
Hm = (0.795(Q・V)1 / 2 / (1+2.58 / V) Q: volume of exhaust gases at 288 k (m^3/sec)
Ht = 2.01 x 10-3・Q・(T-288)・(2.30logJ+1 / J-1) V: velocity of exhaust gases (m / sec)
J = 1 / (Q / V)1 / 2・(1460－296 x V / (T-288))+1 T: temperature of exhaust gases (k)

Section 6
Hazardous Industrial Waste Management

1. Hazardous industrial waste management in Singapore

Waste Management Action Required in Singapore

In Singapore, where many petrochemical plants and the like are located, large quantities of hazardous industrial wastes are generated. For this reason, stringent legislative control is imposed on hazardous industrial wastes, and their control measures have become one of the indispensable actions of environmental measures for Japanese companies. Hazardous industrial wastes include sludge generated from wastewater treatment, toxic metals, and rags soaked with hazardous organic solvent. Legislative control on these wastes is implemented in accordance with the Environmental Public Health (Toxic Industrial Wastes) Regulations under the Environmental Public Health Act (EPHA). The Act is under jurisdiction of the Ministry of Health (MOH), but various control measures, issuance of business licenses and other jobs under the Regulations are done by the Pollution Control Department (PCD) of the National Environment Agency (NEA).

26 Categories of Hazardous Industrial Wastes

The Environmental Public Health (Toxic Industrial Wastes) Regulations divide wastes designated as hazardous industrial wastes into 25 categories, as shown in Table 1-6-1. Most of these industrial wastes so stipulated fall under the Japanese category of specially controlled wastes. The Regulations include responsibilities of generators of hazardous industrial wastes, responsibilities of entities collecting, transporting, storing, treating, disposing of, and otherwise dealing with them, application procedures for a business permit required of such entities dealing with them, and precautions to be taken by such entities in transit.

Table 1-6-1 List of hazardous industrial wastes

Acids	1. Spent inorganic acids. Eg. Hydrochloric acid, sulphuric acid, nitric acid, phosphoric acid, hydrofluoric acid, boric acid and pickling acid. 2. Spent organic acids. Eg. Acetic acid, formic acid, benzoic acid and sulphonic acid
Alkali	1. Spent alkaline solutions 2. Spent ammoniacal solutions 3. Metal hydroxide sludges and oxide sludges
Antimony and its Compounds	1. Spent antimony potassium tartrate
Arsenic and its Compounds	1. Timber preservative residues containing arsenic 2. Waste containing gallium arsenide
Asbestos	1. Asbestos wastes from asbestos/cement manufacturing processes 2. Empty sacks/bags which have contained loose asbestos fibre
Chromium Compounds	1. Plating effluent and residues containing chromium 2. Timber preservative residues containing chromium 3. Spent and aqueous solutions containing chromic compounds 4. Tannery effluent and residues containing chromium
Copper Compounds	1. Plating effluent and residues containing copper 2. Spent etching solutions containing copper from printed circuit board manufacturing 3. Timber preservative residues containing copper
Cyanides	1. Plating effluent and residues containing cyanides 2. Heat treatment residues containing cyanides 3. Spent quenching oils containing cyanides 4. Spent processing solutions containing cyanides from photographic processing
Cadmium and its Compounds	1. Plating effluent and residues containing cadmium 2. Wastes containing cadmium from Ni/Cd battery manufacturing
Isocynates	1. Spent di-isocyanates. Eg. toluene di-isocyanate (TDI) and methylene di-isocyanate (MDI) from polyurethane foam-making process

Laboratory Wastes	1. Obsolete laboratory chemicals 2. Toxic chemical wastes from chemical analysis
Lead Compounds	1. Sludges containing lead oxide/sulphate 2. Spent organo-lead compounds. Eg. tetraethyllead (TEL) and tetramethyllead (TML) 3. Waste lead-acid batteries, whole or crushed
Mercury and its Compounds	1. Effluent residues or sludges containing mercury from chlor-alkali industry 2. Wastes containing mercury from equipment manufacturing involving the use of metal mercury 3. Spent catalysts from chemical processes containing mercury 4. Spent organo-mercury compounds
Metal Catalysts	1. Spent metal catalysts from chemical processes and petroleum refining. Eg. Catalysts containing chromium cobalt
Nickel Compounds	1. Plating effluent and residues containing nickel
Fluoride Compounds	1. Timber preservative residues containing fluorides 2. Spent ammonium bi-fluoride
Organic Compounds containing Halogen	1. Spent halogenated organic solvents. Eg. trichloroethylene, 111-trichloroethane, perchloroethylene, methylene chloride tetrachloromethane and 112-trichloro-122-trifluoroethane 2. Residues from recovery of halogenated organic solvents 3. Packaging materials or residues containing chlorobenzenes and/or chlorophenols and their salts
Organic Compounds not containing Halogen	1. Spent non-halogenated organic solvents. Eg. benzene, toluene, xylene, turpentine, petroleum, thinner, kerosene, methanol, ethanol, isobutanol, isopropanol, methyl ethyl ketone, methyl isobutyl ketone, isopropyl either, diethyl ether, hexane, dimethyl sulphide and dimethyl sulphoxide 2. Residue from recovery of non-halogenated organic solvents
Pathogenic Wastes	Pathogenic wastes from hospitals
Phenolic Compounds	1. Sludge/residues from paint stripping using chemicals containing phenols 2. Residues containing unreacted phenol and formaldehyde from adhesive industry
Polychlorinated Bi-phenyl (PCB) including Polychlorinated Ter-phenyl (PCT)	1. Spent transformer oil containing PCB and/or PCT 2. Retrofilled transformer contaminated with PCB and/or PCT 3. Electrical equipment and parts containing or contaminated with PCB and/or PCT. Eg. capacitors and transformers 4. Containers and all waste materials contaminated with PCB and/or PCT
Polyvinyl Chloride（PVC）	1. All waste materials containing PVC. Eg. PVC insulated wires, PVC pipes and trunking, PVC parts, PVC upholstery and PVC resins
Silver Compounds	1. Spent processing solutions containing silver from photographic processing
Used, Contaminated Oil	1. Used mineral, lubricating and hydraulic oil from machine cylinders, turbines, switch gears and transformers 2. Spent motor oils from petrol and diesel engines 3. Spent quenching oil from metal hardening 4. Oil recovered from solvent degreasers 5. Spent oil water emulsions. Eg. Spent coolants from metal working industries 6. Oil water mixtures (mainly oil).

	Eg. Oily ballast water from ship tankers 7. Oil and sludge from oil interceptors 8. Tanker sludges and oil sludges/residues from storage tanks 9. Oil sludges containing acid from recovery and recycling of used oil
Zinc Compounds	1. Plating effluent and residues containing zinc
Other Wastes	1. Obsolete/abandoned chemicals and pesticides from storage, manufacturing and trading activities 2. Used containers, bags and process equipment contaminated by chemicals and pesticides from storage, manufacturing and trading activities 3. Wastes/residues containing unreacted monomers. Eg. vinyl chloride and styrene monomers, from polymer manufacturing processes 4. Tar residues from distilling and tarry materials from refining 5. Wastes from toxic waste treatment processes. Eg. wastes and residues from solidification, fixation and incineration processes 6. Wastes from toxic chemical drums and tank cleaning activities 7. Chemical and oil slops from ship tankers 8. Wastes from the production, formulation and use of resins, latex, plasticisers, glues/adhesives containing solvents and other contaminants. 9. Wastes from the production, formulation and use of links, dyes, pigments, paints, lacquers, varnish containing organic solvents, heavy metals or biocides.

Entire Treatment by Private Enterprises

In Singapore, it is basically recommended that hazardous industrial wastes generated in factories be recycled or reused within the factory. Treatment and disposal of those wastes incapable of recycling or reusing are consigned to private enterprises with business licenses to do so. There are no municipal treatment and disposal facilities, and private enterprises with business licenses handle everything from collection and transportation to treatment and disposal. As of 2001, some 120 enterprises were granted business licenses for the treatment and disposal of hazardous industrial wastes. Business licenses are classified by type of operations such as transportation, physicochemical treatment, and incineration, and are issued for each type of waste that may be accepted by the enterprise in question. Some are engaged in collection and transpiration only. Of the total of about 120, five enterprises or so are integrated ones performing all operations up to the final treatment and disposal.

The statistics for 2000 indicate that the licensed enterprises collected about 121,500 tons of hazardous industrial wastes, of which 70% were reused after recycling treatment. Remaining 30% were disposed of at the final landfill site at Pulau Samekau, built off the coast of the Singapore Island. Only those stabilized by physicochemical treatment are disposed of at a landfill site. Ash generated in the incineration process is subjected to leaching tests to check the stability. Unstable ash is mixed with cement, and the mixture is stirred until solidify. Thereafter, its stability is checked again. In a leaching test, the mixture of ash and cement is stirred in water maintained at a weak acidic pH for a fixed time and then the water is analyzed to check the level of leaching. This test is conducted in accordance with the United States standard (Testing Method 1331).

For hazardous industrial wastes discharged by factories or the like, an on-line manifest system is established to monitor them through all the stages from collection to final deposal. All records made under this system are placed under the control of the Pollution Control Department (PCD).

In Singapore, PCBs, chlorobenzene, and other chlorine compounds cannot be treated, and they are collected and transferred to Germany or other countries for treatment.

Necessary Consideration for the Environmental Pollution Control (Hazardous Substances) Regulations

In Singapore, in addition to the above-mentioned control measures on hazardous industrial wastes, control on hazardous chemical substances is implemented in accordance with the Environmental Pollution Control (Hazardous Substances) Regulations under the Environmental Pollution Control Act (EPCA). The Regulations correspond to Japan's Poisonous and Deleterious Substances Control Law, and control the handling of chemical substances, including their manufacturing, importing, storing, transporting, using, and labeling. In operating a factory in Singapore, the Regulations need to be considered.

During this survey, we had an opportunity to visit a representative treatment firm for hazardous industrial wastes in Singapore. Below is an outline of this firm's treatment facility.

2. A representative treatment facility for hazardous industrial wastes in Singapore

(1) Outline of the facility

We visited a treatment facility for hazardous industrial wastes to which many Japanese companies consign the treatment of such wastes. The facility, located in the Tuas district at the western edge of the Singapore Island, started operations in 1997. It is an integrated operator extending from collection and transportation to incineration and disposal of substances discharged from various types of factories that fall under the category of hazardous industrial wastes such as oil-stained rags, waste oils, heavily polluted water, and sludge resulting from wastewater treatment. In Singapore, individual treatment (transportation) firms often performed only a single operation, like treatment of waste oils alone, treatment of wastewater alone, or transportation alone. But the facility was established as an integrated operator capable of all kinds of waste treatment at a single site.

Major equipment includes incinerators, physicochemical treatment equipment, and solvent recovery equipment. These pieces of equipment and the treatment technology used at this facility were imported from an environmental engineering company and a hazardous industrial waste treatment company in Japan. The representatives of this facility toured factories in the same line of business in Europe and the United States prior to constructing their facility, and selected the latest equipment. The total capacity is 500 tons/day. 20 to 30% of the wastes treated at this facility are from Japanese companies operating in the country. Of the total treatment volume, 150 tons/day consist of paper, lumber, glass, aluminum, iron, and other substances of monetary value, and are separated for recycling. The number of personnel is 80, and the lot area is 3.5 hectors.

The treatment volumes by waste type are as shown in Table 1-6-2.

Table 1-6-2 Treatment volumes by waste types

（Unit: t/month unless otherwise indicated）

Waste type	Wastewater	Waste solvent	Waste oil	Heavy metal waste	Acid waste	Alkali waste	Solid waste	Empty containers （pieces）
Amount	2,200	2,700	2,000	120	380	300	7	140,000

The firm operating this facility is affiliated with a recycling firm and an energy recovery firm. These three firms cooperate with each other to do an integrated environmental business. A Japanese engineering company has a stake in the holding company of the three.

(2) Procedure for processing an order for treatment

Upon receipt of an inquiry from a customer, the facility first asks the customer to send samples of the waste in question for chemical analysis. On the basis of the analysis results, it determines the treatment method and cost. When the customer accepts the proposed method and cost, the facility concludes a contract with the customer, and visits the customer to take delivery of the waste. After appropriate treatment, any residual waste that needs to be disposed of by landfill undergoes the final treatment so that it passes leaching tests before being transferred to the final deposal site at Pulau Semakau. The facility also has a license to transport all types of hazardous industrial wastes.

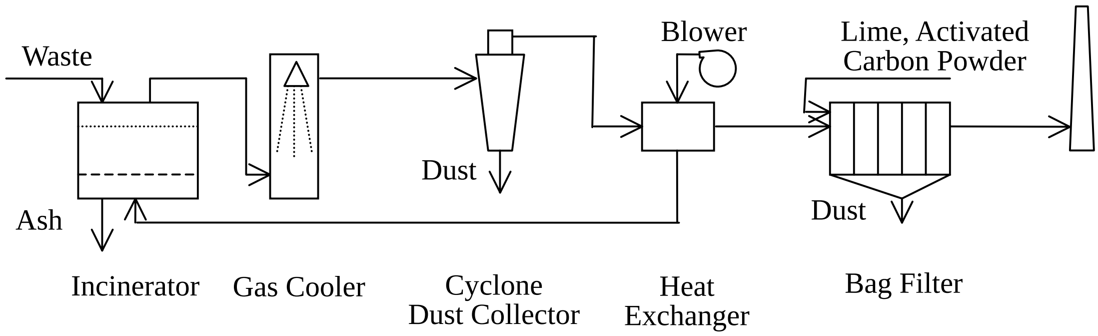
In the entire process from taking delivery of the waste to its final disposal, the facility inputs all relevant data, such as the type of the waste, treatment method, and quantity, into the on-line manifest system being controlled by the Pollution Control Department (PCD). Upon completion of the final disposal, the facility reports the result of disposal to the customer.

(3) Incinerator

The facility is equipped with a fluidized bed incinerator with an incineration capacity of 60 tons/day, incinerating waste oils, waste solvents, sludge, waste organic chemicals, inflammables contaminated with chemicals, wastewater containing organic matter, etc., continuously for 24 hours a day. The incinerator is loaded so as not to exceed 4,000 kcal/kg in calorific value. No auxiliary fuel is used. Liquid wastes are blown into the incinerator by air, solid wastes are carried inside by screw conveyor, and sludge is thrown in by grab. The flow chart for waste gas treatment is as shown in Figure 1-6-1. Waste gas of about 950℃ from the fluidized bed incinerator is rapidly cooled to below 285℃ in the cooling tower in order to inhibit the formation of dioxins. It then passes through the cyclone separator to separate dust with large particle sizes. Thereafter, it flows through the heat exchanger to exchange heat with combustion air, with a result that its temperature drops to about 167℃. Then, lime powder for removing hydrogen chloride, sulfur dioxide, and other acidic gas, and activated carbon powder for removing traces of dioxins are blown in, and the waste gas is lead to the bag filter. Thus, the waste gas discharged from the smokestack meets the standard control limit imposed by the Singaporean government. The dioxins content is below the control limit of 0.1 ng/Nm^3. The analysis values are reported to the Pollution Control Department (PCD) once a year.

The incineration fee charged by this facility is S$330 to 390/ton for wastes containing neither chlorine nor sulfur, and S$600 to 850/ton for those containing either of them.

Figure 1-6-1 Process flow of waste gas from incinerator



(4) Wastewater

Wastewater transferred from a customer’s factory is subjected to a different treatment depending its properties: acidic or alkaline wastewater to neutralization or coagulation sedimentation; wastewater containing cyanide to oxidizing decomposition; and wastewater containing hexavalent chromium to reduction. Part of the treated wastewater is used to cool the waste gas from the incinerator.

The treated wastewater meets the standard control limit for wastewater for discharging into public sewer systems. A pH meter and an automatic shutoff valve interlocked with it are installed just upstream of the discharging exit in accordance with the instructions of the Pollution Control Department (PCD). When the standard control limit for wastewater is exceeded, these devices automatically stop the discharging flow out of the facility. The fee charged for the treatment of wastewater ranges from S$250 to S$350/ton.

(5) Wastes

Some types of wastes contain heavy metals. Those wastes include incinerator ash and dust collected by dust collector, and settled sludge resulting from wastewater treatment. This waste treatment facility accepts wastes from its customers, while at the same time certain amounts of wastes are generated in the facility. Both of these wastes are subjected to leaching tests to verify that they meet the standard control limits prior to transportation to the final landfill site at Pulau Semakau. Those of the wastes failing to meet the standard control limits undergo solidification mixed with cement and are then checked for compliance with the standard control limits prior to the final disposal. The standard control limits used in the leaching tests are generally more lax than those of Japan. For arsenic, for example, the control limit is set at 5 mg/liter against 0.3 mg/liter in Japan.

The fee charged for the solidification by mixing wastes accepted from the customer with cement ranges from S$400 to S$800/ton. The treatment facility is currently planning to install treatment equipment for waste fluorescent lamps containing mercury and other similar wastes.

(6) Miscellaneous wastes

Used solvents and IPA (isopropyl alcohol) are made reusable by vacuum distillation and purification. Aromatic chlorine compounds (such as chlorobenzene) and PCBs, which cannot be treated by this treatment facility, are transported to a treatment firm in Germany. Personnel of the facility verified in person that these wastes transported to Germany were treated at high temperatures. All these wastes are transported to Germany in accordance with the Basel Convention on the Transboundary Movements of Hazardous Wastes and their Disposal.

This treatment facility is equipped with a laboratory and a R&D center, where samples of wastes received from its customers are analyzed in order to determine the optimal treatment method. Leaching tests of wastes solidified by mixing with cement and the measurement of calorific value produced by incineration are also done there. This treatment facility, accredited by the Singaporean government to analyze wastes, is also consigned to analyze wastes received from other waste treatment firms. However, this facility is not capable of analyzing dioxins. Therefore, sampling of dioxins is consigned to an outside accredited firm, and their analysis is conducted by a laboratory in Japan or Europe. The market for dioxins analysis business in Singapore is not large enough to recover funds invested in the installation of dioxins analysis equipment, and the facility has no plan to analyze dioxins itself. The fee charged by an overseas company for analysis of dioxins is about S$2,500 per sample. The customer of the facility is required to pay this amount plus a sampling fee, or a total of S$5,000 per sample (about 350,000 yen). The analysis result is directly reported by the firm consigned for analysis to the Pollution Control Department (PCD).

This treatment facility also monitors groundwater to determine whether the soil within its premises is polluted. To this end, it compares data collected by it with the standard control limit set by the Danish government for groundwater. It has adopted this control limit because it has been used by the Jurong Town Corporation (JTC), the owner of the tract of land where it is located.

In addition, this treatment facility is also planning to conduct purification treatment of fluoride gas used in the semiconductor manufacturing process for recycling it. It is planned to adopt the dry scrubber treatment method, where activated carbon powder is blown into the gas to adsorb aluminum compounds and other substances contained as impurities. At present, there is no facility in Singapore that can treat this gas, which therefore is transported to Japan for treatment.

This facility, using subsidies from the National Science and Technology Board (NSTB), is engaged in research and development of technologies for detoxification and volume reduction of industrial wastes.

Section 7
Other Industrial Environmental Management

1. Other environmental control measures required for industries in Singapore

The preceding sections have dealt with water pollution management, air pollution management, and hazardous industrial waste management. These are major environmental measures indispensable in carrying out industrial activities in Singapore. Acts and regulations related to these measures are also outlined. Other issues related to environmental management that are necessary for industrial activities in the country include noise control measures, soil pollution control measures, and measures to control Legionella bacteria in circulating water of cooling towers. Below is an introduction of the information necessary in taking these additional measures. Considering the fact that Japanese companies usually commission outside analysis firms to measure wastewater, waste gas, and other environmental items, the system of accrediting environmental analysis firms in the country is also introduced below for informative purposes.

(1) Noise control measures

Factories Adjacent to Residential Districts Need to Consider Noise Control

Since factories in Singapore are located considering the degree of environmental loading, the line of business and others, noise rarely becomes an issue for chemical plants and the like located in large industrial estates away from residential districts. On the other hand, light industries and other similar industries adjacent to residential, commercial, or other districts may face the issue of noise pollution. In 2001, the Pollution Control Department (PCD) of the National Environment Agency (NEA) received 148 complaints about noises from factories, the causes of which included inappropriate installation of equipment and poor maintenance of equipment.

Control on noises from factories in Singapore is implemented in accordance with the Environmental Pollution Control Act (EPCA) and the Environmental Pollution Control (Boundary Noise Limits for Factory Premises) Regulations under the Act. The Regulations divides each day into three time zones: the daytime from 7:00 a.m. to 7:00 p.m., the nighttime from 7:00 p.m. to 11:00 p.m. and the midnight from 11:00 p.m. to 7.00 a.m. of the following day, and specify the upper limit on factory noises according to the characteristics of the adjacent facilities that may be affected by factory noise. The upper limit is specified in two terms: the average noise level for each time zone and the measured level for five minutes in each time zone. The specific upper limits on noise levels are given in Table 1-7-1. For factories adjacent to facilities requiring the highest quietness (including natural parks, hospitals, educational institutions, and libraries), for example, the upper limit for the daytime is 60 decibels (A) in terms of the time-zone average and 65 decibels (A) in terms of the five-minute average. For factories adjacent to other factories requiring the most lax control, the upper limit for the daytime is set at 75 decibels (A) in terms of the five-minute average.

When there are two sources of noise in a single factory, the upper limit applied to the factory is somewhat lowered according the differential in noise levels between the two sources.

Upon receipt of a complaint about noise, PCD measures the noise level. When the factory noise level is found in excess of the applicable upper limit, PCD orders the factory to implement a measure to reduce the noise level or repair or adjust the equipment that generates noise. When the implemented measure fails to reduce the noise level, PCD orders the factory to stop its operation or impose a fine or any other specified penalty. Small-to-medium-sized factories adjacent to residential districts in particular need to consider noise control.

Table 1-7-1 Boundary Noise Limits for Factory Premises

（Unit: dBA）

Type of affected premises	Maximum permitted noise level (reckoned as the equivalent continuous noise level over the specified period)		
	Day 7 am - 7 pm	Evening 7 pm - 11 pm	Night 11 pm – 7 am
Noise Sensitive Premises	60	55	50
Residential Premises	65	60	55
Commercial Premises	70	65	60

Type of affected premises	Maximum permitted noise level (reckoned as the equivalent continuous noise level over 5 minutes)		
	Day 7 am - 7 pm	Evening 7 pm - 11 pm	Night 11 pm – 7 am
Noise Sensitive Premises	60	55	50
Residential Premises	65	60	55
Commercial Premises	70	65	60
Factory Premises	75	70	65

(2) Soil pollution control

No Regulation Exists, but Soil Pollution Control Measures are Required

At present in Singapore, there is a statement concerning the prevention of soil pollution in the Environmental Pollution Control Act (EPCA), but no regulations for specific control. However, the Code of Practice on Pollution Control, issued in June 2002, carries a statement concerning soil pollution control in the form of a guideline, introducing procedures for soil pollution investigation and restoration from pollution.

Basically all tracts of land in industrial estates in Singapore are owned by the government, and may be used under a lease agreement for a fixed term. If soil pollution is found upon returning the possession of the tract of land at completion of the project, it will become a large issue whether it was polluted prior to its use or not. If the soil pollution was evidently occurred during the use, the lessee is required to restore the tract of land. This necessitates any lessee to take appropriate soil pollution control measures in anticipation of such a possible eventuality.

The Code of Practice on Pollution Control refers to soil pollution control roughly as follows:

a) An investigation for soil pollution shall be conducted when any tract of land that was previously used by an industry designated as one that may cause soil pollution is going to be used for any other purposes. If soil pollution is confirmed, the tract of land must be restored to a condition suitable for the new application. Industries designated as ones that may cause soil pollution are as shown in Table 1-7-2.
b) The owner or user of the tract of land in question shall conduct, or consign any entity on behalf of oneself to conduct, such investigation for soil pollution and restoration in a manner acceptable to the Pollution Control Department (PCD).
c) The investigation for soil pollution and restoration must be conducted in accordance with the technical guidelines listed below.
   - The Guidelines for Soil Pollution Control for Netherlands
   - ASTM E 1527-00 Soil Evaluation Standards, Phase I
   - ASTM E 1903-97 Soil Evaluation Standards, Phase II
   - ASTM E 1739-95el Soil Evaluation Standards at Petroleum Release Sites
   - New Zealand's Guidelines for Soil Pollution By Petroleum and Hydrocarbon
   - Other guidelines acceptable to PCD
d) A restored tract of land shall be checked by experts so as to confirm that it is restored as required.

A list of such experts is available at *http://www.env.gov/sg/info/cbpu/main.htm*

Voluntary Investigation on Soil Pollution by Some Japanese Companies

Four of the Japanese companies visited during this survey are voluntarily conducting an investigation on soil pollution on their factory premises. They belong to industries such as semiconductor that are not designated as ones that may cause soil pollution, and least likely to cause it.

At their factories, wells are dug at the edges of the premises and groundwater samples are taken for analysis. Groundwater was monitored at regular intervals prior to the construction of the factory and after the start of operations. Some of them are using groundwater standards of the Netherlands and Denmark. The standard of Denmark is not included in the recommended technical guidelines listed above, but seems to have been accepted by PCD.

Table 1-7-2 Pollutive Activities Subject to Site Assessment

a	Oil installations and other premises storing, handling and using large quantities of oils and similar hydrocfabons products, including the following: Oil refineries; Oil depots; Petrochemical complexes; Petrol stations and refuelling depots; Aircraft manufacture and repair industries; Motor repair workshops.
B	Chemical plants, chemical warehouses or terminals including the following: Chemical warehouses or terminals; Pharmaceutical/biomedical plants; Wood treatment and preservation facilities; Large electroplating works; Factories that use, manufacture or store toxic chemicals.
c	Shipyards and grit blasting works
d	Gas works
e	Power stations
f	Toxic wastes treatment facilities
g	Scrap yards
h	Landfill site for municipal or industrial wastes
i	Facilities for the treatment of sewage.

(3) Measures for controlling legionella bacteria

Legionella Bacteria Control Unique to Singapore

Singapore is implementing a unique control measure for Legionella bacteria that may be detected in the circulating water of cooling towers used by many factories. Infection with Legionella bacteria may affect people who have poor resistance to disease such as the elderly people, infants and convalescent persons, and may result in death if things come to the worst. In the wake of victims of Legionella bacteria appearing in Australia, Singapore started to establish regulations on the bacteria. The resulting regulations, namely, the Environmental Public Health (Cooling Towers and Water Fountains) Regulations under the Environmental Public Health Act (EPHA) started to be applied for control of the bacteria in March 2001. The Regulations consist mainly of structural and maintenance standards for cooling towers, and safety standards for cooling-tower cleaning operators.

The structural standards require the installation of shielding walls preventing splashes on operators, consideration of the location of installation, and the adoption of an easy-to-clean structure.

The maintenance standards stipulates, among others, the stopping and cleaning the cooling tower once every six months to prevent the multiplication of Legionella bacteria; sterilization chemicals and procedures to be used during cleaning; bactericides to be injected into circulating water; periodic monitoring of circulating water; reporting of monitoring results; and steps to be taken in emergency.

The maintenance standards provide that two types of bactericides be used alternately every other week, in order to prevent Legionella bacteria from developing resistance to bactericides. They do not stipulate any specific type of bactericide, but specify that chemicals not prohibited under the Poison Act, chemicals meeting the British Standard 5750, bactericides that do not generate hazardous by-products after use, etc., shall be used.

Sterilization Necessary as Part of Compulsory Steps If Legionella bacteria are Detected

It is made compulsory to measure circulating water for Legionella bacteria at regular intervals. There are two types of measuring methods specified: the Standard Plate Count, to be conducted once every month, and the

Legionella Bacteria Count, to be conducted once every three months. The factory must commission an accredited analysis laboratory to make these measurements. The analysis laboratory reports the analysis results directly to the Quarantine and Epidemiology Department of the National Environment Agency (NEA). If Legionella bacteria are detected, within 24 hours, the Quarantine and Epidemiology Department notifies the factory in question of what steps to be taken. The count of Legionella bacteria detected and the corresponding steps to be take are as shown in Table 1-7-3.

As a part of the compulsory steps to be taken if the evaluation rating is "Dangerous" or higher, a detailed process using sodium hypochlorite that has a strong bactericidal action is stipulated for cleaning and sterilization. Sodium hypochlorite, when dissolved in water, generates free chlorine, which has a strong sterilization effect. However, the Singaporean government sets the control limit for free chlorine in wastewater discharged into public sewer systems at 1 mg/liter, a very stringent value. Wastewater resulting from the sterilization process must be treated to below this control limit prior to discharging it into public sewer systems.

Table 1-7-3 Enforcement action for legionella bacteria

(Unit: cfu/millilitre)

Standard plate count	Interpretation	Action
> 100,000	Potentially hazardous situation	Enforcement action will be taken under the Environmental Public Health (Cooling Towers and Water Fountains) Regulations 2001.

Legionella bacteria count	Interpretation	Action
≦10	Maintenance practices may not be satisfactory	Advisory letter to rectify maintenance programme, monitor and follow-up.
＞10 – 1000＜	Potentially hazardous situation	Enforcement action will be taken under the Environmental Public Health (Cooling Towers and Water Fountains) Regulations 2001.
≧1000	Serious condition	Order under Environmental Public Health (Cooling Towers and Water Fountains) Regulations 2001 to shut down the system immediately, decontaminate, clean and disinfect, monitor and follow-up.

(4) Accreditation system for analysis laboratories

Analysis Values for Submission to a Government Agency Need to Be Those Obtained by an Accredited Laboratory

Many Japanese companies commission an outside analysis laboratory to make various environmental measurements. It should be noted that in Singapore, there is a accreditation system for analysis laboratories that analyze the compositions of wastewater, waste gas, solid wastes, etc., and analysis values for submission to the Pollution Control Department (PCD) must be those obtained by these accredited laboratories. The accreditation body is the Singapore Laboratory Accreditation Scheme (SINGLAS) of the Singapore Accreditation Council (SAC).

In Singapore, manufacturers, consumers, contractors, government officials or others depend on analysis by accredited laboratories for assurance that raw materials, products, services rendered by contractors, or the like have the qualities as required by them. The measurement technology and accuracy control of these accredited analysis laboratories conform to the requirements of the international standard, ISO/IEC 17025. The areas covered by the accredited laboratories include the environment, chemical and biological testing, nondestructive inspection, mechanical testing, electrical testing, medical testing, urban engineering, and accuracy control.

On the basis of the international standard, accredited laboratories maintain and inspect analytical equipment; prepare reagents; take and store samples; take custody of standard substances; conduct accuracy control; process data; and prepare reports.

Highly Capable Analysis Laboratories in Singapore

The Singapore Laboratory Accreditation Scheme of the Singapore Accreditation Council (SAC-SINGLAS) is a member of the Asian-Pacific Laboratory Accreditation Cooperation, an international association of laboratory accreditation organizations. The Singapore Laboratory Accreditation Scheme is affiliated with six international associations of laboratory accreditation organizations. Analysis values obtained by accredited analysis laboratories are mutually checked in order to improve the accuracy in analysis. Supported by these activities, accredited analysis laboratories in Singapore are capable of providing analysis values acceptable by international standards.

In the environmental area, there are two governmental accredited laboratories and eight private ones in Singapore. Their points of contact are listed in Table 1-7-4. They are capable of analyzing almost all items, but analysis for dioxins is not possible in Singapore because there is no analytical equipment for that purpose in the country.

Table 1-7-4 List of Accredited laboratories

Government / Statutory Board Laboratories
PSB Corporation Pte Ltd, Chemical and Material Test Centre 1 Science Park Drive, Singapore 118221 Tel: 6772 9552 Fax: 6778 4301
Health Science Authority - Environmental Laboratory, Center for Analytical Science 11 Outram Road, Singapore 169078 Tel: 6229 0778 Fax: 6229 0749
Private Laboratories Accredited by SAC-SINGLAS
M/s ALS Technichem (S) Pte Ltd 14 Little Road, #07-01 & #08-01, Tropical Industrial Building, Singapore 536987 Tel: 6283 9268 Fax: 6283 9689
M/s Analytical Laboratories (S) Pte Ltd 134 Genting Lane, Singapore 349580 Tel: 6295 4213 Fax: 6297 2589
M/s Chemical Laboratory (S) Pte Ltd 520 Balestier Road, #06-01 Leong On Building, Singapore 329853 Tel: 6253 6122 Fax: 6250 4837
M/s Chemitreat Pte Ltd 28 Tuas Avenue 8, Singapore 639243 Tel: 6861 3630 Fax: 6861 3853
Intertek Testing Services (S) Pte Ltd (Caleb Brett Division) 59 Penjuru Road, GATX Terminals, Singapore 609142 Tel: 6265 5385 Fax: 6265 3716
Setsco Services Pte Ltd 18 Teban Gardens Crescent, Singapore 608925 Tel: 6566 7777 Fax: 6566 7718
SGS Testing & Control Services Singapore Pte Ltd 26 Ayer Rajah Crescent, #03-07, Singapore 139944 Tel: 6775 5625 Fax: 6777 2914
Singapore Test Services Pte Ltd 249 Jalan Boon Lay, Singapore 619523 Tel: 6660 7597 Fax: 6261 2617