Technical Manual on Industrial Pollution Control

(Metal plating industry & Marine products-processig industry)

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

MARCH 1996

JAPAN ENVIRONMENT CORPORATION

FOREWORD

Although various incidents of industrial pollution and deterioration of the living environment had occurred in Japan in the period of high economic growth beginning in the latter half of the 1950s, these critical situations were overcome by taking measures throughout the country. Information on such experiences and pollution control techniques, obtained in Japan, would contribute greatly to countries that need pollution control measures at present. It is also one of our duties in international activity for solving environmental problems, to supply environmental information to overseas areas.

Environmental protection techniques have progressed together with technical innovations of production equipment. Private corporations have planned to improve their productivity amid keen competition and endeavored to reduce the impact of their production processes on the environment. By corporate adoption of the "cleaner production policy", environmental protection can be more effectively achieved.

Many technical innovations concerning such areas as production and environmental protection have been made by private corporations. On the other hand, the national government and local public bodies have played important roles in achieving pollution control by taking various measures such as establishment of emission standards, scheduling of environmental pollution protection programs, and providing guidance/assistance to private corporations. Accordingly, it is said that pollution control in Japan has been achieved by cooperative efforts between the government and the people.

The Japan Environment Corporation (abbreviated as "JEC", hereafter) has striven to prevent industrial pollution by operating construction and transfer programs and financing business as a national specific assistance organization for preventing pollution throughout the 30 years since its foundation in 1965. Particularly, although small- and medium-scale corporations were strongly urged to prevent pollution, it was difficult for them to enforce the necessary measures from the aspects of funds and technique. JEC has assisted to enable them to establish pollution control.

This "Technical Manual on Industrial Pollution Control" covers subjects concerning the metal plating industry and marine products-processing industry, according to project cases of JEC and focusing on the small- and medium-scale corporations whose pollution control measures are particularly necessary in developing countries.

JEC entrusted the Overseas Environmental Cooperation Center, with the project of "investigation and research related to building of database for transferring environmental information overseas" and edited "Overview of Japan Environment Corporation (JEC) and Case Studies" containing summaries of JEC'S functions and experiences, construction and transfer programs cases (case files) and financing programs cases (data sheets). The present "Technical Manual on Industrial Pollution Control" complements this "Overview of Japan Environment Corporation (JEC) and Case Studies".

We will be extremely pleased if the experience obtained during implementation of pollution control measures in Japan provides useful reference in countries striving for pollution control and can contribute to protecting the global environment.

Japan Environment Corporation

Osamu Watanabe
President

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Contents

1. Pollution Control Measures in Japan, and JEC

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

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

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

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

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

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

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

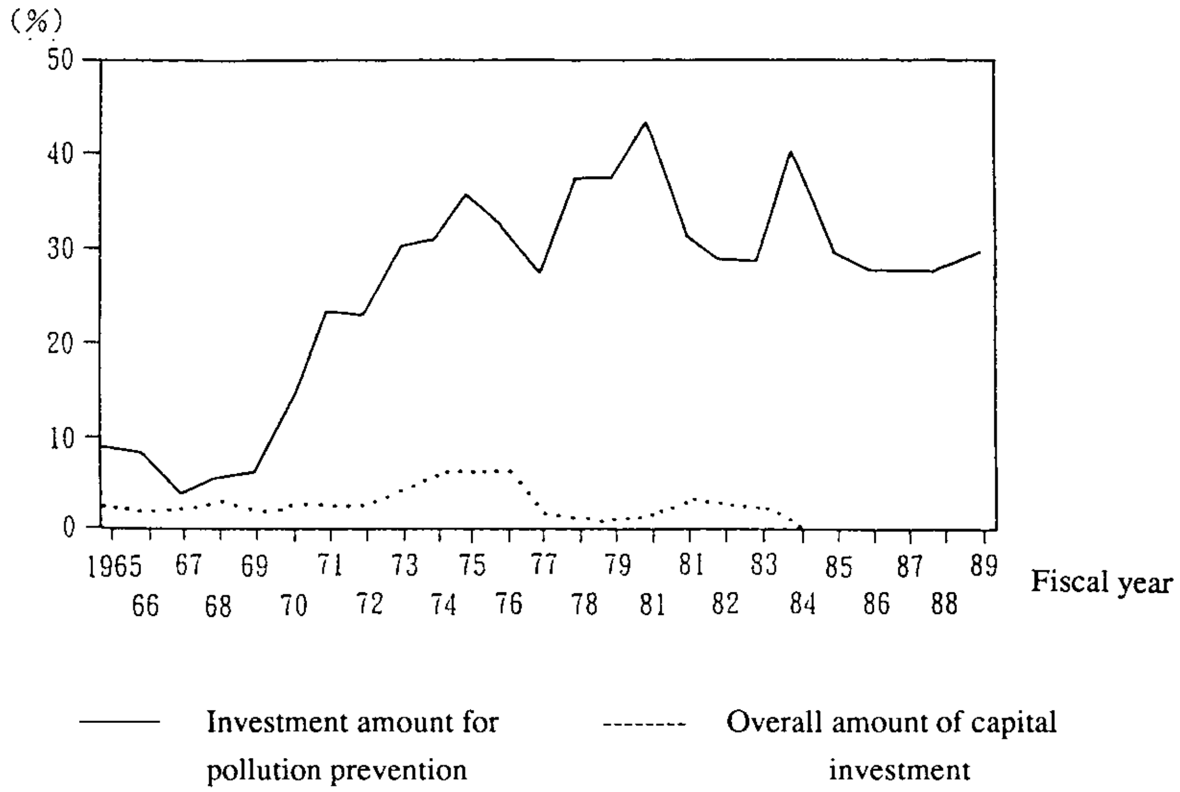
It should not be forgotten that such transfer projects of JEC not only contributed to improving of the on-site environment but at played a leading role in the pollution control measures taken by private corporations. Involving repeated trial and error, these pioneering project cases implemented by JEC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

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

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

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

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



(Note) The ratio of financing by government-affiliated financial organizations to the total investment for pollution prevention is obtained by computing as follows: the ratio of the sum of investments made by the Japan Development Bank and by JEC for pollution prevention and control to the total amount invested for pollution prevention based upon the above data from the Ministry of International Trade and Industry study.

(Source: Quality of the Environment in Japan 1992)

2. Environmental Problems in Developing Countries, and JEC

Among developing countries, some countries and districts in the process of fast economic growth are confronted with industrial pollution and urban environmental problems accompanying unprecedentedly rapid changes of the existing structure of society. They appear to be in a common situation, the same one we experienced involving pollution and environmental problems in Japan.

To assist solving such problems, it seems useful to inform developing countries of these experiences. In particular, the data accumulated by JEC are doubly significant, i.e. (1) Technical information on pollution control measures enforced in business, and (2) Management and business know-how as a financial organization specialized in pollution control. As a part of its new mandate of "providing environmental information to overseas areas", JEC has started a new program of providing information on projects carried out to date and project operation know-how.

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

Since the 1995 fiscal year, as a part of this project, by extracting technical information about pollution control measures involved in the past financing and construction/transfer projects by industrial category, JEC has started to prepare a document summarizing technical guidelines. This document, translated into English, is expected to be widely used as a training text book, oriented toward administrative officials and environmental pollution managing engineers in developing countries. In this fiscal year, the first year of this program, the metal plating industry and the fishery processing industry, which produce significantly great amounts of pollutants especially from small- and medium-scale enterprizes in the Asian region, have been selected for the target sector. The current document entitled " Technical Manual on Industrial Pollution Control — Based on project cases and investigation and research reports of Japan Environment Corporation (JEC) —"is the product.

In May 1993, a "Global environmental fund" was established by contributions from the government and private bodies, and management of the fund was entrusted to JEC. Since then, using the managing yields of the fund, JEC has been providing fund assistance and other support for environmental protection activities conducted by domestic and overseas non-governmental organization (NGO). Although various kinds of projects such as nature conservation and environmental education and training are also eligible for JEC assistance, projects related to industrial pollution control include "International workshops on pollution control measures of small- and medium-scale corporations in Asian region" by the Overseas Environmental Cooperation Center (Japan) and TechnoNet (Singapore), "Activities to provide Vietnam with information about experiences of environmental pollution and civilian activity in Japan" (Indochinese Civilian Cooperation Center) and "Seminar on environmental problems, focusing on air pollution in India" (Association for Overseas Technical Scholarship, Japan)

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3. General Approach to Industrial Pollution Control

Industrial pollution control in Japan had been carried out separately for pollutants in water, pollutants in the atmosphere and solid waste generated in production processes. This is because environmental regulations in Japan had been developed separately for each medium to which pollutants are discharged, that is for water, atmosphere and solid waste, so that individual response to these separate regulations was required. However, such methodology merely encourages the transfer of pollutants among media, and lacks efficient performance in reducing the total amounts of hazardous substances discharged into the environment. Furthermore, it is expensive to have individual facilities installed and operated for the individual medium to which pollutants are discharged.

Having developed varied experience, the concerns, "how to prevent generation of contaminants in the production process or to eliminate the sources, and how to recycle generated contaminants" became dominant now. With such concern, an integrated emission reduction program is examined, instead of examining the treatment method for contaminants and waste with the premise that they are already generated. Although at first such an approach was not considered evidently superior, its superiority was gradually recognized in the history of pollution control in Japan as well as in other industrialized countries and it is internationally recognized now. Essential elements of such an approach are discussed below.

3.1 Organization and Education for Pollution Control

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

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

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

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

3.2 Need for Prior Investigation

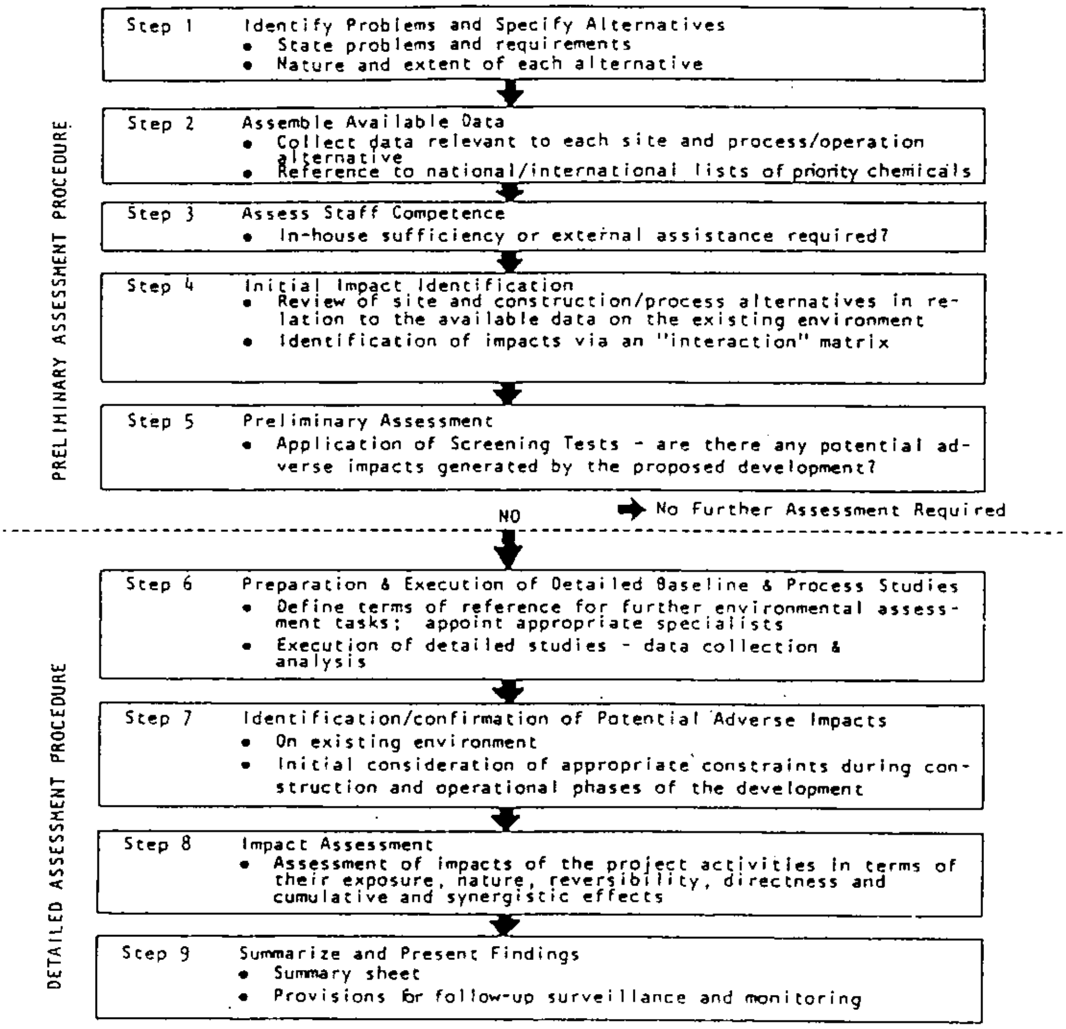
It is desirable to conduct environmental impact assessment when new siting, relocating or expanding a factory, and when renovating a facility. By doing so, the present situation surrounding the factory can be understood and the sources and amounts of contaminants to be generated by the planned production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

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

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

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

Fig. 3-1 Typical Flow of Environmental Impact Assessment



Step 1 Identify Problems and Specify Alternatives
- State problems and requirements
- Nature and extent of each alternative

Step 2 Assemble Available Data
- Collect data relevant to each site and process/operation alternative
- Reference to national/international lists of priority chemicals

Step 3 Assess Staff Competence
- In-house sufficiency or external assistance required?

Step 4 Initial Impact Identification
- Review of site and construction/process alternatives in relation to the available data on the existing environment
- Identification of impacts via an "interaction" matrix

Step 5 Preliminary Assessment
- Application of Screening Tests - are there any potential adverse impacts generated by the proposed development?

No Further Assessment Required

Step 6 Preparation & Execution of Detailed Baseline & Process Studies
- Define terms of reference for further environmental assessment tasks; appoint appropriate specialists
- Execution of detailed studies - data collection & analysis

Step 7 Identification/confirmation of Potential Adverse Impacts
- On existing environment
- Initial consideration of appropriate constraints during construction and operational phases of the development

Step 8 Impact Assessment
- Assessment of impacts of the project activities in terms of their exposure, nature, reversibility, directness and cumulative and synergistic effects

Step 9 Summarize and Present Findings
- Summary sheet
- Provisions for follow-up surveillance and monitoring

Fig. 3-2 Typical Cause-Effect Matrix of Environmental Impact Assessment

		NATURE AND CHARACTERISTICS OF THE PROPOSED DEVELOPMENT						
		A SITE PREPARATION AND CONSTRUCTION Industrial buildings and process structures Highways, roads and tracks Bridges Railways and sidings Transmission lines, pipelines and corridors Barriers, including fences Channel dredging and straightening Canals Dams and impoundments Deepwater ports and marine terminals Blasting and drilling Underground works Surface excavation, incl. cut and fill Land clearing, incl. burning Surfacing or paving Erosion control and terracing Landscaping Noise and vibration	B PROCESS OPERATIONS Cooling water discharge Liquid effluent - industrial and domestic Water demand Septic tanks - domestic and industrial Stack and exhaust emissions Spent lubricants Noise and vibration Odour	C RAW MATERIAL HANDLING Dust Stockpiling Noise and vibration	D ENERGY PRODUCING OPERATIONS Atmospheric emissions Cooling water discharge Liquid effluent Water demand Stockpiling of materials Noise and vibration	E TRANSPORTATION REQUIREMENTS Highways, roads and tracks Bridges Railways and sidings Shipping	F ACCIDENTS/HAZARDS Explosions Spills and leaks Operational failures	G WASTE DISPOSAL AND CONTROL Landfill, spoil and overburden Solid waste disposal
CHARACTERISTICS OF THE EXISTING ENVIRONMENT	1 CLIMATE AND AIR QUALITY Wind directions and speeds Precipitation/humidity Air quality							
	2 WATER Hydrological balance Groundwater regime Drainage/channel pattern Sedimentation Flooding Water quality Surface waters							
	3 GEOLOGY Unique/special features Tectonic/seismic activity and volcanic actitity Mineral resources Physical/chemical weathering Landslide Subsidence							
	4 SOILS Erosion (wind and water) Slope stability Liquefaction Bearing capacity Settlement/heave Earthworks Soil structure							
	5 ECOLOGY Species checklists Plant communities Diversity (species and spatial) Productivity Biogeochemical/nutrient cycling							
	6 ENVIRONMENTALLY SENSITIVE AREAS Prime agricultural land Forestry land (silviculture) Wetlands/estuarine and coastal zones Landfills (solid/toxic waste disposal sites)							
	7 LAND USE AND LAND CAPABILITY Land use Land capability							
	8 NOISE AND VIBRATION Noise Vibration							
	9 VISUAL QUALITY							
	10 ARCHAEOLOGICAL, HISTORIC AND CULTURAL ELEMENTS Archaeological structures and sites Historic/cultural structures, sites and areas							

3.3 Technical Options for Industrial Pollution Control

3.3.1 Group Location and Transfer

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

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

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

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

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

3.3.2 Individual Treatment System versus Joint Treatment System

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

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

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

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

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

3.3.3 End-of-Pipe Technology and In-Process Technology

Since environmental regulations in Japan are oriented toward each medium (water, atmosphere, solid waste) which contains pollutants, industrial pollution control measures have progressed individually to cope with these separate regulations. However, measures which apply "end-of-pipe technology" (terminal treatment) always require additional investment to the production facility, and continuous costs for operation and maintenance. Another disadvantage of "end-of-pipe technology" is transfer of contaminants among environmental media, or generation of secondary pollution; for example, wastewater treatment may produce another pollution as regards solid waste disposal associated with sludge management.

On the contrary, pollution control through the application of in-process technologies (that is, through the review of raw material and processing technology, the production process itself is improved, rationalized or replaced.) enables simultaneously resource and energy conservation and also contribute to the production cost saving. The fact that such an approach, called "Cleaner Production (CP)" is far more effective has already been proved in the experiences of industrial pollution control in most developed countries.

Consequently, regulations themselves are changing as an international trend. Instead of controlling the emissions in each medium (such as water, atmosphere, solid waste emissions) by different laws or specific emission standards, the methodology called the integrated approach is becoming the mainstream. In this approach, each factory is evaluated for its environmental management system, production process and pollution control facilities, according to the technical and economic constraints and environmental requirement, and operational permission is considered. Such an approach is particularly important in the developing countries that should achieve sustainable development with limited resources.

Japan is not an exception. CP technology has brought solutions for the serious problems of industrial pollution, i.e. organic mercury contamination in Minamata (Kumamoto-Prefecture) and pulp and paper effluent contamination in Tagonoura (Shizuoka-Prefecture) where the decisive technical factor contributing to terminating the pollution was not the arrangement of end-of-pipe treatment facility but replacement of the production process. These are the most obvious examples, but many other examples of wastewater rationalization and waste recycling are seen in small- and medium-scale corporations such as the metal plating and textile dyeing industries.

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

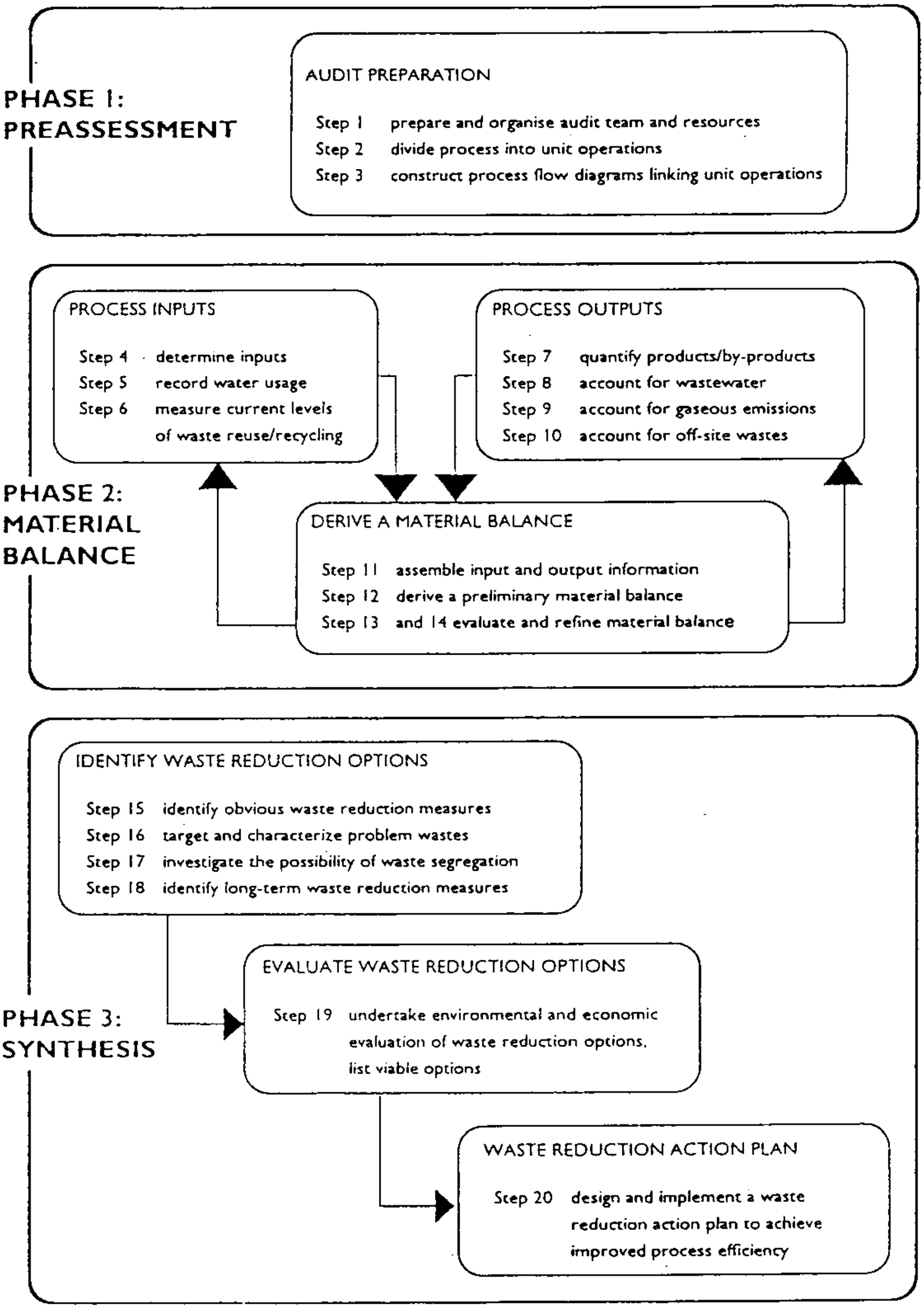
3.3.4 Monitoring and Management

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

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

An environmental audit is composed of systematized procedures described above. As a management tool, an example of the audit process, advocated by UNEP/UNIDO, is shown on the following pages.

Fig. 3-3 Audit of Pollution and Waste Discharge and Processes for Their Reduction According to UNEP/UNIDO



4. Sectoral Approach to Pollution Control

4.1 Metal Plating Industry

4.1.1 Outline of Metal Plating

Plating is a treatment technique for forming various kinds of thin metal coatings on the surfaces of metals and plastics in order to add product characteristics such as beauty, hardness, protection and electric conductivity.

These products include molded and processed metals and plastics with plating surface finish, ranging from automobile parts, electric equipment parts, electronic equipment parts, communication device parts, precision mechanical equipment parts to optical instruments, building hardware, flatware, musical instruments and toys. The plating enterprise characteristically do plating finishing mainly entrusted by parts makers, finished product makers and firms, as subcontractor.

The usual plating process is as follows:

1) Confirmation of material quality and setup of processing conditions
2) Surface polishing as required by clients
3) Pre-washing as required by processing material
4) Racking
5) Plating treatment
6) Deracking
7) Quality inspection and packing

In the plating, 10 to 30 or more processes are involved from pretreatment to drying. Depending upon the plating purposes such as rust prevention, decoration, physical/chemical/electrical properties, various kinds of processes are used.

Very recently, plating techniques have rapidly progressed responding to developments in semiconductor manufacturing, the diversification of product quality requirements, and accountability for environmental protection, and conservation of resources and energy.

4.1.2 Outline of Metal Plating Industry in Japan

(1) Metal plating category

According to the Standard Classification of Japanese Industries the type of industry is classified by the products of each corporation; accordingly, factories and corporations, such as these doing electric machine and appliance manufacturing, semiconductor element manufacturing and metal equipment manufacturing where completed products are manufactured, involve plating treatment as a part of their production process.

However, the electroplating industry categorized by the Standard Classification of Japaness Industries is an industry that mainly does only plating treatment as subcontracted work, accordingly, the electroplating industry industrial classification means plating factory assemblies mainly conducting treatment work as subcontractors.

(2) Product list

Depending on the purpose for which the plated product is used, plated products are classified as follows:

1) For decoration
  Products such as necklaces, plated with precious metals (gold, silver, platinum) and their alloys.
2) For decoration and rust-proofing
  Rust-proofing with adding beautiful appearance to base metals such as steel, cast iron and copper alloys. This product category covers almost all metal utility articles ranging from lighters, bicycles, and building hardware to electrical products and parts, and automobile parts.
3) For corrosion prevention
  Zinc and tin plating on iron and steel base metals. Since the coating metal layer protects of the base metal from corrosion, the corrosion prevention property by plating's thickness is more important than beautiful appearance.
4) For industrial use
  Taking advantage of the physical and chemical properties of the metal plating layer, chrome plating is used for abrasion-proofing, lubrication and heat resistance. Recently, with developments in the electronic industry, gold, silver, copper, nickel, tin and solder alloy plating have become popular. In the electroplating treatment technique, the product to be plated is dipped into a solution of dissolved metal (plating solution), the product is connected at the negative electrode side and a positive electrode plate is put at the opposite side. By passing direct current (DC) through the solution, the metal dissolved in the solution deposits on the surface of the product to form a metal coating.

Metals available for plating in aqueous solution are:

Copper, nickel, chromium, zinc, cadmium, tin, lead, gold, silver, platinum, cobalt, iron, antimony, bismuth, mercury, gallium, _indium, thallium, arsenic, selenium, tellurium, polonium, manganese, rhenium, ruthenium, rhodium, palladium, osmium, iridium, tungsten, etc.

Metals available for plating in both aqueous solution and non-aqueous solution are: Copper, silver, zinc, cadmium, arsenic, antimony, bismuth, iron, cobalt, nickel, etc.

Metals available for plating in non-aqueous solution are:
Lithium, sodium, potassium, beryllium, magnesium, calcium, strontium, barium, aluminum, lanthanum, titanium, zirconium, germanium, molybdenum etc.

Thus, almost all metals can be used for plating.

(3) Scale and locational features of plating corporations

Characteristics of electroplating are that it can be carried out simply by arranging only power equipment, plating bath and several items of pretreatment equipment such as a polishing machine, that various kinds of plating products can be produced by using appropriate chemicals depending on the purpose. An electroplating company often locates next to the integrated metal factory which manufacture automobiles, tableware, agricultural tools, blades or other metal ware, and substitute plating departments of the integrated metal factory (parent factory), as subcontractor. For this reason, plating companies are usually small (Table 4-1-1) and their geographical distribution corresponds to that of parent factory, i.e. concentrated in metropolitan area, including Tokyo, Osaka and Aichi Prefectures.

Table 4-1-1 Status of Metal Plating Corporations (1993: Industrial Statistics)

Category	Total corporations	>100 employees	10-99 employees	4-9 employees	<3 employees
Electroplating	2,565	35	1,064	1,062	404
Hot-dipping	238	11	129	62	36
Plating steel pipe manufacturing	10	4	6	0	0
Other metal surface treatment	7,018	26	844	1,765	4,384

Since their location is also limited to urban districts from the viewpoints of receiving orders, destination of product shipments and labor supply, small-scale plating factories have historically been located in residential areas or commercial areas. But, they are not welcomed by the surrounding residents for the following reasons.

1) Because they handle various hazardous substances, they give the impression of being dangerous.
2) Since ventilation is done in the factory to protect the working environment from acidic mist and dust generated in the work site, exhaust gas and odors are released outward and affect the surrounding area.
3) Dust and noise are generated by the buff-polishing process.
4) Peripheral roads are occupied by unloading and unpacking work for plating materials and products, obstructing residents' traffic.

Along with the population increase in urban districts, as redeveloping former factory sites for housing sites proceeds, coexistence of factories and residents is becoming more difficult; on the other hand, owing to anxiety about whether good labor power can be attained in remote districts plating sites have to be located in urban districts.

To make sure that chemical management and environmental control measures are carried out, and to respond to social needs, measures such as improvement of plating processes and changing of applied chemicals are being taken with the aim of business development and coexistence with residents around each factory.

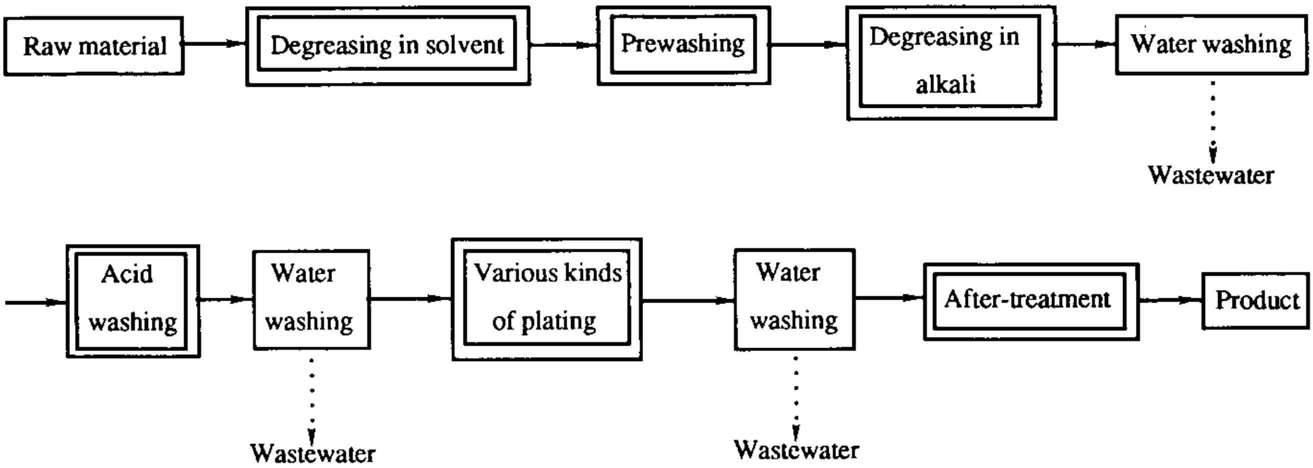
To cope with these tasks, corporations are proceeding with cooperative projects, i.e. building industrial parks, as one measure.

4.1.3 Metal Plating Processes

(1) Basic process

The basic processes of plating are as follows:

Fig. 4-1-2 Basic Process of Metal Plating



(2) Pretreatment Process

Surface polishing, a pretreatment process with the main purposes of removing stains and grease and flattening the surface, has been carried out by mechanical or chemical methods.

In addition, high-precision polishing techniques have been developed to meet new demands for cleanness in the electronic function processing and the product processing of semiconductor materials.

1) Mechanical polishing
To flatten the surface, filing, jet polishing using sands, buffing using oil and emery powder, and barrel polishing for small-size metalware such as spoons, is selected depending upon the state of the surface.

2) Chemical polishing
By dipping into strongly acidic polishing solution, the protruding metal portions of the object are selectively dissolved.

3) Electrolytic polishing
By connecting the object metal to a positive electrode, in the reverse of the arrangement used for electroplating, and passing DC through the solution, protruding portions on the surface of the object are eluated. This is mainly applied to stainless steel at present.

4) Degreasing in alkaline solution

Grease can be removed by dipping metal into alkaline degreasing solution.

5) Degreasing in acidic solution

By dipping metal into acidic degreasing solution, grease, rust and dirt are removed.

6) Degreasing in solvent

Using solvents such as trichloroethylene, grease is dissolved for removal.

The process of each polishing method is shown in Fig. 4-1-3, and examples of compositions of polishing agents, chemical polishing solution and alkaline degreasing solution are explained in Table 4-1-4.

(3) Plating process

The main plating process, as shown later, is carried outby various methods such as electroplating, non-electrolytic plating and hot dipping, according to the kind of product and applied metal.

The electroplating technique is as follows:

A product to be plated is immersed in the metal-dissolving solution and connected to the negative electrode side, the positive electrode is placed at the opposite side, then by passing DC through the solution the metal in the solution deposits on the product surface to form metallic coating.

The non-electrolytic plating technique is as follows:

By utilizing the electrochemical reaction between the dissolved metal ion and the product to be plated, the metal deposits on the product surface to form metallic coating.

Fig. 4-1-3 Polishing Process (1)

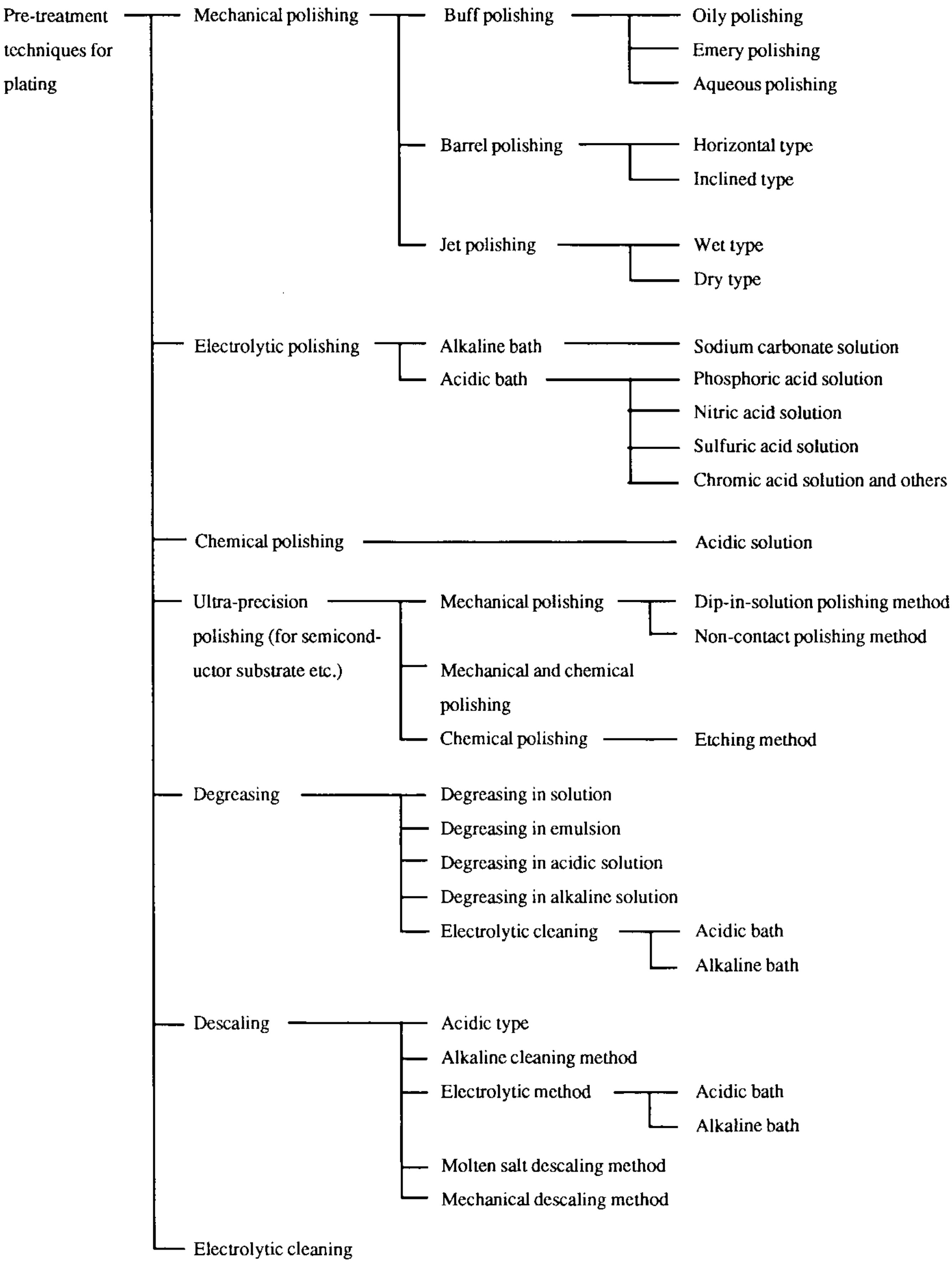


Table 4-1-4 Polishing Process (2)

Conventional polishing materials

Name	Main component	State & properties		Usage
Emery	$Al_2O_3 \cdot Fe_2O_3$ (Natural product)	Black, granular	Sieve fraction No. depends on particle size.	Rough polishing of base material
Aluminum	Al_2O_3 (Artificial product)	Light-brown, granular	Ditto Harder than emery but brittle	Ditto
Corundum	Al_2O_3 (Natural product)	Ditto	Ditto	Ditto
Tripoli	SiO_2 (Natural product)	Red/light-yellow, granular	Amorphous silica, absorbs water and grease, too soft to polish hard metal	Intermediate polishing, mixed with emery for use
Gloss	Fe_2O_3 (Artificial product)	Dark red	Calcined ferric sulfate	Intermediate polishing, for brightening
Red rod (Rosy)	Fe_2O_3 (Artificial product/ Natural product)	Red	High purity ferric oxide, obtained from calcined ferric sulfate, kneaded with high-melting point fat	Brightening and finish polishing agent
Blue rod	Cr_2O_3 (Artificial product)	Green	Hard, kneaded with high-melting point fat	Finish polishing of hard metal
Lime (Machress)	$CaO \cdot MgO$ (Artificial product)	White	Calcined dolomite, water absorptive	Finish, bright polishing

Example: composition & condition of chemical polishing solution

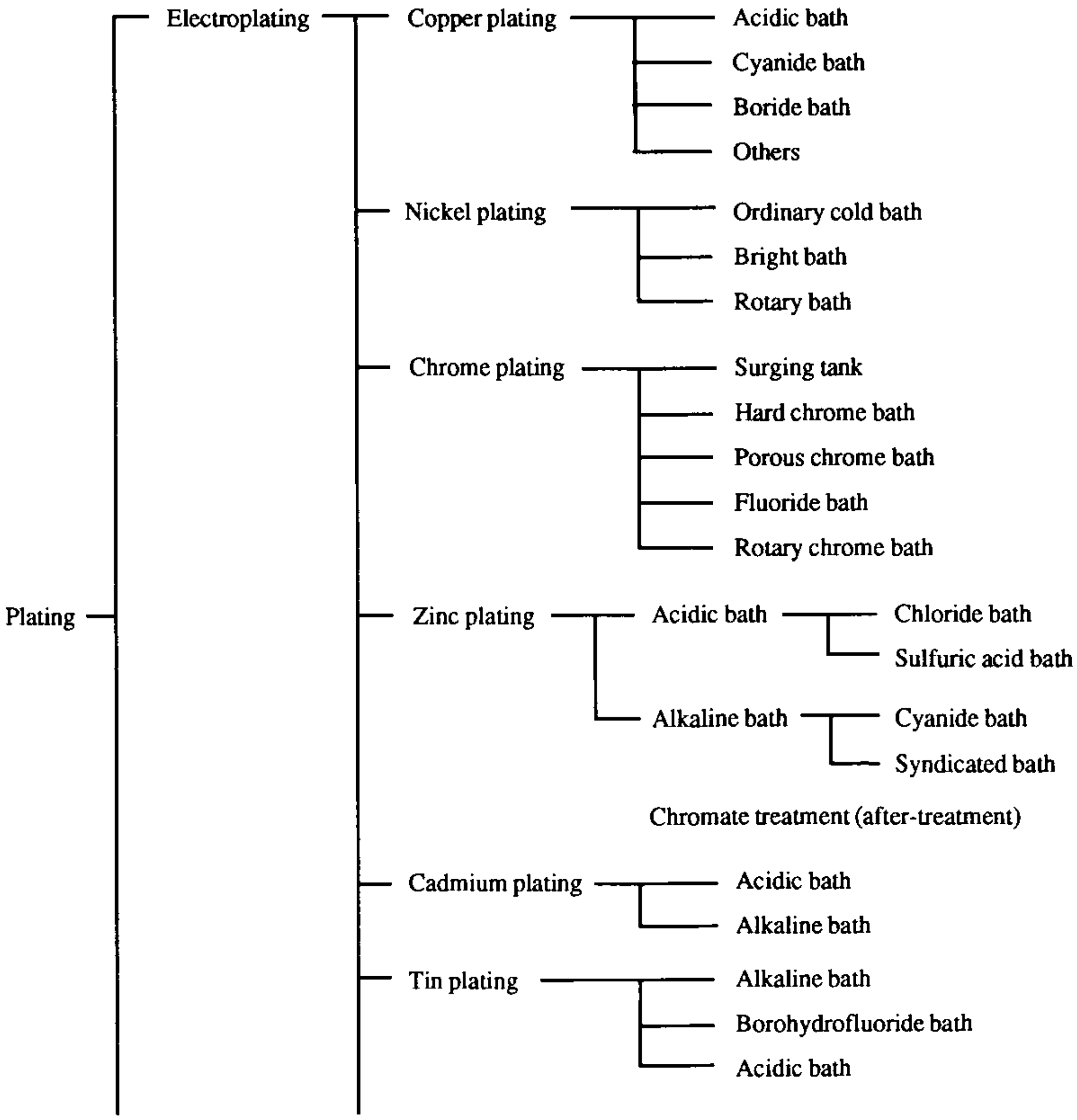
Metal	Composition [gl^{-1}]	Temperature (degrees °C)
Aluminum	H_3PO_4 70 - 80%, HNO_3 2 - 3.5%, H_2SO_4 0 - 40%, CH_3COOH 0 - 0.1%	90 - 100
	HNO_3 130, NH_4HF_2 160, $Pb(NO_3)_2$ 0.2	55 - 80
Iron & steel	H_3PO_4 condensate	120
	$(COOH)_2$ 25, H_2O_2 13, H_2SO_4 0 - 0.1	20 - 30
Copper & its alloys	HNO_3 32, H_2SO_4 64, HCI 1, H_2O 64	Room temperature
	H_3PO_4 550 ml; CH_3COOH 250 ml, HNO_3 200 ml, HCI 5 ml	55 - 80

Alkaline degreasing solution

	JIS H 9121	For copper and brass
NaOH g/l	50	15
Na_2CO_3 g/l	50	40
Na_2SiO_3 g/l	5 - 10	--
Na_2HPO_4 g/l	--	30
Temperature	Boiling	Boiling

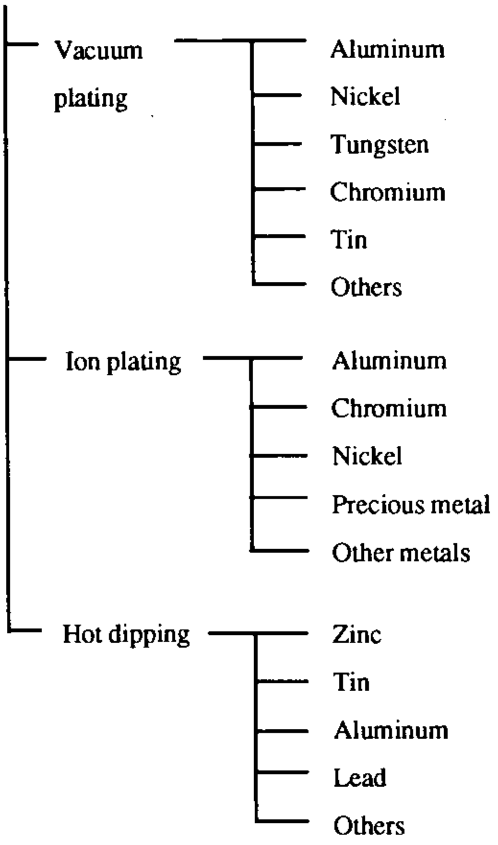
The plating process is mainly carried out using a plating bath. The kinds of plating are summarized as follows:

Fig. 4-1-5 Kinds of Metal Plating



- Lead bath
  - Borohydrofluoride bath
  - Sulfamic acid bath
  - Silicohydrofluoride bath
- (Precious-metal plating)
  - Gold plating
    - Thick layer bath — Cyanide bath
    - Thin layer bath — Ferrous cyanide bath
  - Silver plating
    - Cyanide bath
  - Platinum plating
    - Acidic bath
  - Rhodium plating
    - Rhodium sulfate bath
    - Others
- Iron plating
  - Rhodium sulfate bath
  - Others
- Cobalt plating
  - Cobalt sulfate bath
  - Bright cobalt bath
- Iridium plating
  - Sulfamic acid bath
  - Sulfate bath
- Palladium plating
  - Palladium chloride bath
- (Alloy plating)
  - Brass plating
    - Cyanide bath
  - Bronze plating
    - Cyanide bath
  - Copper-cadmium plating
    - Cyanide bath
  - Nickel-cobalt plating
    - Acidic plating
  - Tin-nickel plating
    - Acidic plating

- Electroless plating
  - Electroless copper plating
    - Copper sulfate solution bath
  - Electroless nickel plating
    - Acidic solution bath
  - Electroless cobalt plating
    - Alkali solution bath
  - (Electroless alloy plating)
    - Electroless nickel alloy plating
      - Ni - Co
      - Ni - Co - B
      - Ni - Co - P
      - Ni - Fe - P
      - Ni - W - P
    - Electroless cobalt alloy plating
      - Co - P
      - Co - Ni - P
      - Co - W - P
  - (Electroless precious-metal plating)
    - Silver plating
    - Gold plating
    - Platinum plating
    - Palladium plating
    - Rhodium plating



The following are typical electroplating baths whose wastewater quality and pollutant load have environmental impact.

(a) Copper

(a-1) Acidic bath

An acidic bath has commonly been used for copper plating. Sulfuric acid is added to increase the electrical conductivity. The concentration has considerable flexibility. Component concentration, temperature and current density of the bath have considerable allowable variance, so the operation does not have to be rigidly controlled.

An example of this plating bath is given in the following table.

Table 4-1-6 Example of Acidic Copper Bath

		Copper sulfate bath	Copper borohydrofluoride bath
$CuSO_4 \cdot 5H_2O$	g/L	150 - 250	--
$Cu(BF_4)_2$	g/L	--	250 - 400
H_2SO_4	g/L	30 - 75	--
HBF_4	g/L	--	2
Additives	g/L	Gelatin, glue 1 - 2	--
Temperature	°C	20 - 50	25 - 75
D_k	A/dm²	2 - 10	15 - 30

(a-2) Alkali bath

A cyanide bath is usually used. In it, a complex salt solution prepared by dissolving copper cyanide in excessive cyanide alkali is used. Although the electrical conductivity is low and copper deposits slowly, a fine, dense and smooth coating is formed.

An example of this plating bath is given in the following table:

Table 4-1-7 Example of Alkali Copper Bath

		JIS H 9121		Rochelle salt bath
CuCN	g/L	20	60	30
NaCN	g/L	30	70	45
Na_2CO_4	g/L	--	--	15
NaOH	g/L	--	25	--
Rochelle salt	g/L	--	--	60
pH	--	11.2	12.5	12.5
Temperature	°C	30 - 40	65 - 80	60 - 70
D_K	A/dm^2	0.3 - 0.5	1 - 2	5 - 6

(b) Nickel

Nickel is widely used for decoration and industrial purposes because of its good appearance and anti-rust properties. It is also used for corrosion prevention, like copper plating.

An example of a plating bath is given in the following table. A watt bath and JIS bath are ordinarily used, and chlorides (for improving the positive electrode dissolution) and boric acid (H_3BO_3, as pH buffer agent) are added to the solution. Various bath compositions are prepared according to purpose.

Table 4-1-8 Example of Nickel Plating Bath

		Watt bath	JIS bath	Bright bath	Rotary plating bath
$NiSO_4 \cdot 7H_2O$	g/L	240	150 - 200	225 - 375	120
$NiCl_2 \cdot 6H_2O$	g/L	40	--	30 - 60	--
NH_4Cl	g/L	--	15 - 20	--	6 - 15
H_3BO_3	g/L	30	15 - 20	30 - 45	15
pH	--	46	5.8 - 6.2	2.5 - 4.5	5.8 - 6.2
Temperature	°C	45 - 70	$\geq$18	40 - 70	20 - 35
D_K	A/dm^2	2 - 10	0.5 - 1	26	--
Surface tension	dyne/cm	--	--	30 - 38	--

(c) Chromium

Chromium is used not only for decoration but also where no discoloration, durable brightness, high hardness and abrasion resistance are required.

The chromium coating is porous, providing no corrosion protection, so an undercoating of nickel or copper is usually applied.

Low concentration ($\leq$150 g/L), medium concentration (200-300 g/L) and high concentration (400 g/L) baths are prepared by adding sulfuric acid (H_2SO_4) to the main component of chromic acid (CrO_3).

(d) Zinc

Zinc plating is used for coating iron to provide corrosion protection property. It is also widely used to giving good appearance by brightness treatment.

The electrolytic bath can be either acidic bath or alkaline. Sulfate for the former and cyanide for the latter. Zinc is used for the positive electrode.

Examples of these plating baths are shown in the following tables:

Table 4-1-9 Example of Zinc Plating (acidic)

		Acidic bath
$ZnSO_4 \cdot 7H_2O$	g/L	250
NH_4Cl	g/L	15
$Al_2(SO_4)_3 \cdot 18H_2O$	g/L	30
$Na_2SO_4 \cdot 10H_2O$	g/L	--
pH	--	3 - 4.5
Temperature	°C	20 - 30
D_K	A/dm²	2 - 3

Table 4-1-10 Example of Zinc Plating Bath (alkali)

		Alkaline bath
ZnCN	g/L	60
NaCN	g/L	23
NaOH	g/L	53
Na_2S	g/L	--
Temperature	°C	40 - 50
D_K	A/dm²	0.5 - 2

(e) Tin

Since tin is resistant to corrosion by acid, alkali and air and is not toxic, the plating process is applied to iron plate for canning as well as to copper wire and household metalware. Either an acidic bath or an alkaline bath can be used.

The acidic bath contains Sn(II) ions and its homogeneous electro-coating property is poor. In practice, sulfate baths, or borofluoride baths is used, and an organic colloid (e.g. glue) is added to prevent generation of resinous material. Sometimes additives (cresol and phenol) and a reducing agent are also added.

The alkali bath contains Sn(IV) ions and forms a bright, homogeneous electrocoating.

Excess alkali is added to sodium stannate solution to prepare the electrolytic bath. Examples of these plating baths are shown in the following tables.

(f) Lead

Lead is used for industrial containers and lead-battery parts because of its good corrosion resistance. An acidic bath is used. Example of this plating bath is shown in the following tables.

Table 4-1-11 Example of Tin Plating Bath (acidic)

		Sulfate bath
$SnSO_4$	g/L	54
H_2SO_4	g/L	100
Cresol sulfonate	g/L	100
ß-naphthol	g/L	1
Glue	g/L	2
D_K	A/dm²	still: 1 to 4, stir: >40
Temperature	°C	Room temperature

Table 4-1-12 Example of Tin Plating Bath (acidic)

		Borofluoride
Tin borofluoride	g/L	200
Free borohydrofluoride HBF_4	g/L	50
Free borohydrofluoride H_3BO_3	g/L	25
Glue	g/L	6
ß-naphthol	g/L	1
D_K	A/dm²	>25 at 20 °C, >50 at 40°C

Table 4-1-13 Example of Tin Plating Bath (alkaline)

$Na_2SnO_3 \cdot 3H_2O$	g/L	80
NaOH	g/L	20
NaCOOH	g/L	7
Glue	g/L	1
D_K	A/dm²	0.5 - 1.5
Temperature	°C	65 - 75
pH	--	12 - 13

Table 4-1-14 Example of Tin Plating Bath (silicofluoride bath, Betts bath)

as lead	g/L	75
all SiF_6^{2-}	g/L	150
Glue	g/L	0.2
D_K	A/dm²	0.5 - 5
Temperature	°C	35 - 40
Positive electrode		Lead

Table 4-1-15 Example of Lead Plating Bath (borofluoride)

		Still bath	Rotary plating bath
Lead	g/L	120	240
Free borohydrofluoride HBF_4	g/L	30	60
Excessive boric acid H_3BO_3	g/L	13.3	27
Glue	g/L	0.2	0.2
D_K	A/dm²	0.5 - 5	1 - 10
Temperature	°C	25 - 40	--
Positive electrode		Lead	Lead

Table 4-1-16 Example of Lead Plating Bath (sulfamic acid)

Lead	g/L	80
HSO_3NH_2	g/L	100
D_K	A/dm²	1 - 5
Temperature	°C	30
Positive electrode		Lead

(g) Precious metal

(g-1) Gold

The main component in the bath is potassium gold cyanide ($KAu(CN)_4$), prepared by dissolving gold cyanide in excess potassium cyanide.

An example of this plating bath is shown in the following table.

Sodium phosphate (NaH_2PO_4) is added to the bath to increase the electric conductivity. Gold is used for the soluble electrode and platinum carbonaceous material is used for the insoluble electrode. Color tone and brightness are adjusted by temperature and current density (D_K) or by addition of copper ion or nickel ion.

Table 4-1-17 Example of Gold Plating Bath

		For conventional plating	For thick layer plating
Au	g/L	2	8
KCN	g/L	15	11
$Na_2HPO_4 \cdot 12H_2O$	g/L	4	
Temperature	°C	60 - 70	70 - 75
D_K	A/dm²	0.1 - 0.5	0.2 - 0.5

(g-2) Silver

Ordinarily, a cyanide bath, containing silver cyanide dissolved in excess potassium cyanide, is used. An example of this plating bath is shown in the following table. The concentration of each component is adjusted within a wide range. The high speed bath is used for plating of bearings.

Table 4-1-18 Example of Silver Plating Bath

		Ordinary bath	High speed bath
AgCN	g/L	40	40
KCN	g/L	50 - 60	60
K_2CO_3	g/L	35	60
KOH	g/L	-	10
Temperature	°C	20 - 30	45
D_K	A/dm²	0.5 - 1.5	10

(g-3) Platinum

An example of this plating bath is shown in the following table. Components of the bath are dissolved in turn as shown in the table. After the solution has been boiled, the plating process is started. Platinum is supplied by refilling with platinic chloride.

Table 4-1-19 Example of Platinum Plating Bath

$(NH_4)HPO_4$	g/L	20
Na_2HPO_4	g/L	100
$H_2PtCl_6 \cdot 6H_2O$	g/L	4
Temperature	°C	70 - 90
D_K	A/dm²	1
Voltage	V	3 - 4

(g-4) Rhodium

This plating is superior for reflecting mirror surface treatment. Examples of this plating bath are shown in the following table.

(g-5) Indium

This plating is resistant to corrosion resistance by air and exhaust gas of internal combustion engine. Because of its smoothness, indium-lead alloy plating or indium-silver alloy plating has a characteristically low coefficient of friction.

Table 4-1-20 Examples of Rhodium Plating Baths

		Sulfuric acid bath	Phosphoric acid bath
H_2SO_4 (concentrated)	cc/L	20	--
H_3PO_4 (85%)	cc/L	--	10 - 40
Rh	g/L	2	2
Temperature	°C	45 - 50	50
D_k	A/dm^2	18	1 - 8
Voltage	V	2.5 - 5	--

Table 4-1-21 Example of Indium Plating Bath

$InSO_4$	g/L	45
Na_2SO_4	g/L	10
NaCl	g/L	5
pH	--	2.0 - 2.8
D_k	A/dm^2	2
Positive electrode	--	Indium

(h) Alloy

(h-1)

Brass plating and bronze plating in alkali bath (cyanide) are common. An example of the plating bath is shown in the following table:

Table 4-1-22 Example of Brass Plating Bath

		Brass color	For rubber bonding
CuCN	g/L	27	27
$ZnCN_2$	g/L	9	11
NaCN (Total)	g/L	55	45
NaCN (Free)	g/L	19	7.5
Na_2CO_3	g/L	30	--
NH_2OH	mL	1.2	--
Rochelle salt	g/L	--	--
CdO	g/L	--	--
D_k	A/dm²	0.3 - 0.5	1.0
Temperature	°C	25 - 40	27 - 35
Positive electrode (Cu/Zn)	--	80/20	75/25

Table 4-1-23 Example of Bronze Plating Bath

		Bronze color	White color
CuCN	g/L	40	10
$Na_2SnO_3 \cdot 3H_2O$	g/L	70	120
NaCN	g/L	55	25
NaOH	g/L	15	15
pH	--	11.5 - 12.5	12.5 - 13
D_k	A/dm²	2 - 3	2 - 3
Temperature	°C	65	60

(h-2) Lead alloy

Lead alloy plating is used for corrosion protection. The plating bath is composed of acidic silicofluoride or borofluoride. An example of the plating bath is shown in the following table:

Table 4-1-24 Example of Lead-Tin Alloy Plating Bath

Composition of coating		Composition of electrolytic bath				
Pb (%)	Sn (%)	Pb	Sn	HBF_4	H_3BO_3	Glue
95	5	85	5	40	25	0.5
90	1150	90	10	40	25	0.5
85	20	80	15	40	25	1.0
75	25	65	25	40	25	1.5
60	40	44	40	40	25	3.0
50	50	35	50	40	25	4.0
40	60	35	60	40	25	5.0

(4) Peeling process

A peeling process is a process to peel off the coating of plating products disposed as off-specification in the quality inspection. Since metals used for plating are dissolved in the solution, considerable amounts of these heavy metals are included in the highly acidic or alkaline waste liquid.

The standard peeling processes are shown in the following table:

Table 4-1-25 Examples of Peeling Process

Kind of plating	Base material	Peeling process
Copper plating	Iron and steel	Electrolysis in chromic acid-sulfuric acid mixture
	Copper and its alloys	After dipping into sodium sulfate and caustic soda solution, brushing
	Zinc and its alloys	After dipping into sulfur and sodium cyanide solution, brushing
	Aluminum	Dipping into high-concentration nitric acid
	Plastics	Dipping into ferric chloride solution
Nickel plating	Iron and steel	After electrolysis in sulfuric acid, dip into hydrochloric acid
	Copper and its alloys	Electrolysis in hydrochloric acid
	Die-cast zinc	Electrolysis in hydrochloric acid
	Plastics	Dipping into hydrochloric acid and hydrogen peroxide solution
Zinc plating	Iron and steel	Dipping into hydrochloric acid or sulfuric acid and then electrolysis in caustic soda
Chromium plating	Iron and steel	Electrolysis in caustic soda or sodium carbonate solution
	Copper and its alloy	Dipping into hydrochloric acid
Solder plating	Iron and steel	Electrolysis in sodium nitrate solution
	Copper and its alloys	Dipping into glacial acetic acid and hydrogen peroxide solution

(5) Future development of metal plating techniques

Metal finishing techniques which have been developed in the plating field are in practical use in the field presented in Table 4-1-26 and their further development is expected.

Table 4-1-26 Development Metal Finishing Techniques

Durable material	Development of zinc type anti-corrosion alloy	Ni-Zn, Co-Zn Various functions demanded besides anti-corrosion property
Decoration	Color plating at negative electrode Oxidation at positive electrode	Electrodeposition of molybdenum Coloring of titanium
Functional parts	High-density printed wiring board (including through-hole plating)	Electroless plating of fine wiring and multi-layered wiring Electroless solder plating, self-contact thin-layer electroless Gold plating
	Substrate plating of hard disk	High-density type
	Optical disk	Application to glass
	Solar energy absorptive plating	Improvement of efficiency and lifespan
	Bar coder, etc. concerning optics	Screening by plating for specific wavelength rays
Mechanical processing field	Etching of hole plate for electric razor	Electroplating Aluminum condenser with 10-15 times increased plate surface area
	Reinforcement of bond strength	Reinforced bond strength plating for flexible copper board
	Etching	Circuit formation by precision etching
Development of new alloys and materials	Electroplating of aluminum	Using ambient temperature, molten salt
	Plating of fine particles	Intermetal compound prepared by plating, molding, sintering of fine particles Nickel plating of silicon carbide, dispersion improvement material
	Complex plating	Chromium-molybdenum etc, Teflon dispersion on chromium, nickel

4.1.4 Sources and Properties of Pollution and Waste

(1) Main sources of wastewater

As shown in the basic process of plating, the main sources of wastewater are the washing water used for the pre-treatment and after-treatment subsequent to each plating process. Since washing of the plating material is basically carried out at the pre-treatment stage and during the after-treatment subsequent to each plating, the chemicals used in each process are discharged to some extent, with the washing process. For example, wastewater contaminated with alkaline degreasing solution is discharged from the washing process subsequent to the alkali degreasing process, wastewater contaminated with acidic degreasing solution is discharged subsequent to the acidic degreasing process, and wastewater contaminated with heavy metals and cyanide is discharged subsequent to the plating process.

Pollutants discharged in the electroplating process, and their sources, are shown below:

Table 4-1-27 Pollutants by Plating Type

Type	Component	Pollution source	
		Process	Chemical related to plating
Liquid organic substance	Grease type activator	Degreasing process	Degreasing solution
Solid inorganic substance	Metal powder, abrasive powder	Various processes	Various kinds of plating solutions
Oxygen	HCI, H_2SO_4 HNO_3, H_3PO_4	Plating electrolytic polishing Etching pre-treatment process	Various kinds of plating solutions
Alkali wastewater	NaOH, KOH Sodium silicate Na_2CO_3, $NaNO_3$ Sodium tripolyphosphate	Degreasing process, polishing process Alkaline plating process Barrel polishing process	Degreasing solution Polishing solution Compound
Cyanide wastewater	Cyanide NaCN, KCN	Alkali washing process Barrel washing process Electrolytic washing process Copper, nickel peeling process Copper, zinc, cadmium plating processes Dipping neutralization process	Degreasing solution Barrel polishing solution Electrolysis washing solution Plating solution Various kinds of plating solutions Dipping solution
Cyanide	$Na_2ZN(CN)_4$ $Na_2Cu(CN)_3$ $Na_3Ag(CN)_4$ $Na_3Au(CN)_2$ $Na_2Ni(CN)_4$ $Na_2Cd(CN)_4$ $K_4Fe(CN)_6$	Zinc plating process Copper plating, copper peeling process Silver plating process Gold plating process Nickel plating peeling process Cadmium plating process Alkali electrolytic washing process	Zinc plating Plating peeling solution Silver plating solution Gold plating solution Nickel plating peeling solution Cadmium plating solution Electrolytic washing solution

Chromium wastewater	Cr_2O^{2-}	Chrome plating process	Chrome plating solution
	CrO_4	Chromating process	Chromating solution
		Etching process	Etching solution
Lead wastewater	$Pb(BF_4)_2$	Solder plating process	Solder plating solution
		Solder peeling process	Solder peeling solution
Copper wastewater	$NaCu(CN)_3$	Cyanide type copper plating process	Cyanide copper plating solution
	$K_6Cu(P_2O_7)_2$	Pyrophosphoric acid copper plating process	Pyrroline copper plating solution
	Copper complex compound	Electroless copper plating process	Electroless copper plating solution
	$CuSO_4$	Acidic copper plating process	Acidic copper plating solution
	$CuSO_4 \cdot (NH_4)_2SO_4$	Ammonium persulfate etching process	Etching solution
	$CuCl_2$	Iron chloride, copper chloride etching process	Etching solution
	$Cu(NH_3)_4^{2-}$	Alkali etching process	Etching solution
	$Cu(BF_4)_2$	Solder etching process	Etching solution
Zinc wastewater	$Ca_2Zn(CN_4)$	Cyanide type zinc plating process	Zinc plating solution
	$ZnSO_4$, $ZnCl_2$	Acidic cyanide-less zinc plating process	
	$Na_2Zn(OH)_4$	Alkaline cyanide-less zinc plating process	
Nickel wastewater	$NiSO_4$, $NiCl$	Nickel plating process	Nickel plating solution
	$Na_2Ni(CN)_4$	Nickel peeling process	Nickel peeling solution
	Nickel complex compound	Electroless nickel plating process	Electroless nickel plating solution
Tin wastewater	$SnSo_4$	Acidic tin plating process	Acidic tin plating solution
	$Sn(BF_4)_2$	Borofluoride tin plating process	Borofluoride tin plating solution
	$Sn(BF_4)_2$	Solder peeling process	Solder peeling solution
	$Sn(BF_4)_2$	Solder plating process	Solder plating solution
	$SnCl_2$	Electroless tin plating process	Electroless plating solution
	$SnCl_2$	Activation process	Activation solution
	$Na_2Sn(OH)_6$	Alkaline tin plating process	Alkaline tin plating solution
Mercury wastewater	$HgCl_2$	Copper etching process	Ammonium persulfate type etching solution
Fluorine wastewater	HF	Solder plating process	Solder plating solution
	HBF_4	Solder peeling process	Solder peeling solution
		Activation, polishing process	Activation, polishing solution
BOD COD	Oil, surfactant, complexing agent, brightening agent, solvent, resin	Degreasing process	Degreasing solution
		Polishing process	Polishing solution
		Acid, alkali resist coating process	Chemical plating solution
		Photoresist coating process	Solvent
		Coating peeling process	Resist agent
		Washing and others	Others

(2) Properties of wastewater

The quality of the washing wastewater discharged in individual process varies greatly depending upon the process, because it is affected by the chemicals used for treatment in the bath.

The wastewater in the degreasing process shows high pH value in the case of alkaline degreasing and low pH value in the case of acidic degreasing. The COD becomes high, affected by added chemicals and removed grease.

The quality of the wastewater in the plating process is shown in the following examples, in which the pH values are affected by metals and the conditions of their usage in the plating process. When a cyanide plating bath is used, the wastewater is alkaline (pH >7) to prevent the generation of cyanide gas.

Table 4-1-28 Example of Plating Wastewater Quality

Type	Copper plating			Nickel plating		Chrome plating		Zinc plating			Chromating	
Item	pH	Cu	CN	pH	Ni	pH	Cr	pH	Zn	CN	pH	Cr
Mean value	9.1	31.7	48.2	7.6	10.7	2 - 6	273	10.4	62.2	229	2.4	848
Range	10 - 11	60 - 100	80 - 150	- 6 --	50 - 80	2 - 3	180 - 350	10 - 12	100 - 150	150 - 300	- 3 --	5 - 10

(Note) unit: mg/L (except pH)

(3) Sources and properties of air emission

Contaminants included in plating waste gas are roughly classified as dust, generated in the pre-treatment process such as polishing and degreasing, and mist, generated in the plating process.

The mist is formed by evaporation of chemicals such as acid, alkali, chromium and cyanide used in the plating baths.

To meet the legal standards for working environments, gas and mist are collected and led to the waste gas treatment equipment, and the work rooms are ventilated.

Though the waste gas treatment is essential, maintenance work, such as cleaning of duct space to remove adhering mist and dust, is also indispensable, because these dust and mist show properties similar to the plating wastewater.

4.1.5 Discharge Control Regulations and Trend

(1) Discharge control imposed on plating industry

Among various kinds of discharge control for air pollution, water pollution, offensive odor, and soil pollution, the water pollution control is the main one stressed in the metal plating industry.

In addition, a working environment where temperature and humidity are high and which is contaminated by hazardous gas must be improved for the personnel engaged in the plating process. Ventilation of work space by simply bringing in or taking out air is not preferable from the air pollution control viewpoint. Since air emission and hazardous gas from the factory and work site are controlled by local regulation in some prefectures, measures for improving the working environment, on the basis of environmental control are required.

Furthermore, this environmental control for protecting sources of water supply, ground water, air and global environment is in a trend that will intensify henceforth, therefore, the plating industry must take account of the following subjects while being aware of trends concerning environmental problems.

1) For protecting the source of water supply, alternative processing methods instead of the existing alkali chlorine process that may produce chloroform (one of the trihalomethane type substances suspected to be hazardous), and strict surveillance of chloroform, fluorine, nickel, nitric acid and nitrous acid are needed.
2) Nitrogen and phosphorous are regarded as subject to the area-wide total pollutant load control for protection from eutrophication in enclosed water areas and for protecting the source of water supply. Particular care must be taken of nitrogen, because it is difficult to be treated by simple chemical treatment.
3) To prevent soil contamination and protect ground water, infiltration through the ground of chlorine type organic solvents and harzardous substances such as trichloroethylene and tetrachloroethylene must be prevented.
4) From the air pollution control and offensive odor prevention viewpoints, strict surveillance of emission of chlorine type organic solvents such as trichloroethylene and organic solvents such as toluene must be done.
5) Since the use of chlorine-type organic solvents is limited in EU in a movement for the phase-out of ozone depleting substances, all organic halogen compounds must be used carefully.

6) For such substances, at issue in Europe and the United States, as EDTA, formalin, chromium (VI), and nickel clothing ornaments, care must be taken from the stand points of legal control and response to the Product Liability (PL) Law.
7) International trends to prevent ocean dumping, in particular, London Convention, will definitely affect the treatment and disposal of industrial waste, so that long-term measures must be taken.

(2) Trends in water pollution control

In December 1958, factory effluent control and the water quality preservation for public water area were enforced with establishment of the "law concerning factory effluent control" (Industrial Effluent Water Law) as well as the "law concerning water quality protection in public water area" (Water Quality Preservation Law), the so-called "two old water-quality Law". The Industrial Effluent Water Law specifies special facilities and imposes the obligation to properly treat the effluent that is discharged accompanying the production work such as manufacturing, with the intention of protecting the water quality in public water areas.

Since the electroplating industry uses chemicals containing harzardous substances such as cyanide, "electroplating facility" and "acid, alkali washing facility" have been named as specified facilities to be regulated by the Industrial Effluent Water Law.

However, in order to avoid frequent incidents such as large numbers of dead fish washing up onto river banks and discontinuation of city water supply because of accidental effluent discharges, the Poisonous and Deleterious Substances Control Law was revised in December 1964, resulting in stricter legal control on the handling of cyanide.

Societal concern about water pollution and air pollution accompanying the economic high growth period increased by the later half of the 1960s, so the Basic Law for Environmental Pollution Control was promulgated in 1967 with the prime object of regulating pollutants to prevent the pollution caused by industry.

The Water Pollution Control Law was promulgated at December 1970. The law contains mainly the following items:
1) The "water area" designated by the "two old Laws" was abolished and total zone of public water area was designated as the target area instead.
2) To reinforce strict observance of the effluent standards, an immediate punishment system was applied.
3) Along with transfer of regulative authority to local governments, more stringent standards than the national standard (more stringent prefectural standards) can be set by the Prefectural governors.

4) A surveillance and measurement system for water quality in public water areas was organized.
5) Competence to conduct on-site inspection with the object of monitoring and measuring effluent quality was included.
6) The principles of establishment, observance and forced consequences of the effluent standards, were integrated into the Water Pollution Control Law.

As described later, 74 specified facilities such as electroplating facilities, 7 hazardous substances such as cyanide chromium (VI) compounds, and 14 parameters related to the conservation of living environment such as pH, BOD, COD and SS were designated in the Enforcement Ordinances of the Water Pollution Control Law.

Small-scale corporations (effluent volume 50 m^3/day) were excluded from the application of the effluent standards related to the living environment parameters, but corporations where effluent containing hazardous substances, such as plating wastewater, is discharged shall be subject to control, even if effluent volume is small.

Following the incidents of discharge of heavy metals (e.g. cadmium) and organic solvents (e.g. trichloroethylene), and contamination of ground water, the Water Pollution Control Law was reinforced. Items defined as hazardous substances included PCBs in 1975, trichloroethylene and tetrachloroethylene in 1989, and 13 substances such as dichloromethane in 1993. The effluent standards for 4 substances such as lead were reinforced.

It is no exaggeration to say that every time the effluent standards are reinforced, a substance related to the electroplating industry is involved.

On the other hand, with the trend to handle problems from wider viewpoints ranging from pollution measures to environmental protection, developing, the Earth Summit was held in 1992, followed by the Environment Basic Law which was established in 1993. Consequently, the Basic Law for Environmental Pollution Control was abolished. At present, corporations are required to take measures in accordance with the Basic Environment Program formulated in the framework of Environment Basic Law.

Although the electoplating industry includes many small-scal corporations, it needs techniques for finishing products with high-value-added function while taking sufficient environmental control measures.

Table 4-1-29 Uniform Effluent Standards (hazardous substances such as cadmium <Related to Article 1>)

Substances	Standard values
Cadmium and its compounds	0.1 (mg/L)
Cyanide	1 (mg/L)
Organic phosphorus compounds (limited to parathion, methyl parathion, methyl demeton and EPN)	1 (mg/L)
Lead and its compounds	0.1 (mg/L)
Chromium (VIII) compounds	0.5 (mg/L)
Arsenic and its compounds	0.1 (mg/L)
Mercury, alkyl mercury and other mercury compounds	0.005 (mg/L)
Alkyl mercury compounds	not detectable
PCB	0.003 (mg/L)
Trichloroethylene	0.3 (mg/L)
Tetrachloroethylene	0.1 (mg/L)
Dichloromethane	0.2 (mg/L)
Carbon tetrachloride	0.02 (mg/L)
1 • 2-Dichloroethane	0.04 (mg/L)
1 • 1-Dichloroethylene	0.2 (mg/L)
Cis-1 • 2-Dichloroethylene	0.4 (mg/L)
1 • 1 • 1-Trichloroethane	3 (mg/L)
1 • 1 • 2-Trichloroethane	0.06 (mg/L)
1 • 3-Dichloropropane	0.02 (mg/L)
Thiuram	0.06 (mg/L)
Simazine	0.03 (mg/L)
Thiaben	0.2 (mg/L)
Benzene	0.1 (mg/L)
Selenium and its compounds	0.1 (mg/L)

(3) Current Water Pollution Control Law

(a) Specified facilities

In the current Water Pollution Control Law, a "specified facility" is defined as a facility that discharges effluent containing hazardous substances such as cadmium and substances with high COD indices, and "specified effluent" is defined as the effluent discharged from a specified facility, regarding the enforcement of legal control.

For the electroplating industry, the following facilities are stipulated as specified facilities:

66. Electroplating facility
65. Surface treatment facility using acid or alkali
63. Facility used by metal product manufacturing industry or general machine and equipment manufacturing industry, such as:
    * Emission gas cleaning facility

(b) Uniform effluent standards

These are indicated in the Tables 4-1-29 and -30. Since there is the possibility of discharge of hazardous substances, such as cyanide by the electroplating industry, the effluent standards are applied even if the amount of discharged effluent is small.

Table 4-1-30 Uniform Effluent Standards (Parameters related to the conservation of living environment)

Parameters	Allowable limit
pH	≥5.8 and ≤8.6: for effluent discharged to public water areas, excluding sea areas ≥5.0 and ≤9.0: for effluent discharged to sea areas
BOD	160 (120 average per day) (mg/L)
COD	160 (120 average per day) (mg/L)
SS	200 (150 average per day) (mg/L)
n-Hexane extracts (mineral oil content)	5 (mg/L)
n-Hexane extracts (animal and plant oil/fat content)	30 (mg/L)
Phenol content	5 (mg/L)
Copper content	3 (mg/L)
Zinc content	5 (mg/L)
Soluble iron content	10 (mg/L)
Soluble Mn content	10 (mg/L)
Chromium content	2 (mg/L)
Fluorine content	15 (mg/L)
Coliform group number	3,000 average per day (count/mL)
Nitrogen content	120 (60 average per day) (mg/L)
Phosphorus content	16 (8 average per day) (mg/L)

(c) Areawide total pollutant load control

The system for enforcement of areawide total pollutant load control was established in the 1979 fiscal year. Effluent discharged from specified factories within theTokyo Bay, Ise Bay and Seto Inland Sea catchment basins is strictly controlled, for water quality conservation in these enclosed water areas.

The pollutant load amount allowable for discharge is set from the volume of effluent specified, corresponding to the kind of industry, and from the definite COD decided on by prefectural governors, each specified factory must measure the load amount for itself and report it, to ensure that this remains within the allowable limit.

The areawide total pollutant load control system has been strengthened three times up to date, and the fourth intensification will be done soon.

The allowable effluent load amount is set as follows:

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

where

L: Allowable pollutant discharge load amount (kg/day)

C_j, C_i, C_o: Definite COD (mg/L) decided by prefectural governors
(j, i, o depend upon the setup date)

Q_j, Q_i, Q_o: Effluent volume notified corresponding to C_j, C_i,C_o, respectively.

In the third revision, the following C values were applied, depending upon the setup date, from April 1, 1994:

1) Setup before June 30, 1980: C_o
2) Setup July 1, 1980 through March 31, 1989: C_i
3) Setup after April 1, 1989: C_j

In a separate Table of the Enforcement Ordinance, Water Pollution Control Law, the following C value limits are shown for the electro plating industry. In accordance with these values, prefectural governors decide on their own values for individual corporations.

Table 4-1-31 C Values for Electroplating Industry

Industry Category		COD (mg/L)					
		C_o		C_i		C_j	
		Lower limit	Upper limit	Lower limit	Upper limit	Lower limit	Upper limit
201	Electroplating industry	40	80	40	80	40	70

(4) More stringent prefectural control

Since there is the possibility of discharge of hazardous substances such as cyanide by the plating industry, many local governments have set up stricter effluent control regulations, referred to as "more stringent prefectural regulation" than the standards set by the national government, and are enforcing them. Some of the more stringent regulations are set for specific water areas and for effluent volume. Some of such cases are shown in the table 4-1-32.

By contracting a pollution prevention agreement with an individual corporation, a local government may sometimes enforce much more stringent discharge limits.

Table 4-1-32 Examples of More Stringent Prefectural Standards

Local government	Industry category	Water area	BOD	COD	SS	Cadmium	Cyanide	Lead	Chromium	Fluorine	Phenol	Copper	Zinc	Remark
Chiba prefecture	Existing corporations with capacity of <500 m³/day					0.1	1	1	0.5					Chromium is Cr (VI).
Kyoto prefecture	Electro-plating and hot dipping	Yodo River	120 (100)		150 (120)						1			
		Uji River	120 (100)		150 (120)						1			
		Others	160 (120)	160 (120)	200 (150)						5			COD limit is applied to sea areas, lakes and marshes.
		All areas				0.1	1	1	0.5	15				Chromium is Cr(VI).
Nagano prefecture	Surface treatment by acid and alkali								2			3	5	Effluent volume < 50 m³
									1			2	3	Effluent volume ≥ 500 m³
	Electro-plating								2			3	5	Effluent volume < 50 m³
									1			2	3	Effluent volume ≥500 m³
Nagoya city	Surface treatment electro-plating		25 (20)	25 (20)	30 (20)									Applied to existing factory

(Note)
- Unit: mg/L
- Unit of values in parentheses: average per day

4.1.6 Response of Industry and Role of JEC

Social concerns about the water pollution and air pollution brought about by the rapid economic growth has been increasing since the mid-1960s; consequently, many regulations have been enforced and reinforced. The metal plating industry in particular was alleged for causing water pollution and has been compelled to conform to such regulations.

Initially, the metal plating industry responded to the effluent standards for cyanide and chromium by installing simple wastewater treatment tanks and reaction vessels, but as the control of individual contaminants was intensified, measures were taken by increasing and expanding wastewater treatment functions, for instance by increasing the dosages of treatment chemicals and extention the precipitation time. However, as countermeasures were stalled due to lack of financial resources and installation sites, each factory was forced to review comprehensively its facilities, with the viewpoint of pollution control at source level, such as introducing the closed system of wastewater. And, as regards the hazardous substances which are difficult to treat, measures were taken such as phase-out of cadmium plating in principle, introduction of newly developed low-cyanide or cyanide-free plating techniques. The joint treatment of high-concentration waste liquids was also undertaken. Industrial associations took initiatives of providing technical guidance on such measures, and promoting the construction of joint treatment facilities, as well as the organization of the joint personnel training to ensure successful pollution control.

JEC took the initiative in the financing of the pollution control movement. The metal plating industry needed significant funding to cover the expenses of pollution control measures, but private financing organizations were reluctant to make loans to the industry. So, JEC actively offered pollution control funds to the metal plating industry. The funds offered by JEC contributed not only to expansion of pollution control facilities but also to enhancement of technical experience in the wastewater treatment industry which was under development, indirectly resulting in their technical development.

JEC also conducted projects involving pioneering techniques and methods for pollution control measures and has played an exemplary role in demonstrating pollution control measures for private corporations. Typical cases of the JEC construction and transfer programs will be described in Section 4.1.17; a project done in Katsushika ward, Tokyo in 1965 and a project done in Yoshida-machi, Niigata Prefecture in 1972, which are particularly good examples of pioneering cases. These projects are regarded as model cases regarding pollution control measures. Among the 21 metal plating factory parks developed so far in Japan. 12 were developed through the JEC construction and transfer program. All of the wastewater treatment facilities in these industrial parks used pioneering techniques when they were installed.

Survey and research programs have supported the application of these pioneering techniques. A number of projects have been conducted by JEC in the survey and research field contributing to the establishment of techniques in the technically new field of pollution control and to the compiling of information about the construction of joint-use pollution control facilities. As shown in Section 4.1.18, the conclusions from such research projects were: to ensure proper treatment for plating wastewater and waste, both technical response at the treatment facility and pollution control at source level, including improvements of the production process, are necessary and, furthermore, development of joint waste treatment control facility involving local authorities is effective. Such concepts became the guidelines for pollution control in the metal plating industry.

Trends in Metal Plating Techniques

— Excerpt from Centennial Journal of All Japan Metal Plating Cooperation Federation —

1970 - 1974

Accompanying the establishment of the Environment Agency, the Water Pollution Control Law was enforced to specify the effluent regulatory standards: 1 ppm for total cyanide, 2 ppm for total chromium, 0.5 ppm for chromium (VI) and 0.1 ppm for cadmium. Participants in the plating cooperative association passed a resolution abolishing cadmium plating, because of the difficulty in meeting the current cadmium regulatory standard.

With enforcement of the stricter regulations, copper pyrophosphate was introduced into the copper cyanide solution used in the copper plating process and an effective leveling agent was developed for copper sulfate plating, resulting in popularization of this type of plating.

For zinc plating, the traditionally used high-or medium-concentration zinc cyanide baths began to be replaced by low-concentration zinc cyanide baths, and successful research on zincate bath headwayed its practical use. At the same time, low-concentration chromate bath became widespread, which contributed to the steady progress in pollution control.

The technical development brough benefits not only for pollution control measures but also for production techniques, e.g., automation of all zinc plating processes including after-treatment, such as low-concentration chromating.

For decorative plating, the post-nickel = micro-crack chrome process was developed, and played an important role in improving corrosion resistance. Progress in copper sulfate plating, accompanied by the improvement of leveling agents and homogeneous electrodeposition properties, led to its application to the through-hole plating of printed boards. Complex plating also progressed and graphite fluoride eutectoid nickel plating was reported. During this period, operation of the Jonan Treatment Center, Pollution Control Cooperative Association started in 1972, and its performance is still effective in treating high-concentration cyanide waste liquid.

The "dollar shock" caused by President Nixon's actions in 1971, followed by the first oil shock caused by OPEC in 1973, were severe ordeals for Japanese industry. The metal plating industry, thereafter, concentrated on various research and development work: low-concentration or low-temperature processes, rationalization of electric power use and review of process combination.

1975-1979

Characteristics in this period were practical applications of resources- and energy-conservation measures integrated with pollution control techniques. Approaches toward achieving closed system for wastewater by thorough review of the washing process were tried everywhere. Experimental data on both continuous- and batch-type washing based upon theory were reported, and the newly-introduced multistage counter-current washing process spread in this industrial field. Due to the introduction of this washing process into plating factories, the volume of water consumption was markedly reduced. Progress in the use of closed systems, of course, is connected to the recycling of resources. Partial circulation of washing water (for recycling) and direct recycling of the plating solution utilizing the first washing bath for the recovery bath are now practiced in many factories. Further advanced recovery and recycling of valuable metals such as nickel and copper as well as of precious metals such as gold and silver were well under way.

In chrome plating, the replacement of the traditional lead alloy positive electrode, by a ferrite electrode had great impact on the avoidance of lead pollution. The chrome plating process using chromate (III) was imported. (Remainder omitted here.)

4.1.7 Basic Policy for Pollution Control and Programming

(1) Viewpoint for target-setting

(a) Pollution control

When the Basic Law for Environmental Pollution Control was established in 1967 in Japan, the following items, 1) air pollution, 2) water pollution, 3) noise, 4) vibration, 5) offensive odors and 6) Ground subsidence [Item 7) groundwater pollution was added later] were defined as pollution, and following rearrangement of the legal control system, technical measures against pollution were taken by cooperative efforts of the government and private sectors.

In the metal plating industry, measures were needed mainly against 1) air pollution, 2) water pollution and 3) noise. Water pollution control measures were regarded as particularly essential because hazardous substances and various kinds of heavy metals are used in this industry.

The most primitive target in the environmental conservation program is to observe these legal requirement and to meet the regulative standards for environmental discharges, such as water quality, etc.

(b) Cleaner production

As already described in Section 3.3.3, the "Cleaner Production" approach, in which measures are taken for energy conservation, resource conservation and water use rationalization in the production process, are very effective for reducing the air- and water pollution. In particular, in a new factory, the overall production cost can be remarkably improved by programming resource- and energy conservation in parallel with pollutant load reduction at the planning stage.

This cleaner production approach, with the simultaneous objectives of controlling pollution, conserving resources, and saving production cost, is even more effective in developing countries where sustainable development with limited resources is required. To be able to attain these objectives through this cleaner production approach, the basic premise is that sophisticated production process control and product quality control should also be attempted.

(c) Environmental management

Combining the pollution control under the legal system with the process control under the cleaner production approach, production activity compatible with environmental conservation should be achieved. Accordingly, management program involving planning, implementation, evaluation and review should be in place in each corporation. Such control is called "environmental management."

(2) Items to be considered for formulation of pollution control program options

(a) In-process improvement measures

In the metal plating industry, a number of in-process improvement techniques, i.e. 1) recovery of heavy metals and scale as valuable substances, 2) multistage counter-current type washing method, 3) reduction of volume of plating solution, 4) temperature control and 5) replacement by non-hazardous chemicals, have been developed and widely adopted.

With consideration of individual circumstances such as product contents and existing equipment in each corporation, introduction of these techniques, with highest priority given to the most readily available one, should be attempted.

(b) Wastewater treatment

Wastewater treatment techniques are applied either to the unit treatment system or the combined treatment system depending upon the wastewater properties, treatment targets and cost, and sludge disposal cost.

Since the wastewater produced in the electroplating industry is mainly inorganic matter containing cyanide and heavy metals with acidic or alkaline properties, chemical treatment methods, such as oxidation decomposition and neutralization are mainly used. On the other hand, recently, organic wastewater has been discharged from the degreasing process. For such organic wastewater, containing nitrogen and phosphorus, biological treatment is increasingly applied.

(c) Control of air emission and noise

When measures for control of emission of gas and noise are examined, the working environment must be simultaneously examined to see whether it meets legal standards such as the Law on Industrial Safety and Hygiene.

Treatment techniques must be decided taking account of both the working environment and the impact on the surrounding environment.

(d) Waste management

When a waste disposal measure is being planned, it is necessary to determine whether the waste is salable as valuable material or is to be disposed of as industrial waste.

Although in the latter case, the waste disposal will be usually entrusted to an industrial waste management contractor, the generator of the waste is obligated to take responsibility up to final disposal, in accordance with the legal premises and procedures regulated by Waste Disposal and Public Cleansing Law, etc.

Also, waste disposal must be done in obedience to both domestic law and international agreements such as the London Convention.

(3) Setting-up of pollution control programs

(a) Understanding of the current status

At the initial stage of planning, an understanding of the status of projects in the corporation is necessary. The situation of on-going projects and their actual impacts on the environment are evaluated, to extract problems to be improved.

It is important to understand the present situation correctly. If not, the overall plan may become misdirected.

(b) Setting of the target

To set targets, give first priority to the "clean production" concept. Consideration of environmental conservation and the promotion of greater productivity should be attempted throughout the whole project. If measures for improving the production process are taken when replacing or renovating existing equipment, a more rational outcome will be obtained.

Though high-level targets are not always easily attainable, setting low-level targets is useless. Accordingly, the best way to view attainability is by setting a long-term target first, then elevating the target stepwise.

(c) Choices from "program options"

Measures with attainable targets are selected by extracting individual options such as cleaner production, wastewater treatment techniques, air emission and noise control measures as well as by considering conformity with the overall project.

(d) Evaluation of economic efficiency

It is also important to compare several different programs from the economic efficiency point of view.

Furthermore, versatility is necessary when doing comparison and examination of different subjects, e.g. fixed cost for equipment, running costs for maintenance and administration, costs of retrieval and benefits gained by recovering valuable materials, renovation work done in expection of increased yield, projects utilizable for fund support, and financing systems.

(e) Decision on program

The foregoing items must be summarized in the form of an environmental control program. The program may be set up with a long-term target backed up stepwise with successive targets as described above.

(f) Implementation system

The environmental control program should also include organizational aspects such as inplementation and evaluation systems.

(4) Monitoring of effect of the program

(a) Evaluation of effect

The state when the environmental control program is actually implemented, and the effects, must be evaluated in the light of the target.

If the target attainment is insufficient, it shall be ascertained whether the reason for this is a implementation method, organization, or the program itself.

To understand the effect, various data, from the factory's operational data to the automatically measured wastewater quality data, are required. Accordingly, both individual evaluation and integrated evaluation are needed.

Assuming that it is not always feasible for a single corporation to monitor the implementation of the program, public organizations such as cooperative association may be considered.

(b) Review of plan

If the target is not sufficiently achieved, the implementation plan shall be reviewed. It is desirable to repeat this process to attain the long-term target.

4.1.8 In-process Improvement Measures

(1) Appropriate layout and piping of metal plating equipment

To conduct the plating process safely and rationally, the plating equipment must be appropriately layed out. Furthermore, with appropriate piping, the equipment can safely discharge each wastewater individually, without mixing acid-, alkali- and cyanide-containing wastewaters together.

Provided that expansion and renovation of factory or renewal of equipment are systematically conducted, it is easy to allocate the equipment and piping appropriately. However, in a case when the renovation or renewal is conducted under restricted circumstances such as constraints imposed by the existing building and equipment, first priority may be given to the easy or conventional setting work at that time, resulting in formation of an unsuitable or irrational layout for the working flow line and wastewater flow route. Small-scale corporations in particular must be careful of this. Otherwise, the second best policy should be chosen; i.e., corresponding to the working space situation, the effluent is discharged through a conduit and drippings on the floor are discharged through a pit so they can be treated separately.

(2) Saving removed plating solution

In order to reduce plating cost and wastewater treatment cost, it is important to save the removed plating solution. The following handling is indicated:

1) Prepare a jig fitted to the shape of the articles to be plated.
2) Ideally prolong the drip cutting time, after lifting an article from the plating bath. But precise directions must be given to the operator on the spot to improve working efficiency.
3) Plating solution recovery work shall be correlated with impurity measures.

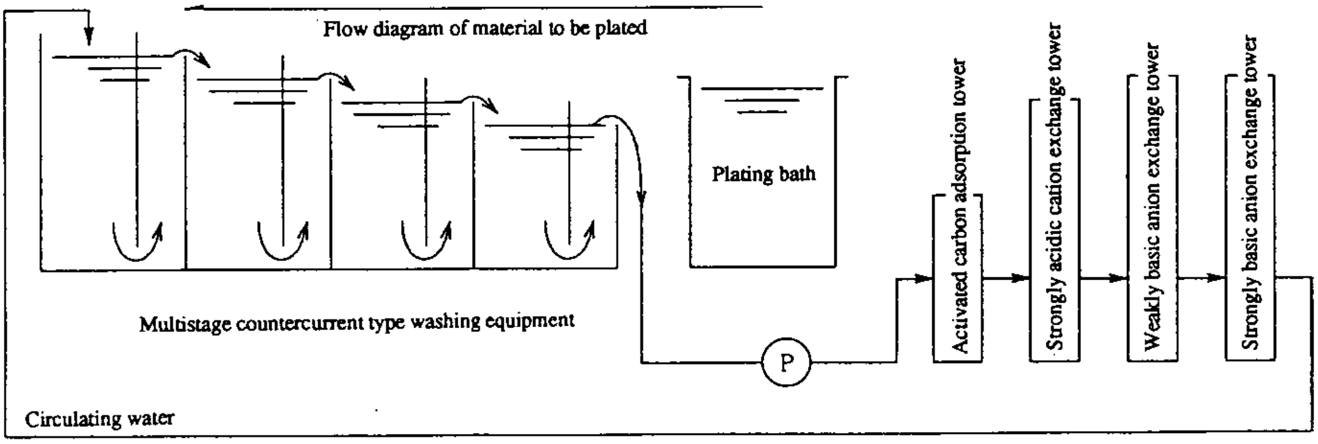
(3) Improvement of water washing

The multistage counter-current type water washing process is preferable. By reducing wastewater volume and increasing its component concentration, a compact sized wastewater treatment facility can be used and improved wastewater treatment efficiency and reliability can be achieved, resulting in saving of wastewater treatment cost.

In general, the larger the number of water washing stages, the smaller is the volume of washing water that can be applied. For example, in some urban areas where high charges for city water supply and wastewater discharge are imposed, 3-4 stage counter-current type washing is actually applied.

A sample case is one in which multistage counter current type washing is applied to the lead plating process and the wastewater is recycled for washing water after treating the wastewater using the ion exchange method.

Fig. 4-1-33 Multistage Countercurrent Washing Combined with Recycling of Ion Exchange-Treated Water

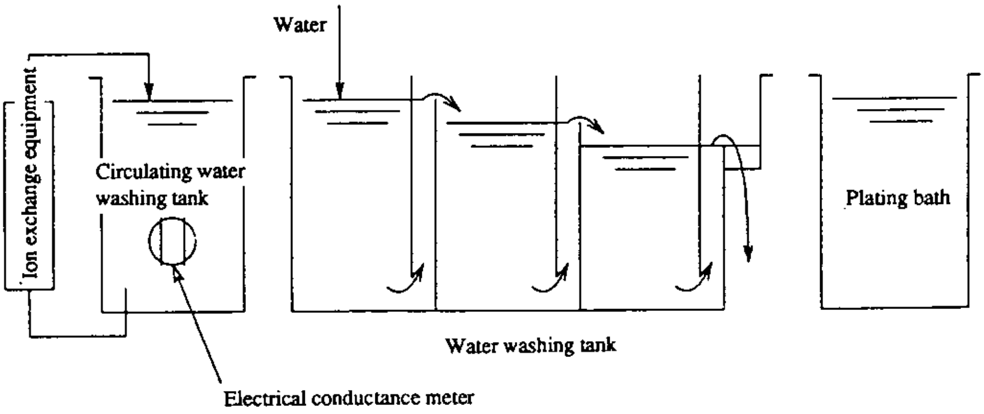


(4) Washing water recycling using ion exchange resin

A circulating water washing tank equipped with ion exchange equipment is installed at a stage after the multistage counter-current washing tank, and the washing water in the tank is recycled for reuse. The ion exchange resin has a longer regeneration cycle as smaller ion volume is brought into the recycling water washing tank.

The timing for regeneration of the ion exchange resin is monitored by a conductance meter.

Fig. 4-1-34 Circulating Washing Using Water Recycled by Ion Exchange Equipment



(5) Recovery and recycling of plating solution

The directly recycled plating solution and the plating solution recovered in the recovery tank are immediately returned to the plating bath, if the temperature of the plating bath is high and its evaporation volume is large.

If the temperature is normal or the evaporation volume is small, additional treatment including recovery of valuable matter shall be done independently.

(6) Measures to cope with impurities accumulated in plating solution

It is important to prevent the plating solution from deterioration caused by foreign matter falling into the bath or by matter taken in from a previous process.

Recovered and reused plating solution may accumulate impurities, consequently causing poor quality of plated products. The difference between disadvantageous and advantageous effects introduced by the recovery and reuse process must be clarified before measures are taken.

The impurities easily accumulated in plating solutions are: chlorine ion, sulfate ion, iron and nickel in chrome plating solution; and iron, copper, chromium, and decomposed components of brightening agent in cyanide plating solution.

Simply removing floating oily matter from degreasing solution, the lifetime of the solution can be elongated.

(7) Separation of drainage canals in plating process

Since chemicals used in each handling unit are quite different in each plating process series, dividing each drainage canal according to the type of process is a prerequisite. Original wastewater could possibly be contaminated by the oozing into it of other wastewaters discharged from different types of processes, so that each wastewater must be surely led to its own wastewater tank by piping.

(8) Understanding wastewater volume from each process

To ensure collection of the wastewaters according to their process type with easy operation control and low-cost treatment, the wastewater volume divided according to process type, must be correctly understood.

If the volume exceeds the capacity of the wastewater treatment facility, feedback to the process control room must be done. On the contrary, if the volume is quite small, some procedure such as switching the operation from the original continuous type to the batch type is desirable.

(9) Measures for preventing oil and solvent outflow

When degreasing of a solution tank has been carried out using solvent, in order to prevent ground water contamination by spilled solvent such as trichloroethylene, the tank shall be dried to remove solvent before water washing.

When floating oil is removed in the degreasing process, the degreasing efficiency is sustainable and the problem of oil being carried over from the degreasing process to the plating bath can be avoided.

Oil content in the wastewater discharged from the degreasing process may adhere to the level sensor, sometimes causing it to malfunction, so that maintenance of the sensor and the like is necessary.

4.1.9 Wastewater Treatment Techniques

(1) Choice of wastewater treatment technique

(a) Division of wastewater

Wastewater treatment varies greatly depending upon the hazardous substances regarded as objects of the treatment, and if the treatment is mishandled by mixture with other wastewater, not only is the treatment efficiency is reduced but hazardous gas can be generated, so that correctly dividing the wastewater and leading it to the proper wastewater treatment equipment are important basic procedures.

Plating wastewaters are basically divided as follows:

Cyanide-containing wastewater:
1) Cyanide wastewater (low-concentration wastewater such as washing wastewater)
2) High-concentration cyanide wastewater

Chromium-containing wastewaters:
1) Chromium wastewater (low-concentration wastewater such as washing wastewater)
2) High-concentration chromium wastewater

Acid, alkali wastewaters:
1) Acid, alkali wastewaters (washing wastewater excluding cyanide, chromium type)
2) High-concentration acid, alkali wastewaters

Others:
Borofluoride-containing waste liquid, phosphorus, nitrogen containing waste liquids, chelate-containing waste liquid. These should be divided and treated separately.

(b) Treatment of cyanide-containing wastewaters

(b-1) Oxidation decomposition treatment

The cyanide wastewater is decomposed to carbon dioxide gas and nitrogen gas by the alkaline-chlorine treatment method. Metals contained in the wastewater deposit as hydroxides and are separated. Sludge is dehydrated and disposed of.

In the alkaline-chlorine treatment method, using sodium hypochlorite as the chlorination agent, the following 2-stage reaction occurs:

1st stage reaction: $NaCN + NaClO \longrightarrow NaCNO + NaCl$

2nd stage reaction: $2NaCNO + 3NaClO + H_2O \longrightarrow N_2 + 3NaCl + 2NaHCO_3$

In the 1st stage, avoiding the generation of toxic cyanide chloride, rapid reaction proceeds in alkaline condition. On the other hand, in the 2nd stage, rapid reaction proceeds in neutral condition.

To decompose cyanide completly, a 2-stage reaction under different pH conditions is required.

The reaction conditions are as follows:

For 1st stage reaction: pH $\geq$10.5, ORP $\geq$300 mV

For 2nd stage reaction: pH =7.5-8.0, ORP =600 mV

To decompose cyanide (as CN^-) 1 g, theoretically the necessary amount of sodium hypochlorite is 7.16 g in 100%-solution. For 12%-effective chlorination agent, the amount is 60 g, but in practice, more than that amount is needed.

(b-2) Treatment of cyanide complex

1) Treatment of cyanide complex with zinc, cadmium and copper

These complex compounds are easily decomposed by sodium hypochlorite in the alkaline-chlorine method.

2) Treatment of nickel-cyanide complex

Though nickel-cyanide complex can also be decomposed by sodium hypochlorite, this takes more than 24 hours, so wastewater control is carried out to avoid contamination of the cyanide-containing wastewater.

(3) Treatment of iron-cyanide complex

Both iron ion Fe(II) and Fe(III) form stable iron-cyanide complex such as ferrocyanide complex and ferricyanide that are difficult to treat by the alkaline-chlorine method. They are produced from the iron material dropping into the plating bath to be dissolved, and they contaminate the wastewater. They are usually removed by reaction with zinc or copper to form insoluble deposits, and then separated.

Since cyanide-containing wastewater usually contains zinc and copper ions, the cyanide 2-stage reaction treatment solution undergoes the following reactions:

i) Add reducing agent (sodium sulfite, sodium bisulfite) to the cyanide 2-stage reaction treatment solution until pH = 5-7, ORP = 200 mV is indicated, and stir for more than 20 minutes to reduce the remaining chlorine and ferric cyanide. Then, adjust pH to 9-10 to remove iron-cyanide together with the metal hydroxide. If pH >10, iron-cyanide elutes again, so the pH adjustment must be accurately carried out.

ii) Combine the cyanide 2-stage reaction treatment solution with the chromium reduction treatment solution to create a deposit. To prevent chromium from eluting, an excess of reducing agent is required.

(c) Treatment of chromium-containing wastewater

In the treatment of chromium wastewater, chromium (VI) is reduced to chromium (III) by a reducing agent, and then the chromium hydroxide deposit is separated. The sludge is dehydrated and disposed of. Chromium wastewater and high-concentration chromium wastewater can be safely and surely treated using sodium bisulfite reducing agent ($NaHSO_3$).

$$4H_2CrO_4 + 6NaHSO_3 + 3H_2SO_4 \longrightarrow 2Cr_2(SO_4)_3 + 3Na_2SO_4 + 10H_2O$$

Rapid reaction occurs as pH is lowered. After the reaction, pH is adjusted to 8.5 - 10 to form chromium hydroxide.

Calcium hydroxide and caustic soda are used as alkaline agents. When caustic soda is used, such fine deposits are obtained that careful separation must be done. If $pH > 11$, chromium hydroxide elutes again, so that strict pH control is needed.

$$Cr_2(SO_4)_3 + 3Ca(OH)_2 \longrightarrow 2Cr(OH)_3 + 3CaSO_4$$
$$Cr_2(SO_4)_3 + 6Na(OH) \longrightarrow 2Cr(OH)_3 + 3Na_2SO_4$$

The reaction condition are as follows:
Reducing reaction: $pH \leq 3$, $ORP \leq 250$ mV
Hydroxide deposition: pH = 8.5 - 10

The theoretical amount of sodium bisulfite needed to reduce 1 g of chromium is 3g. In practical use, a little more is required. If double the theoretical amount is used, chromium hydroxide is not formed. In such a case, an aluminum salt is added. After the chromium reduction, if it is mixed with the cyanide-containing oxidation treatment solution, the oxidation reaction to chromium (VI) occurs again, so that addition of excess reducing agent is recommended.

(d) Treatment of wastewater containing heavy metal

Plating wastewater containing heavy metal deposits metal hydroxides when pH is adjusted.

Although the optimum pH value adjustment varies depending upon the kind of metal, it is mainly in the range from 5.8-8.6. However, it should be noted that as pH increases, zinc, chromium and aluminum form complex ions and these metals re-dissolve.

Metals react mainly as follows:

$Cr_2(SO_4)_3 + 6NaOH — 2Cr(OH)_3 + 3Na_2SO_4$

$CuSO_4 + Ca(OH)_2 — Cu(OH)_2 + CaSO_4$

$ZnSO_4 + Ca(OH)_2 — Zn(OH)_2 + CaSO_4$

To improve coagulation efficiency, a polymer type coagulant is used.

The separated sludge deposit is concentrated, dehydrated and disposed of.

(e) Treatment of chelate-containing wastewater

(e-1) Coagulating sedimentation method

Depending upon the chelater used, following methods are applied:

1) Gluconic acid, citric acid, tartaric acid and EDTA:

After adjusting pH < 3 to elute complex metal chloride ion, add the metal ion such as iron salt, aluminum salt or calcium salt as coagulant.

2) Pyrophosphate complex compounds:

After adjusting pH $\leq$ 3 to elute complex metal chloride ion, add calcium chloride and calcium hydroxide to adjust pH $\geq$ 9.

3) Ammonium salt-containing wastewater:

This will form metal ammonium complex. If the ammonium concentration is as low as 100 mg/L, it can be treated by forming metal hydroxide. If the ammonium concentration is high, reduce the concentration using the stripping method or treat by the chelate resin method or by forming metal sulfate.

(e-2) Treatment by forming sulfate

The metal sulfate products show smaller solubility than other compounds and have stable sediment configuration, but they it generate hydrogen sulfide in the acidic condition and easily becomes colloidal with consequent difficulty in separating solid from solution. Organic polymer sulfate is a commercial product to cope with such problems. However, this is so expensive that forming metal hydroxides as far as possible and removing them by coagulation treatment is done first, then it is used for after-treatment.

(e-3) Treatment by ion exchange method (chelate resin method)

Chelate resin is used for general methods (regeneration type) and for mercury adsorption (non-regeneration type).

The chelate resin is preferably used for after-treatment of the wastewater such as neutralization, coagulation and sedimentation, but it can be used directly when low concentration of metal.

(f) Treatment of oil component

(f-1)

The floating oil component unemulsified in the degreasing bath is adsorbed by the oil adsorbent composed of propylene or polystyrene and removed.

(f-2) Coagulation treatment

The oil component contained in wastewater can be removed by coagulation treatment using an inorganic coagulant such as iron salt and aluminum salt. The metal ions contained in the plating wastewater react as an inorganic coagulant, so it is not particularly necessary to add any other coagulants.

(g) Treatment of COD, BOD components

(g-1) Chemical oxidation treatment

Using chlorine, sodium hypochlorite and hydrogen peroxide, the COD component is oxidized to decompose it. In the case where the waste liquid containing an oxidizing agent such as ammonium persulfate etching waste liquid is produced, it can be effectively utilized as the oxidizing agent.

(g-2) Electrolytic oxidation treatment

For treating the concentrated cyanide waste liquid and waste liquid containing COD components, electrolytic oxidation treatment is used. This method is suitable for treating small amounts of waste liquid with COD > 2,000 mg/L.

(g-3) Activated carbon adsorption treatment

Activated carbon is characterized by its selective adsorption of organic substances, so it is widely used for removing COD, BOD and coloring matters. although affected by kind, configuration and through-water passing velocity, the adsorption capacity is about 5-50 g COD/kg. If saturated, the activated carbon can be regenerated.

Good adsorptivity of activated carbon must always be maintained by regeneration and replacement. Activated carbon is so expensive that it is generally used in the final finishing stage of the wastewater treatment.

(g-4) Biological treatment

Plating wastewater is rarely treated biologically, because the wastewater contains heavy metals and various other hazardous substances. If plating wastewater is treated together with domestic wastewater at a comparatively large-scale corporation, the mixture can be biologically reacted after the plating wastewater is pre-treated by the coagulation process.

Since biological treatment can be managed at low expense and micro-organisms suitable for treatment of the wastewater can be easily cultured, it is preferable to apply biological treatment for organic substances.

(h) Treatment of fluorine

(h-1) Treatment of fluorine

Calcium salt is added to the fluorine-containing wastewater to deposit slightly-soluble calcium fluoride.

(h-2) Treatment of borofluoride

Fluorine, contained in borohydrofluoric acid used for solder plating solution and its salts, are treated as follows:

1) Add aluminum salt, heat and then add calcium hydroxide to form calcium fluoride that can be easily removed.
2) Add aluminum salt, allow to react for a long time at normal temperature and then add calcium hydroxide to form calcium fluoride that can be easily removed.
3) When the concentration of borohydrofluoric acid is low, its condensation is carried out by the ion exchange method. An easily regenerated weak basic anion exchange resin is used. By combining this with cation exchange resin, the deionized water can be reused for water washing.

(i) Treatment of phosphorus

(i-1) Coagulation treatment

Phosphate, used for degreasing solution, chemical polishing solution, and pyrophosphoric acid plating solution, consists of ortho-phosphoric acid and pyrophosphoric acid, so that coagulation sedimentation treatment using calcium hydroxide, iron salt and aluminum salt can be done.

Because the iron salt and aluminum salt react to coagulate in neutral condition, if joint treatment together with other heavy metals is carried out, the use of calcium hydroxide which reacts to coagulate in alkaline condition is preferable. In this treatment, the wastewater is first acidified (pH around 3) then calcium hydroxide is added to make the mixture alkaline (pH 9-10) to remove heavy metals; then made further alkaline, to pH >10, to remove phosphoric acid.

(i-2) Treatment of chemical nickel plating wastewater containing phosphorus.

The phosphorus contained in the chemical nickel plating solution forms hypophosphite ion ($H_2PO_2^-$) and phosphite ion (HPO_3^{2-}). The former does not coagulate with calcium, iron and aluminum, so that the following method is applied for its treatment:

1) Phosphorus is oxidized and decomposed by sodium hypochlorite, then coagulated by calcium hydroxide.
2) For high-concentration waste liquid such as chemical nickel plating solution, phosphorus is decomposed to phosphoric acid, using the electrolytic oxidation method, then phosphoric acid is removed, together with COD components and nickel, by the coagulation sedimentation method.

(j) Treatment of nitrogen

(j-1) Break point treatment

In break point treatment, ammonia, which contains nitrogen, is decomposed by a chlorine agent, to form nitrogen gas. The main reaction is as follows. Here, some of the nitrogen remains as nitrogen oxide:

$$2NH_3 + 3HClO \longrightarrow NH_2Cl + NHCl_2 + 3H_2O$$
$$NH_2Cl + NHCl_2 \longrightarrow N_2 + 3H_3O^+ + 3Cl^-$$

The amount of chlorine used relative to the nitrogen in ammonia is about 7.7:1, but if reducing substances such as sulfate and ferrous salt are contained in the mixture, an excess of the chlorine agent is consumed.

(j-2) Stripping treatment

The nitrogen contained in the ammonia structure in wastewater is released into the air as ammonia gas under alkaline condition ($pH \geq 11$). Efficiency of the treatment is lower in winter due to low temperatures, and the ammonia gas released into the air stinks has an extremely offensive odor, so an another measure is necessary.

(J-3) Zeolite adsorption treatment

Nitrogen is treated using zeolite which selectively adsorbs ammonium ion.

(j-4) Ion exchange treatment of nitrogen contained in nitric acid

In this method, nitrate ion is adsorbed using Cl type cation exchange resin. To desorb nitrate ion from the ion exchange resin, brine is used.

(j-5) Removal of biological nitrogen

The biological nitrogen removal method is composed of the nitration reaction where nitrogen, contained in the organic structure and ammonia structure in wastewater, is changed to nitric acid in an aerobic atmosphere, and the denitrification reaction where nitrogen from the same structures is changed to nitrogen gas in an anaerobic atmosphere. Nitrifying bacteria are involved in the nitration reaction and denitrifying bacteria are involved in the denitrification reaction. The former do not require organic substance because of autotrophism, and the latter need organic substance because of heterotrophism.

When biological treatment is used to remove organic substance, the nitration process and the denitrification process can be further added to the treatment, but these bacteria are sensitive to hazardous substances, so that careful handling is needed. However, research on and development of this promising biological treatment are proceeding now.

(k) Treatment of trichloroethylene and related compounds contained in wastewater

Trichloroethylene, tetrachloroethylene (perchloroethylene) and 1,1,1-trichloroethane (methyl chloroform) contained in wastewater can be removed by the aeration method and the activated carbon adsorption method. But gas released into the air by the aeration method still contains parts of these substances, so that after-treatment by the activated carbon adsorption method must follow the above treatments before gas can be released. Accordingly, the activated carbon adsorption treatment is applied either directly or sequentially, i.e. aeration followed by adsorption.

(2) Combination of unit processes

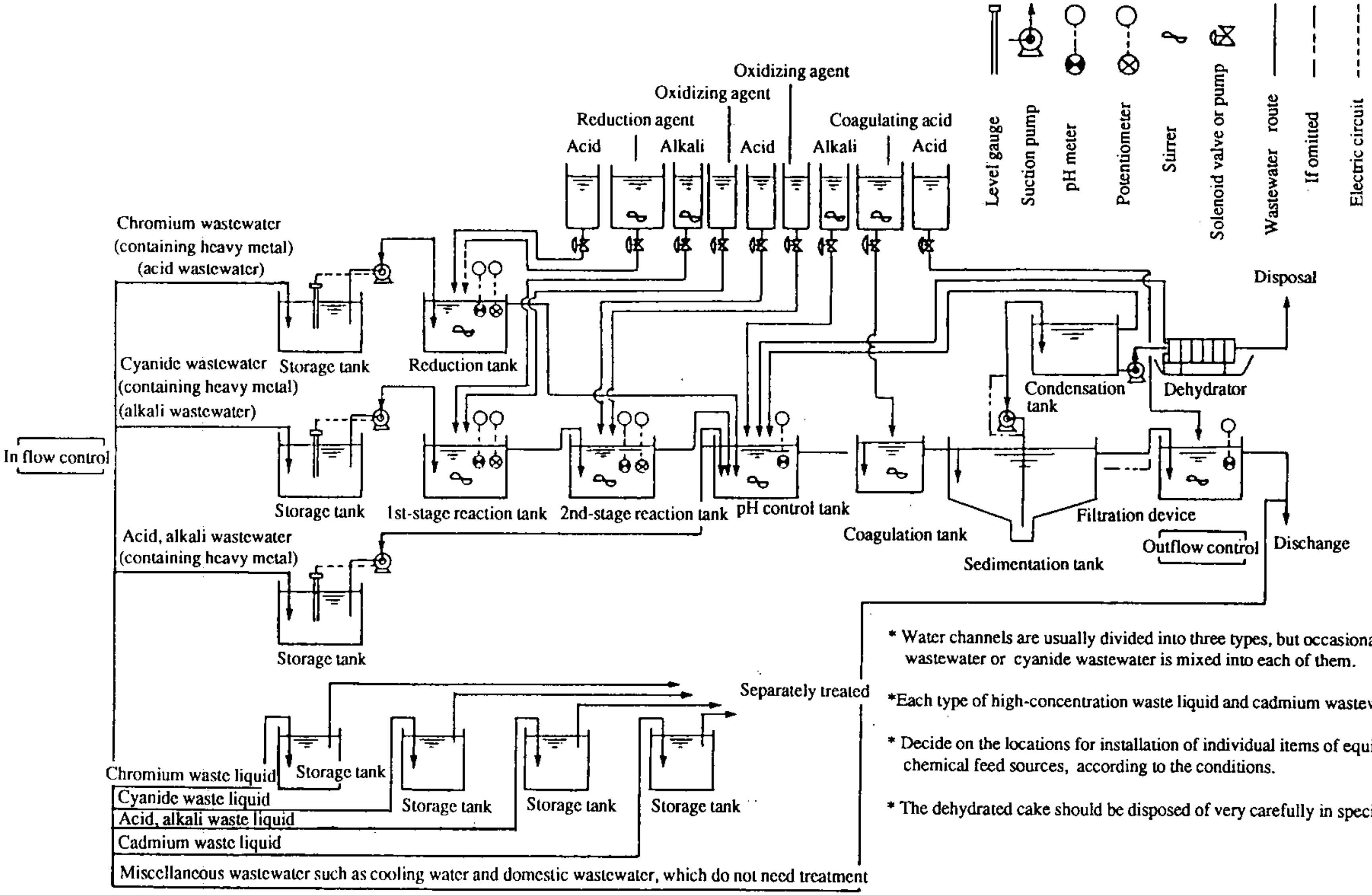
The basic processes in plating wastewater treatment are: cyanide oxidation decomposition treatment, chromium (VI) reduction, heavy metal removal, pH adjustment and integrated control.

To carry out continuous wastewater treatment, each hazardous substance in individual wastewater, is treated, then pH adjustment is conducted for the mixed wastewater.

On the other hand, when bath style wastewater treatment is carried out, cyanide-containing wastewater and chromium-containing wastewater are separately treated in individual batch system, and sent to separate storage tanks, but after the pH adjustment they are mixed and the same treatment follows as in the continuous treatment.

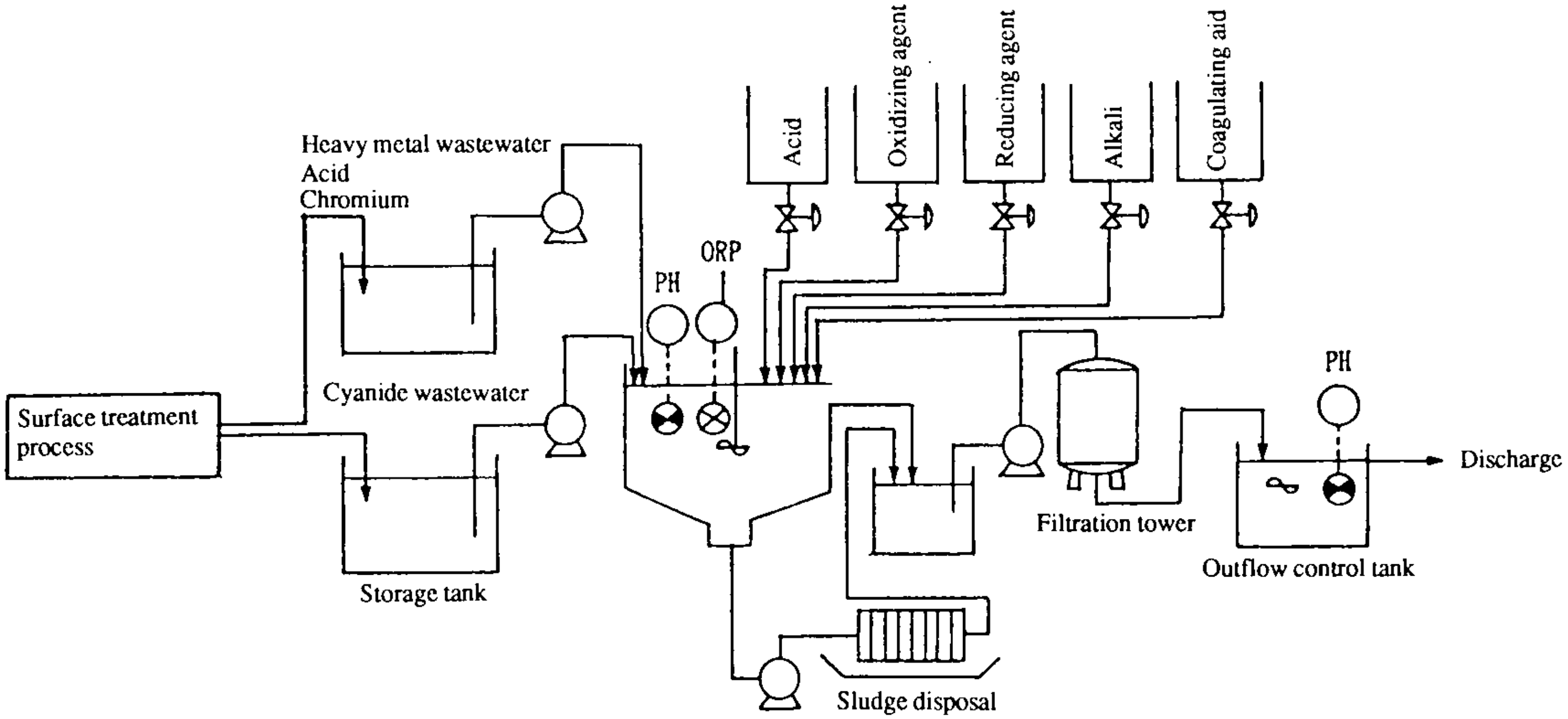
The flow sheet diagram for each type of treatment is shown on the following page. In this process, some components with COD, phosphorus, fluorine (except borofluoride) etc. can be removed simultaneously.

Fig. 4-1-35 Standard Type Flow Sheet Diagram



- * Water channels are usually divided into three types, but occasionally, chromium wastewater or cyanide wastewater is mixed into each of them.
- *Each type of high-concentration waste liquid and cadmium wastewater is treated separately.
- * Decide on the locations for installation of individual items of equipment and chemical feed sources, according to the conditions.
- * The dehydrated cake should be disposed of very carefully in specified places.

Fig. 4-1-36 Batch Type Flow Sheet Diagram



(3) Example: trial calculation of wastewater treatment cost

This example of trial calculation of wastewater treatment cost is excerpted from the guidelines formulated in 1980 by the Environment Agency as guidance for removal of nitrogen and phosphorus from wastewater (The general mechine and equipment manufacturing industry is used for most examples shown.)

[Pre-conditions]

i) Treatment techniques

Existing techniques: Neutralization method for acid-, alkali wastewater, alkaline-chlorine method for cyanide wastewater

Phosphorous measure: Addition of coagulation sedimentation

Nitrogen measure: Addition of biological nitration denitrification method

ii) Treatment effect

		Raw water quality		Treated water quality		
		Range	Mean value	Existing technique	Phosphorus measure	Nitrogen measure
BOD	(mg/L)	10 - 130	70	28	20	5
COD	(mg/L)	6 - 110	60	30	20	20
SS	(mg/L)	10 -	100	30	15	12
T-N	(mg/L)		15	13	13	4
T-P	(mg/L)		15	6	1	6

[Treatment cost] (Wastewater volume: 100 m ³/day scale)

		Existing technique	Phosphorus measure	Nitrogen measure
Fixed cost	(¥/m³ • day)	215,000	256,000	335,000
Running cost	(¥/m³)	17	21	51
Sludge disposal cost	(¥/m³)	29	35	31

(4) Sludge treatment

Since sludge produced by the wastewater treatment contains heavy metals, proper treatment and disposal must be conducted in accordance with the concerned regulations to prevent secondary pollution. In Japan, the sludge that is usually regarded as the industrial waste, is entrusted to industrial waste managenment contractors for transfer and disposal.

The sludge discharged from the wastewater treatment facility contains much water. If the sludge were to be immediately transferred and disposed of as-is, treatment would be difficult and expensive. Accordingly, pre-treatment by dehydration is generally done before the transfer.

There are several methods for sludge dehydration and their technical development is now under way. Because of its advantages, including possible automatic operation, reduced sludge water content and availability to small-scale corporations, the press filtration machine for sludge dehydration (filter press) is generally used.

When a storage tank with appropriate capacity is installed, sludge treatment can be smoothly carried out, and is less affected by operation changes.

For a small-scale corporation, instead of extending this kind of handling to sludge treatment, sludge transfer by using a vacuum vehicle may be much more practical and convenient.

4.1.10 Control of Wastewater Treatment Facility

(1) Compatibility of treatment capacity with wastewater

Operation content/scale and chemicals, which had been applied or planned when the wastewater treatment equipment was installed, may change according to time and changes of demands for product quality. Consequently, variations of programmed wastewater volume, water quality and component compositions may exceed the treatment capacity of the equipment and the compatibility of techniques.

When the wastewater volume increases and the wastewater treatment capacity becomes insufficient due to growth of the business, expansion and renovation of the treatment equipment are needed.

On the other hand, for example, with the increased use of chelate chemicals and cyanide complex removal of heavy metals and cyanide becomes more difficult when conventional techniques are applied. To cope with such water quality changes, the treatment techniques must be reviewed.

At regular interval or whenever an operation outline or chemical handling has been changed, the compatibility of treatment capacity with wastewater in the present wastewater treatment facility must be reviewed. In this case, to understand the changes of components in the wastewater, analysis of the wastewater quality must be done concerning the state of ions, etc. in addition to the all wastewater concentrations.

(2) Allocation and maintenance/inspection

Maintenance and inspection of the wastewater treatment equipment, focusing on its regular functions or malfunction must always be done. If it is possible to inspect each wastewater along its flow route, maintenance and inspection can be readily done.

Although the wastewater treatment equipment may usually be assigned at limited space, since inspection and maintenance operations are important in addition to checking the data of the installed automatic control equipment and wastewater quality monitoring equipment, the wastewater treatment equipment also must be carefully positioned.

(3) Unit operation function

To make sure that wastewater of various qualities are properly treated, and to prevent the discharge of hazardous substances from each process, the wastewater treatment equipment includes many combined unit operations such as neutralization treatment and coagulation treatment. If the functions of these unit operations are inadequate, the reasonable quality of meeting the standards connot be achieved.

Such a situation may occur in a case when the quantity or quality of the wastewater has exceeded the wastewater treatment capacity range, as described before. Accordingly, operation control and the content of each operation in the plating process must be examined immediately.

This type of situation can also occur in other cases where a defect is inherent in the structure or specifications of the equipment itself, so that perfect operation is impossble even when the applied technique is adequate. For example, in the case of a reaction vessel, oxidation, reduction, and neutralization reactions are greatly affected by the shape of the vessel, method and efficiency of stirring, stream of wastewater, and locations of injector and sensors.

To evaluate the effects of wastewater treatment, not only the operation control but also the function of devices in unit treatment equipment must be checked. If some trouble with the equipment is found, take the necessary measures immediately. If this is done, the trouble can sometimes be solved by comparatively minor repair or improvement.

(4) Automatic control by oxidation-reduction potential (ORP) and pH

In a case where the wastewater treatment is conducted by oxidation-reduction reaction, automatic control using ORP is generally conducted. Since ORP changes depending upon the pH of the wastewater, automatic control using pH is simultaneously conducted to achieve smooth operation.

In a case where continuous type treatment equipment is used, particularly when the pump operates intermittently, automatic control using ORP and pH may occasionally mismanage the system, resulting in increased amounts of additives, increased treatment cost and inadequate treatment. Thus, when the amount of wastewater is rather small compared to the treatment capacity of the equipment, batch type treatment equipment may be recommended for use instead.

For cyanide-containing wastewater, even though the pH adjustment has been completely once, the carbonate content (measurable as alkalinity) of the wastewater may have the effect of increasing the pH value again at the discharge basin, so that some sort of careful handling such as elongation of retention time may be needed.

(5) Maintenance of sensors used for automatic control

Sensors such as pH meters, ORP meters and level meters used for automatic control may indicate erroneous measured values when oil and heavy metal hydroxides in wastewater adhere to them.

Periodic cleaning, calibration and functional checking of these meters are required. Record the data from these processes in the operation control diary and utilize them for operation control.

(6) Concentration checking of chemicals

Since the appropriate concentration level of each chemical solution used for the treatment is determined according to the properties of the wastewater, the treatment chemicals must be prepared beforehand by diluting them to the specified concentration levels.

For example, when a cyanide-containing wastewater is being treated using the alkaline-chlorine method, if the wastewater is silver cyanide-containing wastewater or copper-cyanide-containing wastewater diluted sodium hypochlorite must be used as the chlorine agent. The situation is the same when an organic type polymer coagulating agent is used for coagulating sedimentation treatment.

Since the diluted treatment chemicals are easily decomposed causing their efficiency to become degraded, they should be used immediately after they are prepared.

(7) Measures against COD, BOD, phosphorous and nitrogen

For the corporations that usually discharge treated water to enclosed water area such as lake and pond and inner bay, their measurements are mainly focused on COD, BOD, phosphorus and nitrogen; however, conventional oxidation-reduction treatment and neutralization treatment are insufficient to meet the standards.

The wastewater discharged from the degreasing process contains many components with high COD and BOD. For such wastewater, by not allowing the chemical concentration to rise above the necessary level, the wastewater load can be reduced to some extent.

Phosphorus and nitrogen contained in wastewater discharged from the metal plating industry are usually difficult to control using coagulation treatment. In particular, chemical nickel plating wastewater must be entrusted to an industrial waste management contractor.

(8) Simple analysis of wastewater and treated waters

To make sure that wastewater treatment is effective, the objects of water quality testing must include wastewaters, treated waters and waters discharged from each process, plus in some case, the treated water from each handling unit. The current effectiveness of the treatment must be understood.

Since water quality analysis methods are legally specified by Notification of the Environment Agency and JIS, the data to be submitted officially must be obtained by these methods or analysis must be entrusted to an authorized analysis organization involved in the environmental measurement business.

The water quality testing linked to the operation management of the wastewater treatment facility should preferably be carried out by a simple analytical method that is characterized by rapid measurement and frequent measurements, though the accuracy is relatively low. In this case, correlation with regular analytical methods must be checked before use.

(9) Management of wastewater treatmemt equipment control records

Since the metal plating industry handles hazardous substances, the wastewater treatment is carried out in conformity with the legally determined effluent standards.

Accordingly, actual data (consumption of electric power and chemicals) as well as reports (operation control, maintenance and inspection of wastewater treatment equipment) must be systematically recorded and managed in daily report notes and monthly report notes.

Furthermore, these records must be analyzed and arranged in correlation with the metal plating industry outcome (kinds and inventory of plating products). Thus, the wastewater treatment cost in correlation with the plating process can be classified, and, consequently, the concept of "cleaner production", i.e. energy and resource conservation in the integrated wastewater control measures and plating process systems, and rationalization of the plating cost, can be realized and controlled.

(10) Reserved spare items

Spares units of basic parts and consumables used for the wastewater treatment equipment must always be kept on hand and stored.

In particular, the pH electrode, for example, is a delicate precision instrument. On the other hand, fuses and thermal switches are parts designed to break down to protect a main unit.

As described in operation manual for wastewater treatment equipment or the like, it is important to check daily operation reports, and then for items requiring frequent replacement and consumables used in large amounts, to keep the necessary parts and consumables on hand.

Furthermore, their durability and storage method must be noted.

4.1.11 Measures against Accidents

(1) Measures against accidental damaging of plating bath

Even though ordinary handling of the plating process and the wastewater is completely controlled, unexpected incidents, e.g. an earthquake, may cause serious accidents, such as spilt hazardous substance.

Accordingly, precautionary measures, e.g. provision of storage tank to hold plating liquid, must also be taken.

As a practical method for this, a storage tank with some capacity is provided underneath each plating bath, so that solution in the bath can be received in the tank, even if the bath is damaged. Usually, the plating solution is filitered and stored at reasonable temperature. By doing so, measures for energy conservation and collection of impurities are taken.

It is desirable that oven after the plating work has finished, the wastewater treatment equipment shall continue the operation until the wastewater storage tank is empty.

(2) Measure against accidental damaging of wastewater treatment facility and chemical solution tank

If the piping of chemical solution tanks containing sodium hypochlorite solution and sodium chlorite solution is damaged resulting in mixing of these solutions with acidic solution, hazardous chlorine gas and sulfur dioxide gas will be generated by the reaction.

As a precautionary measure, alkaline solution tank, neutralization tank and coagulation tank shall be allocated to receive chemical solution that has accidentally flowed out.

(3) Installation of automatic level control and alarm equipment

While the wastewater is being transported from the storage tank to the treatment equipment by automatic operation of a pump, if something has adhered to the sensor of the level meter, or if malfunction of the pump occurs, the storage tank may overflow or become empty.

Similar trouble may occur when solution is being injected into the chemical solution tank. Overflow of chemical solution from the tank can occur due to careless operation.

To prevent such accidents, alarm equipment shall be installed to provide a warning when the solution level exceeds the allowable range. To confirm that it is in proper working order, i.e. providing an alarm when abnormal condition occurs, daily maintenance checks must be carried out.

4.1.12 Treatment and Disposal of Waste

(1) Recovery of valuable matter such as heavy metals

The plating solution removed from the plating bath is condensed and circulated for reuse. Recovered heavy metals are sold to metal refineries.

Such waste which undergoes recycling with the object of reuse is not regarded as industrial waste, and accordingly it is not subject to legal control.

(2) Sludge disposal

As described in the sludge treatment paragraph, solid waste such as sludge produced mainly by the wastewater treatment process is defined as industrial waste according to the "Waste Disposal and Public Cleansing Law".

Among industrial waste discharged from the metal plating industry, that which satisfies the following requirements is defined as "specially controlled industrial waste", and must be more strictly controlled than general industrial waste.

General industrial waste shall be appropriately treated by the corporation as its own responsibility.

When general industrial waste or specially controlled industrial waste is treated and disposed of by the owners themselves, to prevent hazardous substance from being released to the surrounding environment, owners are obligated to carry out the treatment and disposal in accordance with the legally determined technical standards, and to submit reports on what has been done.

However, ordinarily it is so difficult for a factory to do treatment and disposal itself that these matters may be entrusted to a professional company: the legal definition also states that the entrusted company shall be legally approved as an industrial waste collection and transport company, and industrial waste management contractor concerning the handling of industrial waste or specially controlled industrial waste.

Also, there must be proper management of the manifest that testifies to proper treatment and disposal of the waste. The manifest is in the custody of 3 parties, i.e. the waste generator, collection and transport company and waste service company. The waste generator holds 2 kinds of manifest: shipment manifest and a manifest to testify to the final disposal. There must be 4 copies of the manitest for industrial waste, and 6 copies for specially controlled industrial waste (including copies or confirmation of collection and disposal).

Table 4-1-37 Specially Controlled Industrial Waste (concerning metal plating industry)

Kind of industrial waste	Facility (Water Pollution Control Law)	Limit, content concentration (mg/L)
Waste acid		pH $\leq$ 0.2
Waste alkali		pH $\geq$ 12.5
Waste oil (including trichloroethylene)	66) Electroplating facility • Trichloroethylene surface treatment facility	
Matter treated for disposal	Waste oil	Waste solvent (limited to trichloroethylene)
	Waste acid, waste alkali	Trichloroethylene 3
	Items other than waste acid and waste alkali	Trichloroethylene 0.3
Waste oil (including tetrachloroethylene)	66) Electroplating facility • Tetrachloroethylene surface treatment facility	
Matter treated for disposal	Waste oil	Waste solvent (limited to tetrachloroethylene)
	Waste acid, waste alkali	Tetrachloroethylene 1
	Items other than waste acid and waste alkali	Tetrachloroethylene 0.1
Sludge, waste acid, waste alkali (including mercury)	63) • Waste gas cleaning facility (metal product mfg.)	Sludge: alkyl mercury detected, mercury 0.005 Waste acid, waste alkali: alkyl mercury detected, mercury 0.05
Matter treated for disposal	Waste acid, waste alkali	Alkyl mercury detection, mercury 0.05
	Others	Alkyl mercury detection, mercury 0.005
Sludge, waste acid, waste alkali (including cadmium)	63) • Waste gas cleaning facility (metal) 65) Acid alkali surface treatment facility 66) Electroplating facility	Sludge; cadmium 0.3 Waste acid, waste alkali: cadmium 1
Matter treated for disposal	Waste acid, waste alkali	Cadmium 1
	Items other than waste acid and waste alkali	Cadmium 0.3
Sludge, waste acid, waste alkali (including lead)	63) • Waste gas cleaning facility (metal) 65) Acid alkali surface treatment facility 66) Electroplating facility	Sludge: lead 3 Waste acid, waste alkali: lead 10
Matter treated for disposal	Waste acid, waste alkali	Lead 10
	Items other than waste acid and waste alkali	Lead 3
Sludge, waste acid, waste alkali (including chromium (VI) compounds)	63) • Waste gas cleaning facility (metal) 65) Acid, alkali surface treatment facility 66) Electroplating facility	Sludge: Cr(VI) 1.5 Waste acid, wate alkali: Cr(VI) 5
Matter treated for disposal	Waste acid, waste alkali	Cr(VI) 1.5
	Items other than waste acid and waste alkali	Cr(VI) 5

Kind of industrial waste	Facility (Water Pollution Control Law)	Limit, content concentration (mg/L)
Sludge, waste acid, waste alkali (including As)	65) Acid, alkali surface treatment	Sludge : As 1.5 Waste acid, waste alkali: As 5
Matter treated for disposal	Waste acid, waste alkali	As 1.5
	Items other than waste acid and waste alkali	As 5
Sludge, waste acid, waste alkali (including cyanide)	66) Electroplating facility	Sludge : CN 1 Waste acid, waste alkali: CN1
Matter treated for disposal	Waste acid, waste alkali	CN 1
	Items other than waste acid and waste alkali	CN 1
Sludge, waste acid, waste alkali (including trichloroethylene)	66) Electroplating facility	Sludge : trichloroethylene 0.3 Waste acid, waste alkali: trichloroethylene 3
Matter treated for disposal	Waste acid, waste alkali	Trichloroethylene 3
	Items other than waste acid and waste alkali	Trichloroethylene 0.3
Sludge, waste acid, waste alkali (including tetrachloroethylene)	66) Electroplating	Sludge : tetrachloroethylene 0.1 Waste acid, waste alkali: tetrachloroethylene 1
Matter treated for disposal	Waste acid, waste alkali	Tetrachloroethylene 1
	Items other than waste acid and waste alkali	Tetrachloroethylene 0.1

(Note)

- Kinds of industrial waste are defined by Enforcement Ordinance 2.2 "Waste Disposal and Public Cleansing Law".

The final disposal methods are landfill disposal and ocean disposal, but the ocean disposal will become practically impossible to do hereafter due to the revised London Treaty.

There are 3 types of landfill disposal sites: least controlled landfill sites, controlled landfill site and strictly controlled landfill site, and disposal locations have been allotted depending upon the kind of waste. But, since environmental control measures have not been fully taken for the industrial waste disposal until now, and residents do not frust them, it is difficult now to reserve landfill disposal treatment sites. At present, approval of the local government is required for construction of a landfill disposal site and it must be inspected before use.

JEC has been engaged in final disposal site construction and transfer projects.

4.1.13 Air Pollution Control

(1) Local exhaust ventilation

To protect the working environment, ventilation and dedusting are carried out by pulling air through a hood installed above the plating bath. The emission gas removed is led to the deduster and the emission gas cleaning equipment through ducts. Since the emission gas contains hazardous substances, the hoods and ducts must be made of corrosion-resistant materials with a leak-proof and condensation-resistant structure.

Furthermore, since collected dust accumulates easily and remains inside the ducts, daily maintenance such as cleaning must be done.

(2) Dust collector and emission gas treatment equipment

Both wet type and dry type dust collectors and emission gas cleaning equipment are used.

Usually these are located on the roof, so, since it is difficult to maintain them properly, extra care must be taken.

The emission standards for toxic gases emitted from factories are decided by ordinances of each local government. The case of Tokyo is shown in the following table:

Table 4-1-38 Emission Standards for Toxic Gases From Factories (Tokyo)

Types of toxic gas	Types of facilities	Standards by average quantity (unit: cm^3 or mg, for chromic acid) of toxic gas per 1 m^3 of total emission, converted to standard conditions, discharged into the atmosphere.
1. Ammonia	Ammonia-generating facility (except smoke/soot facility)	250
2. Fluorine and its compounds	Kiln and fusion furnace used for manufacturing glass or glass product (raw material: fluorite or sodium silicofluoride) (fire grade area ≥ 1 m^2, burner volume for liquid fuel ≥ 50 L/hr, or transformer normal capacity ≥ 200 kVA) or facility generating fluorine or its compounds (except smoke/soot facility)	10
3. Formaldehyde	Formaldehyde-generating facility (except smoke/soot facility)	50
4. Hydrogen sulfide	Hydrogen sulfide-generating facility (except smoke/soot facility)	30
5. Hydrogen chloride	Hydrogen chloride-generating facility (except smoke/soot facility)	25
6. Chlorine	Dissolver used for manufacturing ferric chloride, Reactor and absorber used for manufacturing chemical products	10
7. Nitrogen oxide	All facilities generating chromic acid.	200
8. Chromic acid	Facility generating nitrogen oxides (except smoke/soot facility)	1

4.1.14 Protection of Working Environment

In the metal plating process, even if the plating solution is spilt on the floor, work continues there in a high temperature and high humidity atmosphere, so that a safe and hygienic environment must be maintained.

Accordingly, it is desirable to do full arrangement of temperature control, lighting, ventilation and removal of noise and vibration; furthermore, adjustment of materials, chemicals and tools should be done.

Standards for working environment determined by the Law on Industrial Safety and Hygiene are shown in the following table:

Table 4-1-39 Standards for Working Environment, and Countermeasures for Non-compliance Cases

Item	Standards for working environment	Measures for meeting standards
Lighting	Precision work ≥ 300 lux Ordinary work ≥ 150 lux Coarse work ≥ 70 lux	Lighting
Temperature	5 - 28 °C	Air conditioning, ventilation
Humidity	< 85%	Air conditioning, ventilation
Noise	< 90 db	Partition, insulator
Ventilation	The total opening area of windows and other openings must be always ≥ 1/20 relative to floor area	Ventilation equipment

4.1.15 Benefits from Pollution Control Activities

It is certainly true that pollution control requires investment. But various kinds of secondary benefits may result from the enforcement of pollution control measures. Such benefits contributs directly or indirectly to future business management, and in this sense, the cost of pollution control measures is not always regarded as unnecessary waste of money.

For example, by enforcing the environmental control measure in the cleaner production approach, productivity and product quality will be improved. To ensure the safe working environment and reduce the pollution load on the environment, treatment of the wastewater and emission gas must be completed in an interior environment; by doing so, distribution of adverse effects to the exterior environment is prevented. By wide notification of the progress of such measures, positive corporate image can be maintained. The concepts of ecological investment and provision for greening of the environment are becoming popular now, and they will contribute beneficially to various aspects, such as attracting investments, product sales and staff recruitment.

Typical benefits are shown below:

1) Contribution to cleaner production
  - Rationalization of use of water and raw materials
  - Reduction of chemicals used
  - Energy conservation by temperature control of plating baths
  - Reduction of pollution load, for example by wastewater treatment
  - Saving on wastewater treatment costs
  - Saving on waste treatment and disposal (intrusted to outside company) costs
  - Promotion of productivity
  - Thorough quality control of products

2) Benefits of wastewater treatment
  - Protection of water quality on effluent discharge water area
  - Protection of working environment

3) Benefits of dust collection and emission gas treatment
  - Protection of working environment
  - Control of external air pollution

4.1.16 Construction and Transfer Programs by JEC

The industrial pollution control projects directly implemented by JEC for small- and medium-scale corporations are as follows:

1) Construction of joint pollution control facilities such as wastewater treatment facilities jointly used by concerned corporations.
2) Construction of new factory sites and buildings thereon with the objective of allowing factories located in densely-populated urban areas, and causing pollution, to transfer to pollution-free zones.

For small- and medium-scale corporations and small-scale local governments with little experience in pollution control measures, it may be difficult, from the financial and technical viewpoints, to do independent arrangement of pollution control facilities. Provided that such corporations intend to take joint pollution control measures, JEC , instead of these corporations, will construct the pollution control facility and transfer it to them. The expense of constructing the facility will be returned to JEC within a 10 to 20-year term. The local government handling administration and environmental matters in this region will provide assistance and mediation for the project implemented by JEC.

Since the metal plating industry has rather a heavy investment load in pollution control measures compared to production facilities, drastic countermeasures, such as factory transfer, will occasionally be taken in order to install new pollution control facilities. Accordingly, projects concerning the metal plating industry are mainly carried out in accordance with items 1) and 2) described above.

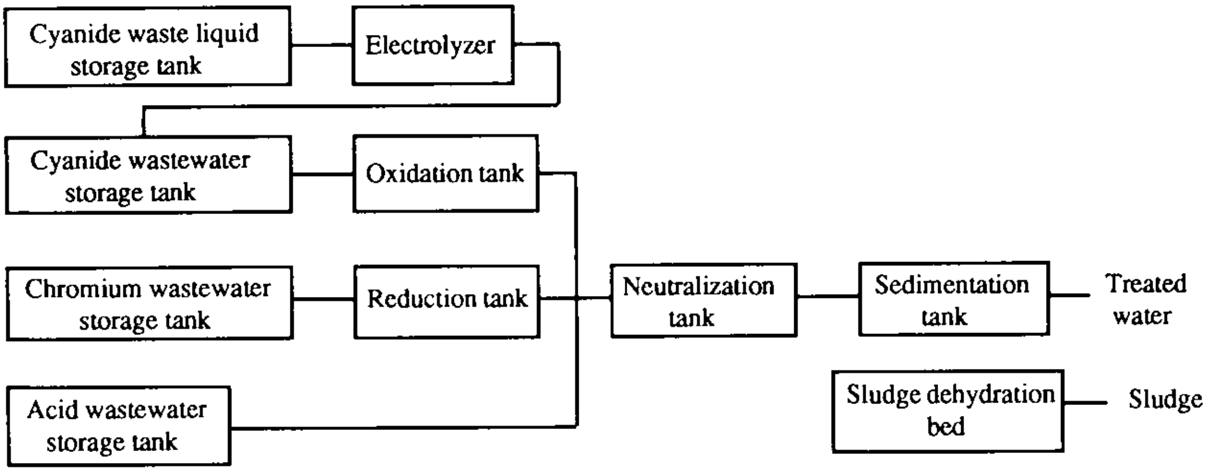
When JEC was established, pollution control as early as 1965 were mainly directed toward metal plating factories, because their cyanide effluents had caused problems for society due to pollution.

As a cooperative project with the Tokyo Metropolitan government, JEC organized a cooperative association consisting of a leading electroplating corporation and 6 corporations engaged in its sub-contracted polishing work. With the goal of joint use, a factory complex and pollution control facility were constructed. Because of restricting circumstances (location of clients, employees' commuting situation, etc.), the cooperative association was allowed to do this construction in a large urban area and a 6-floor multi-layered factory apartment building equipped with modern automatic plating equipment, integrated and jointly used installations (joint office, conference rooms, warehouse, lavatories, dining room, rest areas, medical room, training center, baths, electric power equipment, heating devices, building equipment, etc.) as well as rationally designed joint wastewater treatment facility and joint emission gas treatment facility, was built.

This factory complex was regarded not only as a technical model for controlling pollution but as an incentive model for high-quality business management, improving both the image of the corporation's identity and the zone environment.

Metal plating wastewater is classified into 4 types:cyanide-containing washing water, chromium-containing washing water, acid washing water and aged cyanide-containing waste liquid. Since the aged cyanide-containing waste liquid can be as high as 10,000 to 100,000 ppm, after decomposing it to carbon dioxide gas and nitrogen gas in an electrolizer to decrease the cyanide concentration, it is mixed with the cyanide-containing washing water. Then the cyanide-containing wastewater is alkalized using sodium hypochlorite and sodium carbonate, to undergo oxidation decomposition treatment. The chromium-containing wastewater is mixed with sodium bisulfite and sulfuric acid to reduce the chromium, and strongly toxic chromium (VI) is changed to weakly toxic chromium (III). These treated cyanide-containing wastewater and chromium-containing wastewater, together with acid wastewater, are neutralized using sodium carbonate in neutralization tank and, after settling hydroxide of chromium, iron and other heavy metals in sedimentation tanks, are separated into supernatant liquid and sludge. The supernatant liquid is discharged to a sewer, and the sludge is extracted from the tank for disposal after dehydration on a bed as well as drying outside. The quality of the treated water becomes: total cyanide ≤ 2 ppm, total chromium ≤ 2 ppm, pH 5.8-8.6 and SS ≤ 70 ppm.

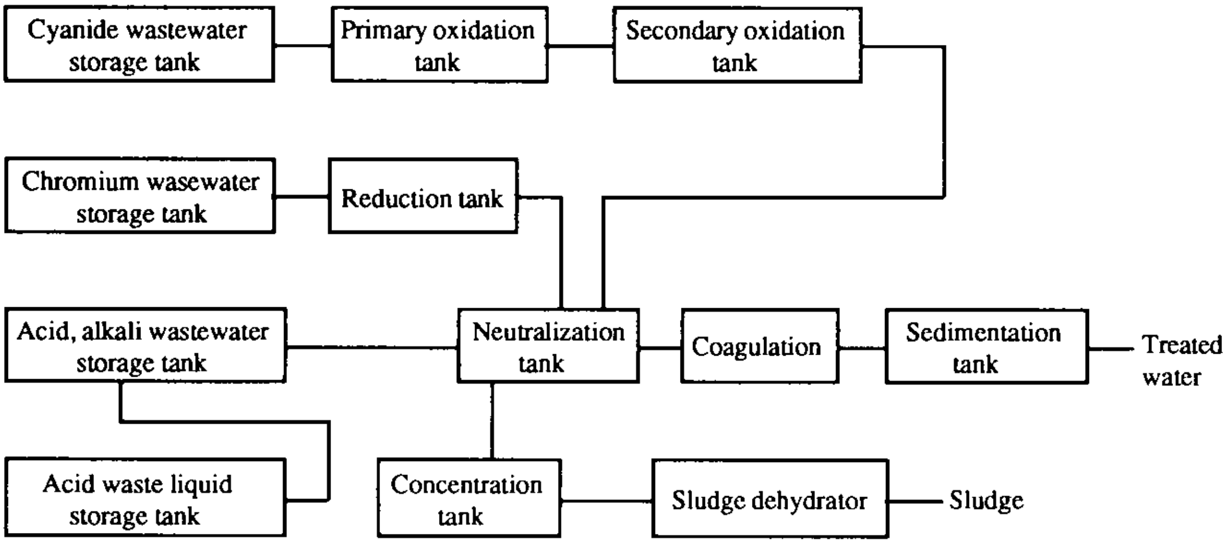
[Treatment process flow chart]



From 1966, JEC began implementing projects in which factories were transferred as groups to a new factory parks, constructed by JEC in suburban zones, where joint wastewater treatment facilities were installed. Along with the reinforced regulations, treatment techniques advanced and the significance of pollution control measures and their economic value were recognized. Consequently, in these modern facilities, automation and power-saving type equipment were arranged and spare equipment was reserved.

Joint wastewater treatment facility in metal industrial park, Takasaki, Gunma Prefecture (wastewater treatment capacity: 1027 m^3/day, established in 1971)

[Treatment flow chart]



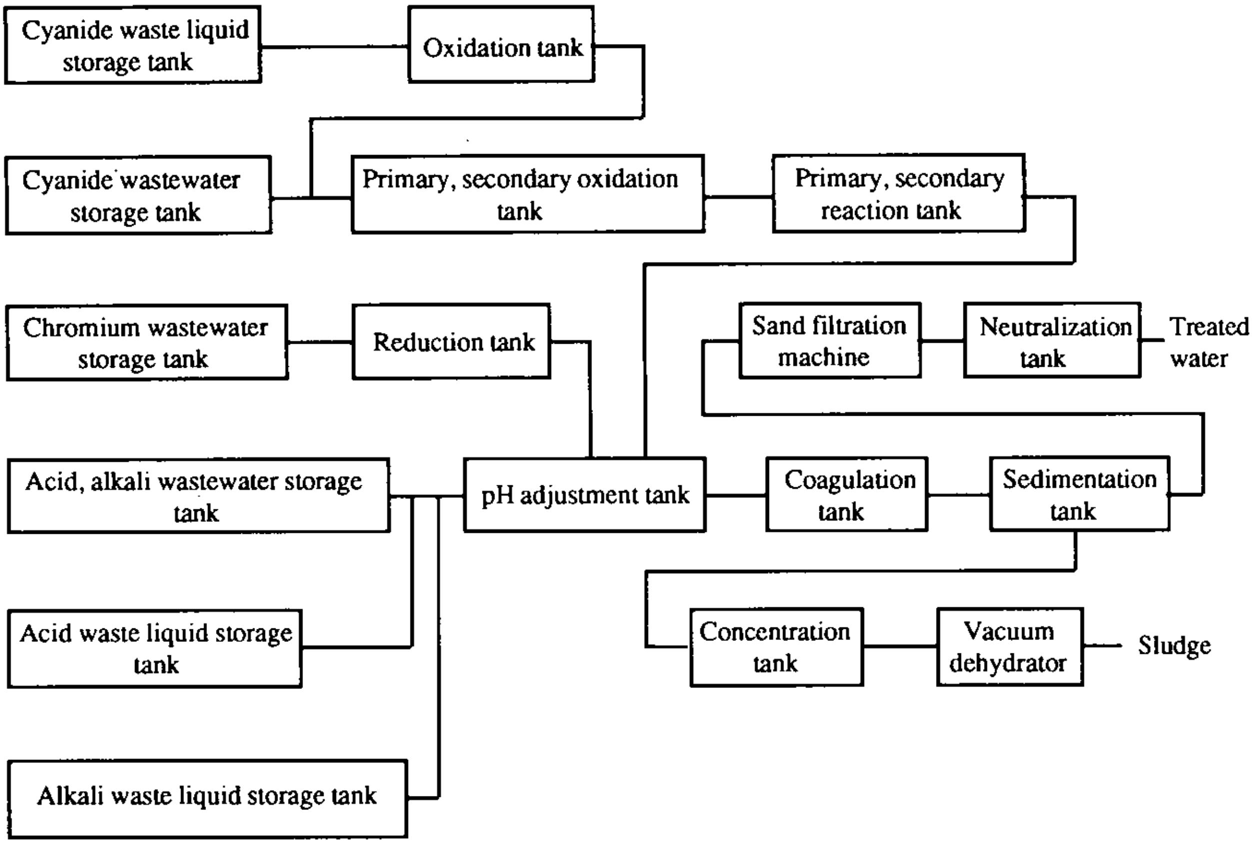
Lime is used for neutralization. Treated water quality: total cyanide $\leq$ 1 ppm, total chromium $\leq$ 2 ppm, SS $\leq$ 70 ppm

Photo. 4-1-40 Metal Plating Complex in Katsushika, Tokyo (established 1968)

Photo. 4-1-41 Industrial Park in Takasaki, Gunma Prefecture

Joint wastewater treatment facility in plating center, Kobe, Hyogo Prefecture (wastewater treatment capacity 50 m^3/hr, established in 1975)

[Treatment flow chart]

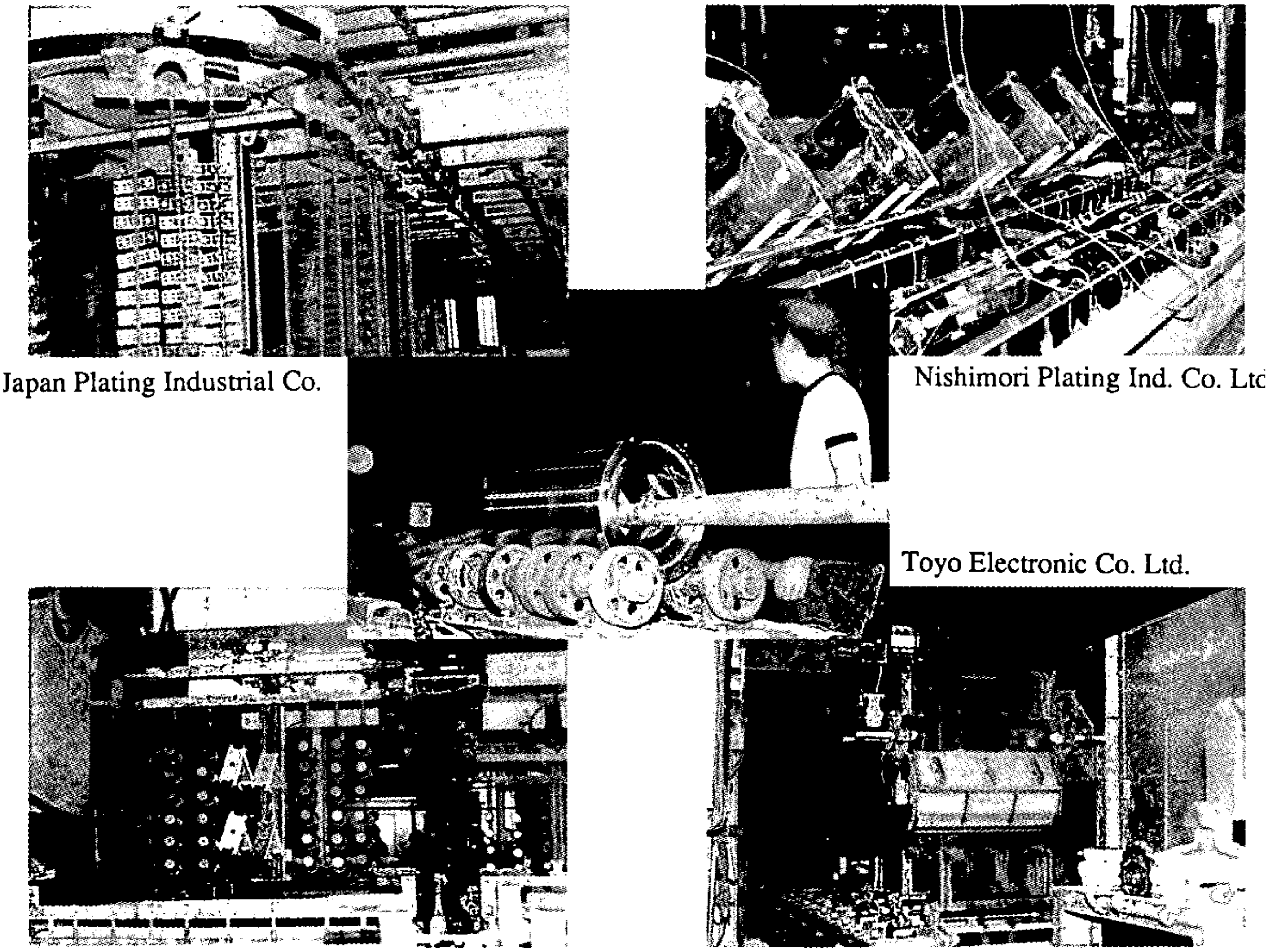


[Treatment process]

After adding sodium hypochlorite to the cyanide waste liquid , the concentration is lowered by the stripping method. Gas generated in the cyanide decomposition is treated by a scrubber. Passing through the primary and secondary oxidation tanks, cyanide in the cyanide-containing wastewater is decomposed by sodium hypochlorite. Then by adding sodium bisulfite in the primary reaction tank, the residual chlorine and ferricyanide are reduced; and by adding ferrous sulfate and zinc sulfate in the secondary reaction tank, the iron-cyanide complex deposits zinc ferrocyanide, completing the cyanide treatment. In the pH adjustment tank, metal hydroxides are formed in the alkaline range and are neutralized at the final discharge stage. Quality of treated solution: total cyanide $\leq$ 0.7 ppm, total chromium $\leq$ 1.9 ppm, SS $\leq$ 80 ppm. This is approved for discharge into public sewers.

In some cases when a new plating factory was to be built, residents in the region have been concerned about pollution from the plating factory, accordingly, they did not fully agree to allow construction of the proposed factory due to their legitimate concern about the observance of national standards as well as of more stringent prefectural standards. In the Ichikawa area, in Chiba Prefecture, confronted with the requirement of reducing the effluent concentration to less than 1/10 of the national effluent standards (total cyanide $\leq$0.1 ppm, total chromium $\leq$0.5 ppm, zinc $\leq$ 0.5 ppm, copper $\leq$ 0.3 ppm, SS $\leq$ 20 ppm), a closed wastewater system was implemented. This is an example of a pioneering project where the "cleaner production" approach was applied.

Photo. 4-1-42 Metal Plating Center in Kobe, Hyogo Prefecture



Japan Plating Industrial Co.

Nishimori Plating Ind. Co. Lt

Toyo Electronic Co. Ltd.

Hanshin Plating Seiko

Shinko Plating Industrial Co.

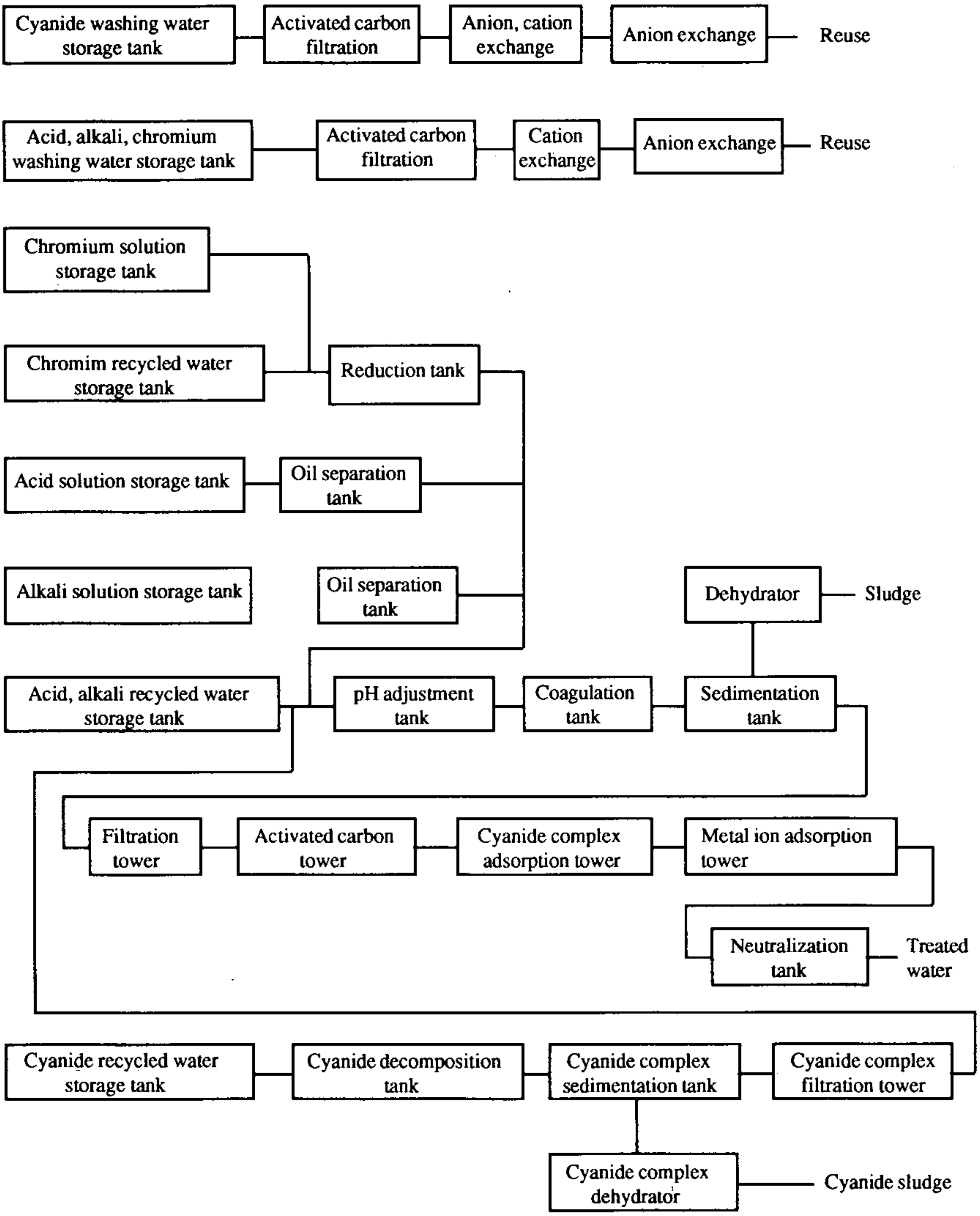
Joint-use factory and joint wastewater treatment facility in Ichikawa Metal Plating Park is described in detail below in case (1).

The recent-developed ion exchange treatment technique is available for wastewater treatment with the goals of meeting legal standards and recycling wastewater.

Joint wastewater treatment facility

(owner: Metal Plating Cooperative Association, Tokatsu, Chiba Prefecture, treatment capacity: 214 m3/day, established 1981)

[Treatment flow chart]



[Treatment process]

Wastewater from the washing process undergoes adsorption treatment using activated carbon and both anion and cation ion exchange resins, and is then returned to the washing process and reused.

Chromium-containing waste liquid and chromium recycled water-containing wastewater undergo reduction treatment in the reduction tank and fluorine treatment using aluminum sulfate and lime (batch type treatment). Then they are mixed with the acid and alkali waste water to be treated.

After decomposing cyanide and settling cyanogen complex compound, this is collected by filtration and the cyanide-containing wastewater is mixed with the acid and alkali wastewater to be treated. The sludge is dehydrated by filter press, separated as cyanide sludge, and treated.

The acid and alkali wastewater undergo coagulation-sedimentation treatment and then adsorption treatment, passing through the activated carbon tower, the cyanide complex adsorption tower and the metal ion adsorption tower. The ion exchange resin is regenerated at the facility.

Later on, as the metal plating and the associated wastewater treatment technique have developed, the production and pollution control facility is usually designed and manufactured in an integrated system. As consequence, the joint wastewater treatment facility has lost its merit, e, g, bypassing the technical difficulties in individually installing treatment facilities, and therefore, is very rarely selected for a treatment option.

The final project that JEC transferred electroplating factories to an industrial park with a joint-use wastewater treatment plan was the case of Osaka Plating Joint Wastewater Treatment Facility/Joint-use Building (Wastewater treatment capacity 250 m^3/day, completed in 1987), which is described in detail later (Detailed Case (2)).

In the following cases, the project expense amounts are expressed as the nominal values at the time of construction. For reduced values at present, refer to the separate conversion table at the Appendix.

Detailed Case (1) — Ichikawa Metal Plating Joint-use factory and joint wastewater treatment facility (1978) "Thorough application of resource recycling and implementation of the cleaner production"

Details of Facility Construction

Ichikawa City, Chiba Prefecture has developed as an industrial city located adjacent to the east side of Tokyo. Most of the metal plating industry in this city has worked here since before location control for factories and corporations was legally enforced in accordance with the City Planning Law in 1968. In 1973, with the progress of City Planning, sites on which these factories and corporations were located were designated as residential sites, accordingly resulting in factories being in ineligible locations.

Residents of this region closely watched environmental pollution and made an abundance of complaints against noise, offensive odor and dust released from plating factories. The sea area of this region was mostly used for seaweed culture, so fishermen made stringent protests about seawater contamination.

Each corporation had taken some pollution control measures, but was not able to take drastic measures because of its small site.

The Ichikawa municipal government decided to support the transfer of these corporations, located randomly in the city, to a coastal landfill site recommended as suitable for an industrial park. At the time, each corporation vowed its intent to do the full control of pollution, to residents and fishermen of this region, wishing to obtain their agreement on factory construction.

To ensure that these corporations put their pledge into effect and to reduce the seawater contamination load, the municipal government specified for them more stringent standards concerning effluent standards, with allowable levels less than 1/10 of these in the national standards.

With little confidence about being able to cope with these strict regulations by themselves, these corporations planned to install a joint wastewater treatment facility.

Accepting the proposal from the cooperative association organized by these corporations, JEC decided to assist them in achieving their transfer and constructing the joint-use factory and joint pollution control facility.

Outline of Project

Facility user:
Ichikawa Surface Treatment Cooperative Association
Members: 6 electroplating corporations capital:22 million yen (average)
Employees: 22 (average)

Project implementation:
August 1976 to March 1978

Facility scale:
Joint wastewater treatment facility
Treatment capacity: 213.3 m^3/day
Office area: 142 m^2
Joint-use factory building
Total floor area: 3,450 m^2

Site area: 7,941 m^2
For joint wastewater treatment facility: 800 m^2
For joint-use factory building: 5,541 m^2
For road: 1,600 m^2

Project expense: 858 million yen
For site: 276 million yen
For construction of joint wastewater treatment facility: 135 million yen
For construction of joint-use factory: 359 million yen
For design and supervision: 11 million yen
For office: 77 million yen

Design of Wastewater Treatment Facility

The basic concept for the wastewater treatment is as follows:

Traditional and conventional processes may be incapable of meeting strict effluent standards and achieving compatibility with the load of advanced wastewater treatment.

The conclusion reached is that drastic review of the production process to reduce hazardous substance and heavy metals in wastewater is likely to result in extensive saving of initial cost as well as of running cost in the wastewater treatment process.

Thus, surveying and study of the design standard data such as effluent quantity/quality and wastewater treatment processes (continuous, batch type) were considered as an integrated system which included the production process.

As a result of the survey and study, the following outlines were established:

1) Recycling within each plating process and factory is the basis of the design (closed system). To minimize the produced industrial waste, measures for recovery and reuse of heavy metals in order to conserve resources shall be taken and ion exchange methods shall be planned.

2) To meet the effluent standards for treated water, i.e. cyanide ≤ 0.1 mg/L, COD (Mn) ≤ 10mg/L, advance wastewater treatment shall be done jointly.

3) To prevent discharge of plating solution to outside in case of accident or emergency, all wastewater shall be conveyed by pump. The factory shall be structured to have a spare storage capacity for plating solution in case of emergencies. The wastewater is to be monitored by recording its cyanide content and pH value. If it has somehow becomes ineligible for discharge, the treated water shall be returned to the system.

Characteristics of Wastwater Treatment

1) The wastewater types were classified into 3 types of usual wastewater; 1) cyanide type, 2) nickel type, 3) acid or alkali type, and 2 types of batch (renewal) wastewater such as 4) acid-replaced type and 5) alkali-replaced type; total 5 types.

2) The wastewater from each plant process undergoes adsorption treatment using ion exchange resin in the final process to recycle it. To improve the treatment efficiency of the ion exchange resin, the ion concentration in the wastewater should be as low as possible, so many water washing baths (processes) with countercurrent type (countercurrent multistage washing) processes were installed.

3) For chromium-containing wastewater, a cartridge type ion exchange resin tower was separately installed at each corporation to carry out adsorption treatment in the water washing process at each corporation. Saturated ion exchange resin and high-concentration chromium-containing waste liquids should be returned to the chromium mineral refinery for recycling. Therefore, chromium-containing wastewater is being individually treated at each corporation, without applying the joint wastewater treatment.

4) For cyanide-containing wastewater, the high-concentration cyanide washing wastewater from the process, the wastewater recycled through ion exchange resin and aged plating bath solution are jointly treated. Metals such as copper and zinc in wastewater are electrolyzed in the electrolizer and deposits are recovered. Then cyanide undergoes goes electrolytic treatment, chemical treatment using sodium hypochlorite and coagulation-sedimentation treatment to obtain sludge. After removal of excess chlorine ion, the sludge is returned to the cyanide-containing wastewater storage tank and again undertook electrolytic treatment.

5) To reduce the cyanide content to 0.1 mg/L or less, in addition to the chemical treatment using sodium hypochlorite, advanced ion exchange resin treatment should be added to the process, to remove iron-cyanide complex compounds. To prevent contamination of other types of wastewater with cyanide-containing wastewater split on the floor, these baths were carefully distributed.

6) Nickel-containing wastewater undergoes ion exchange resin treatment to produce recycled water. Nickel sulfate in the wastewater is recovered for use in the plating process or recovered as nickel metal in the electrolizer.

7) In the final wastewater treatment process, to completely remove heavy metals, the wastewater undergoes additionally treatment using selective exchange resins in addition to the coagulation-sedimentation treatment.

8) To reduce COD (Mn) to 10 mg/L or less, the discharge water is treated with activated carbon.

9) Emission gas from each plating process is released after scrubber treatment, and washing water used in the plating process is reused in the pre-treatment process. Discharge from the joint wastewater treatment facility is also reused as much as possible.

10) In the office of the wastewater treatment facility, analytical instruments were arranged so that analytical control of the plating solutions in each corporation can be done, as well as the wastewater analysis in the joint wastewater treatment facility.

Wastewater Quantities and Qualities for Each Corporation

Item	Cyanide wastewate	Nikel wastewater	Acid, alkali wastewater	Acid-replaced wastewater	Alkali-replaced wastewater
Wastewater quantity m^3/day	4.3	31	174	2	2
Total cyanide mg/L	4,660				
Cu mg/L	2,630				
Ni mg/L		1,560			
Fe mg/L			222	20,000	3,000
Al mg/L			27.8		
Sn mg/L			21.8		
Zn mg/L	367		10		
Cr^{+3} mg/L			1.0		

Treated Water Quality Standards

Item	Water quality standards	Item	Water quality standards
Hydraogen ion concentration	5 - 9	Copper content	≤ 0.3 mg/L
Cyanide compound(s)	≤ 0.1 mg/L	Soluble iron content	≤ 1 mg/L
COD (Mn) method	≤ 10 mg/L	Chromium content	≤ 0.5 mg/L
Suspended solids	≤ 20 mg/L	Nickel content	≤ 1 mg/L
n-Hexane extract content (mineral oil)	≤ 1 mg/L	Aluminum content	≤ 1 mg/L
Zinc content	≤ 0.5 mg/L	Tin content	≤ 1 mg/L

Operational Condition after Facility Completion

When the facility was completed, the efficiency of the wastewater treatment facility was demonstrated before residents of the region and concerned fishermen by drinking the treated water as potable water.

Operation after the facility was completed went smoothly and recycling of the wastewater resulted in remarkable saving of water consumption.

The wastewater treatment cost was about ¥250/1 m^3 wastewater (excluding labor cost and facility depreciation cost). It is almost the same as the cost of city water.

In comparison with the originally estimated value, an increase in the amount of activated carbon replacement needed resulted in higher wastewater treatment cost. The reasons were high COD concentration and low removal rate for surfactant adsorbed by activated carbon. As a measure to solve this problem, the amount of surfactant applied was reduced as much as possible.

It was originally planned that nickel metal in the nickel type wastewater would be recovered by electrolytic sedimentation treatment, but the total amount of nickel were actually recovered by the ion exchange treatment as nickel sulfate that was reused in the plating process.

It was originally planned that iron-cyanide complex would undergo adsorption treatment using ion exchange resin, but potassium tartrate in the copper plating bath solution actually adhered to the ion exchange resin to reduce the amount of iron-cyanide complex adsobed. Accordingly, the iron-cyanide compounds were transferred to the settling sludge and the dehydrated sludge was actually disposed of as industrial waste.

Wastewater Treatment Flow Chart

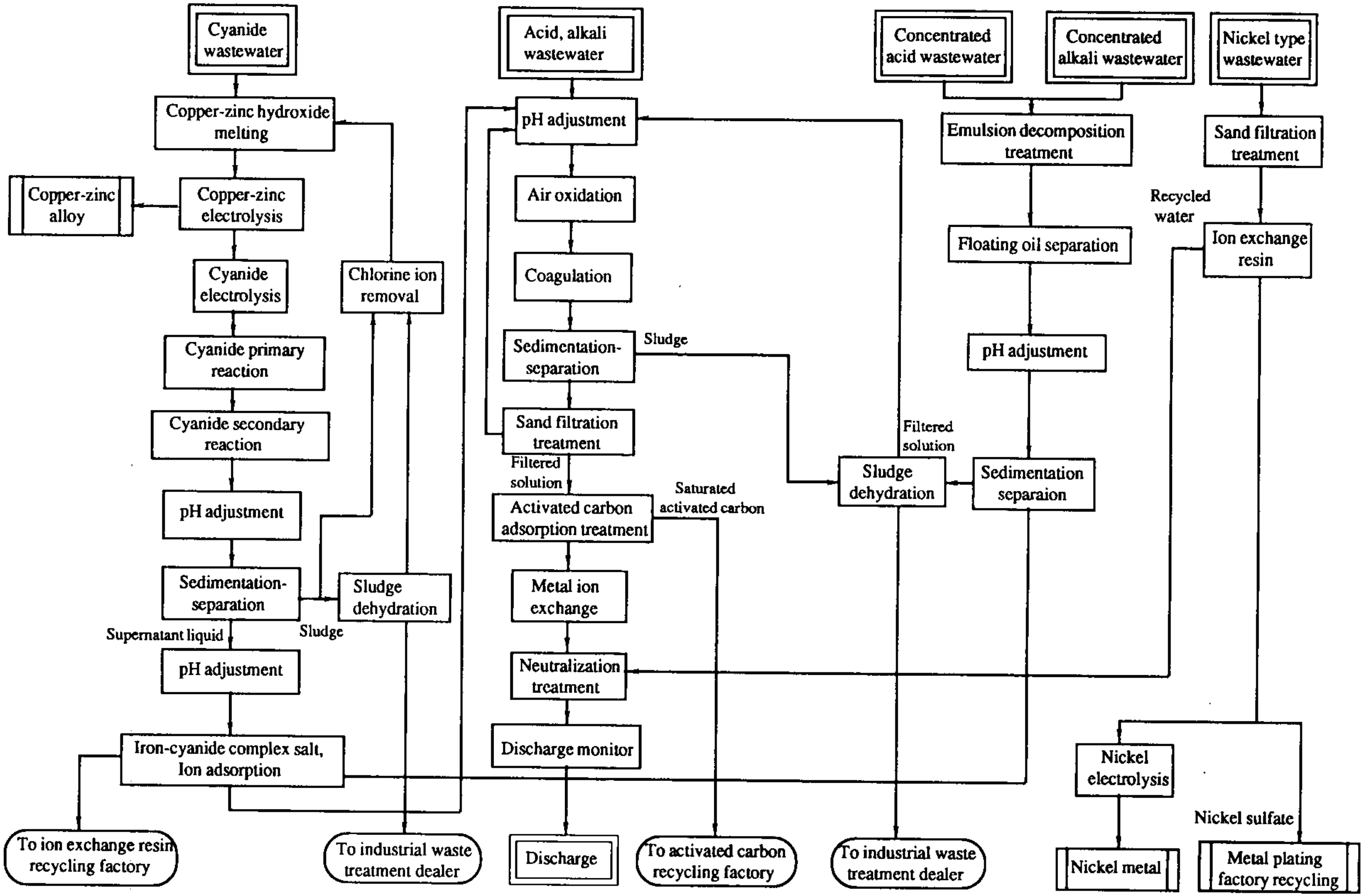


Photo. Ichikawa Metal Plating Joint-Use Factory

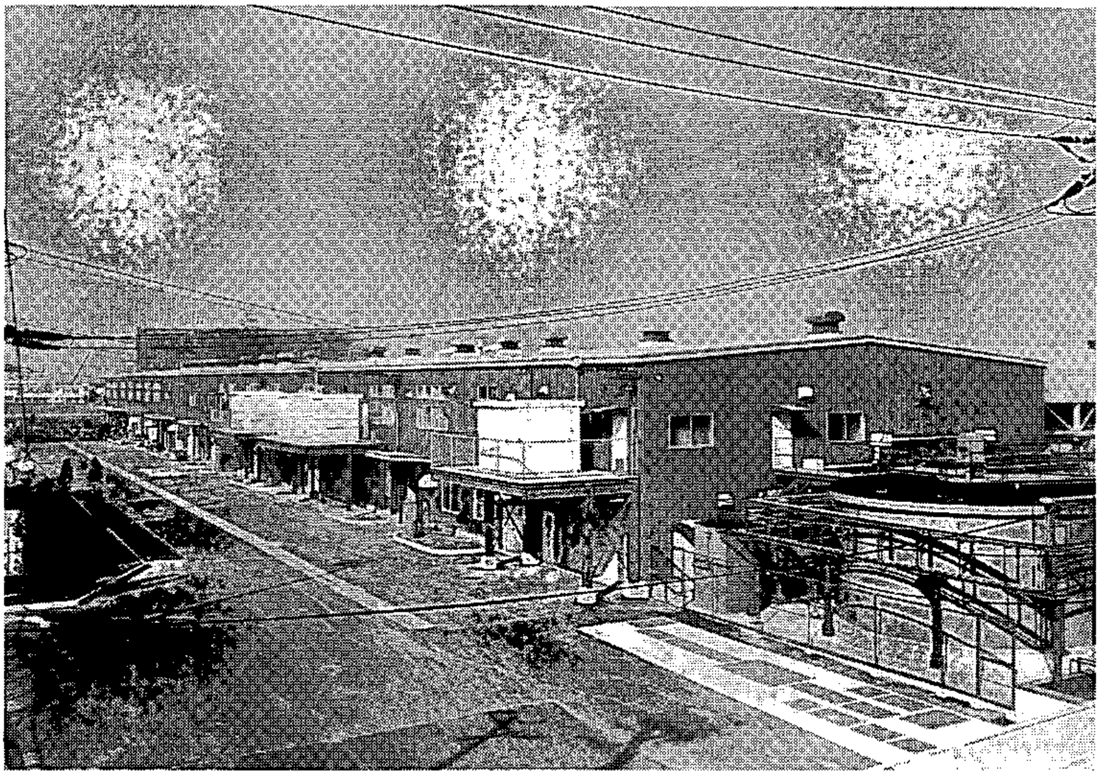
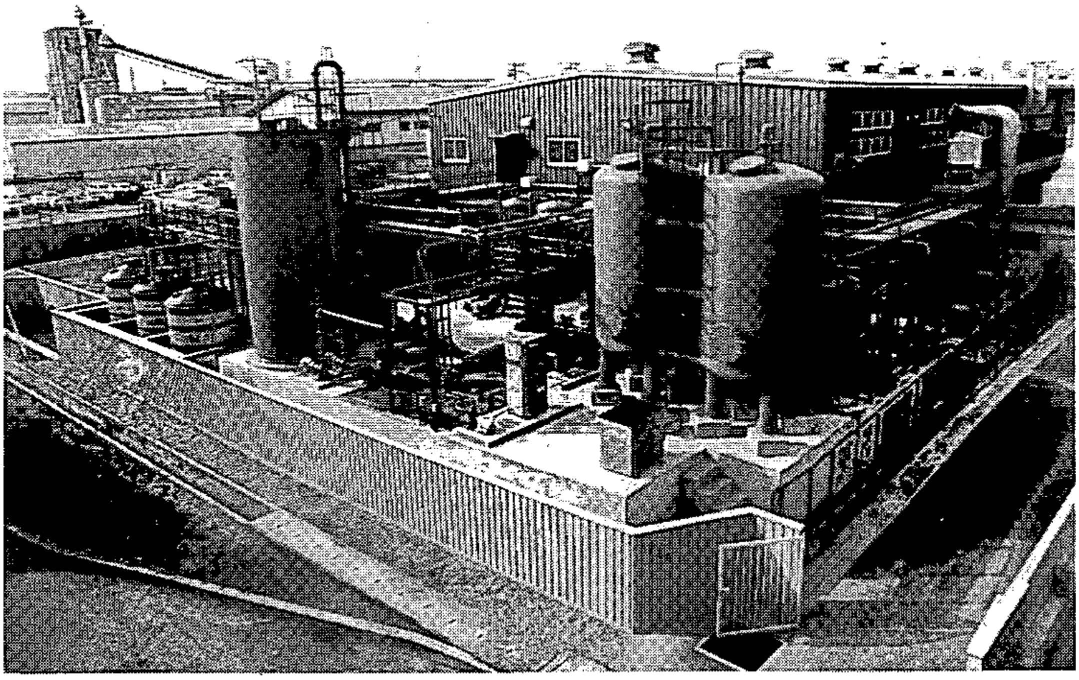


Photo. Ichikawa Metal Plating Joint Wastewater Treatment Facility



Detailed Case (2) — Osaka plating joint wastewater treatment facility, joint-use factory (1987)

"Managerial infrastructure reinforcement with aggressive pollution control"

Details of Facility Construction

As a JEC factory park project, the facility was constructed for transfer of small-scale electroplating corporations from their current locations in the urban area in Nishi-yodogawa-ku, Osaka-shi, where the plating factories were randomly distributed among residences.

Factory effluent was one of the essential objects of pollution control measures in the meta plating industry. Osaka city urban area had a good public sewer system. The electro-plating corporations located in the urban areas of Osaka city had been discharging their effluents into public sewers. The plating wastewater did not cause direct polution-related damage to the residents living around the factories. However, plating factories of these corporations were equipped with such old type production equipment and simple wastewater treatment equipment that the effluent occasionally did not meet the standards for the sewer intake. Also, no emission gas treatment measures had been taken and the working environment was poor. Complaints from neighboring residents about emission gases, noise and shipping work on the road were frequent.

Though plating corporations were anxious to solve these problems, their sites were too small for them to take any measures and install new production equipment.

To cope with such circumstances, the Osaka local government recommended that these corporations apply for the factory park project of JEC (construction of joint use factory, joint pollution control). With the intention of transferring factories, JEC consulted with 17 corporations about a transfer fund program, and eventually decided to proceed with the project with 7 corporations. Under mediation by the local government, the new plating factory location was decided; a seaside site remaining after a leading corporation had moved elsewhere.

Facility user: Nishi-Yodogawa Plating Park Cooperative Association
(comprising 7 electroplating corporations)

Project implementation period: March 1985 to March 1987

Facility scale:	Joint wastewater treatment facility: Capacity	250 m^3/day
	Joint-use factory building: Total area	3,820 m^2
Site area: 6,700 m^2	Joint wastewater treatment facility:	810 m^2
	Joint-use factory building:	5,300 m^2
	Road:	590 m^2

Project expense: 1,254 million yen	Joint wastewater treatment facility:	201 million yen
	Joint-use factory building:	472 million yen
	Site:	461 million yen
	Office work:	120 million yen

Tightening of Effluent Standards

Along with the group transfer of factories, the effluent quality standards applied at the new site were more strict than those applied to individual corporations at the former site. The reason: previously effluent from individual corporations had been discharged into the public sewers, but after the transfer, it was collected and treated at the joint wastewater treatment facility, then directly discharged into the river. In accordance with the Water Pollution Control Law, regulations applied to effluents of larger volume became more stringent, and the same trend in regulation was applied to the discharge "directly to river" compared with "discharge to sewer". Furthermore, the new measures required treatment of boron, COD, BOD, SS, oil and phosphorus. In any case, the effluent eventually flowed into Osaka Bay, a closed type sea area to which the specified action law was being applied, so that the environmental impact assessment would be conducted in the same sea area around the outlet for effluent, being subject to the area-wide total pollutant load control for COD and phosphorus.

Prior Investigation and Examination of Wastewater Treatment Processes

To decide the wastewater volume and quality to be a standard for designing the wastewater treatment facility, the following items were surveyed for each individual corporation:

1) Production amounts and product kinds
2) Plating processes and transfer time to succeeding process for each
3) Kinds, volumes and concentrations of plating baths
4) Kinds and concentrations of chemicals
5) Wastewater volume and drainage system
6) Progress and degree of automation of production processes and names of equipment makers

According to this survey, it was found that, even though the same kinds of plating processes was involved, concentration of plating baths, kind and concentrations of chemicals differed greatly, consequently wastewater qualities also differed, depending upon each corporation.

In some corporations, the concentration of chemicals was not scientifically controlled, instead operators just observed the proceeding plating product in the bath visually and adjusted the dosing chemicals according to their experience, not taking the subsequent wastewater treatment into account.

It was thought impossible to meet treatment standards for boron, ammonia, fluorine and COD using conventional wastewater treatment method.

Furthermore, it was difficult to divide the construction cost concerning the joint wastewater treatment facility fairly between the corporations concerned. To solve the problem, a compromise treatment procedure was proposed, i.e. pre-treatment of wastewater discharged from each corporation was done individually until the treated wastewater attained a specific standard level, and then the wastewater was collected at the joint treatment facility to undergo after-treatment.

After comparative examination of these treatment procedures, it was found that the complete joint treatment procedure was somewhat higher in its running cost but its total construction cost was as little as half that for the "partial joint treatment" procedure, so the complete joint treatment process was adopted.

Characteristics of Wastewater TreatmentProcess

1) Direct chemical process, instead of using ion exchange equipment, was applied to treat washing wastewater.
2) A professional treatment company was to be entrusted with the treatment of high-concentration cyanide waste liquid; no treatment facility was to be installed for this.
3) For wastewaters, e.g. ammonium chloride wastewater, impossible to treat at the joint treatment facility, the corporations producing these were to independently install their own pre-treatment facilities.
4) It is impossible to completely treat cyanide complex wastewater using chemicals, so an adsorption process using ion exchange resin was to be applied. Also, COD and BOD compounds were to be adsorbed and removed by activated carbon.
5) Regarding phosphorus wastewater, chemicals not containing phosphorus could be substituted for the traditional plating bath, so a special treatment process for phosphorous wastewater was no longer necessary.

The recycling of water used was to conducted individually by each corporation concerned installing its own equipment. In this facility, it was decided that wastewater should be recycled by each corporation voluntarily installing its own equipment. In the joint treatment facility, the policy, "Washing wastewater treated by ion exchange equipment is recirculated to the factory for its reuse." was not applied. The reasons fo this are:

1) To increase the treatment efficiency of ion exchange treatment, an increase of the water washing frequency in the production line and reduction of the ion concentration would be required; however, on the contrary, many items of standardized automatic production equip-

ment would be installed on the new production lines, thus the ion concentration in wastewaters would become comparatively high, resulting in high treatment cost.

2) Because a wide variety of product shapes were expected to be plated, a wide fluctuation range of wastewater concentrations was expected.

3) If abnormal wastewater were to be discharged by some corporation and its proper treatment was not done immediately, all corporations would suffer from damage while they using ill-treated water.

4) If production equipment of each corporation and the joint wastewater treatment facility were rigidly integrated because of the water system, such an integrated state would become an ob struction to each corporation's progress and to the diversification of production equipment.

Operation and Equipment of the Wastewater Treatment Facility

In the wastewater treatment facility, the operation and equipment control was to be handled by one operator working 8 hrs/day. For safety, operation of the treatment equipment was controlled automatically. Chemicals used for treatment were also automatically prepared to defined concentrations.

As measures against malfunction of devices, and for maintenance, spare pumps were kept in reserve in the treatment lines. Spare parts for the ion exchange tower and the activated carbon tower were also kept in reserve.

To determine the wastewater amount discharged from each corporation, instead of measuring the wastewater amount, the amount of supplied water was measured. The reason was: the amount of supplied water could be readily measured using simple, low-cost meters. The data obtained were useful for controling operation of the production equipment. The water supply piping was separately laid and equipped with flow meters corresponding to each wastewater treatment line.

Items to be considered concerning the Discharge

Special concern regarding discharge of the plating wastewater was: careful handling of the wastewaters from different treatment lines without mixing them together and handling of hazardous wastewaters without infiltration underground. Accordingly, work place floors were partitioned into zones (zoning) corresponding to individual wastewater treatment lines. Also, the wastewater was directly conveyed from the plating equipment through piping to avoid spilling on the floor.

The pipes were painted using a color coding corresponding to each wastewater type so these could be easily distinguished.

A joint channel was laid from each factory to the joint wastewater treatment facility, and the wastewater piping equipped with leakage monitors, was passed through the channel. Also, expansion joints were fixed on the wastewater piping as a measure for preventing wastewater leakage, mainly that due to ground subsidence and changes of wastewater temperature.

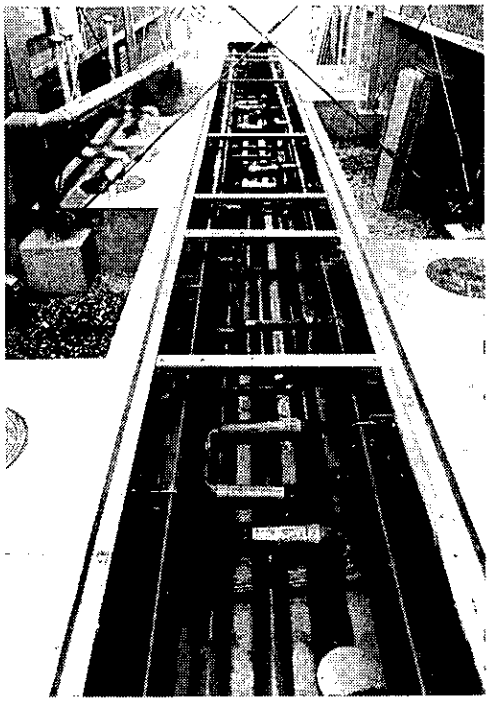
One problem for a joint treatment facility is: when an abnormal wastewater flows into the facility, identification of the source corporation which discharged the wastewater is very difficult.

To cope with such cases, classified retention tanks were placed at the wastewater outlets of each corporation. If abnormal wastewater appears at the joint treatment facility, the cause can be pursued by inspecting the wastewater temporarily held in the retention tanks.

Plating wastewater must be prevented from spreading on floors of the working rooms. Here, as a precaution, anti-corrosion materials were used for the gently graded floor with a culvert. However, wastewater was never passed through the culvert, because the wastewater used for floor cleaning could occasionally be contaminated with plating effluent.

Measures for exhaust gases such as cyanide gas, hydrogen chloride gas, chromic acid mist and ammonia gas was to be individually taken in each corporation. Joint treatment of these items was not yet popular when the facility was built.

Photo. Channel (joint use) for water distribution pipes, and wastewater retention tank



Contents of Factory

Outline of Nishi-yodogawa Metal Plating Park Cooperative Association (7 corporations)

Name of corporation	Kind of plating	Base material for plating	Site area m^2	Building area m^2	Employees	Wastewater volume m^3
Corporation A	Cu-Ni-Cr, Cr	Automobile parts	1,004	840	21	42
Corporation B	Zn, Cu	Building metal ware	1,149	760	10	30
Corporation C	Zn	Building metal ware	998	552	6	33
Corporation D	Cu-Ni-Cr, Zn	Decorative goods	832	300	13	28
Corporation E	Zn	Building metal ware	488	300	5	46
Corporation F	Zn	Screw	331	304	8	38
Corporation G	Cu-Ni-Cr, Cu	Decorative goods	495	322	7	26

Joint Wastewater Treatment Facility

Wastewater treatment capacity:	250 m^3/day (31.25 m^3/hr x 8 hrs/day)
Treatment time:	8 hrs/day
Facility manager:	1 person
Treatment process:	
Cyanide-containing wastewater:	Oxidation treatment by sodium hypochlorite
Chromium-containing wastewater:	reduction treatment by sodium bisulfite
Acid, alkali wastewaters:	Neutralization, coagulation, sedimentation, cyanide complex salt adsorption, activated carbon adsorption, neutralization treatment

Quantity and quality of raw water

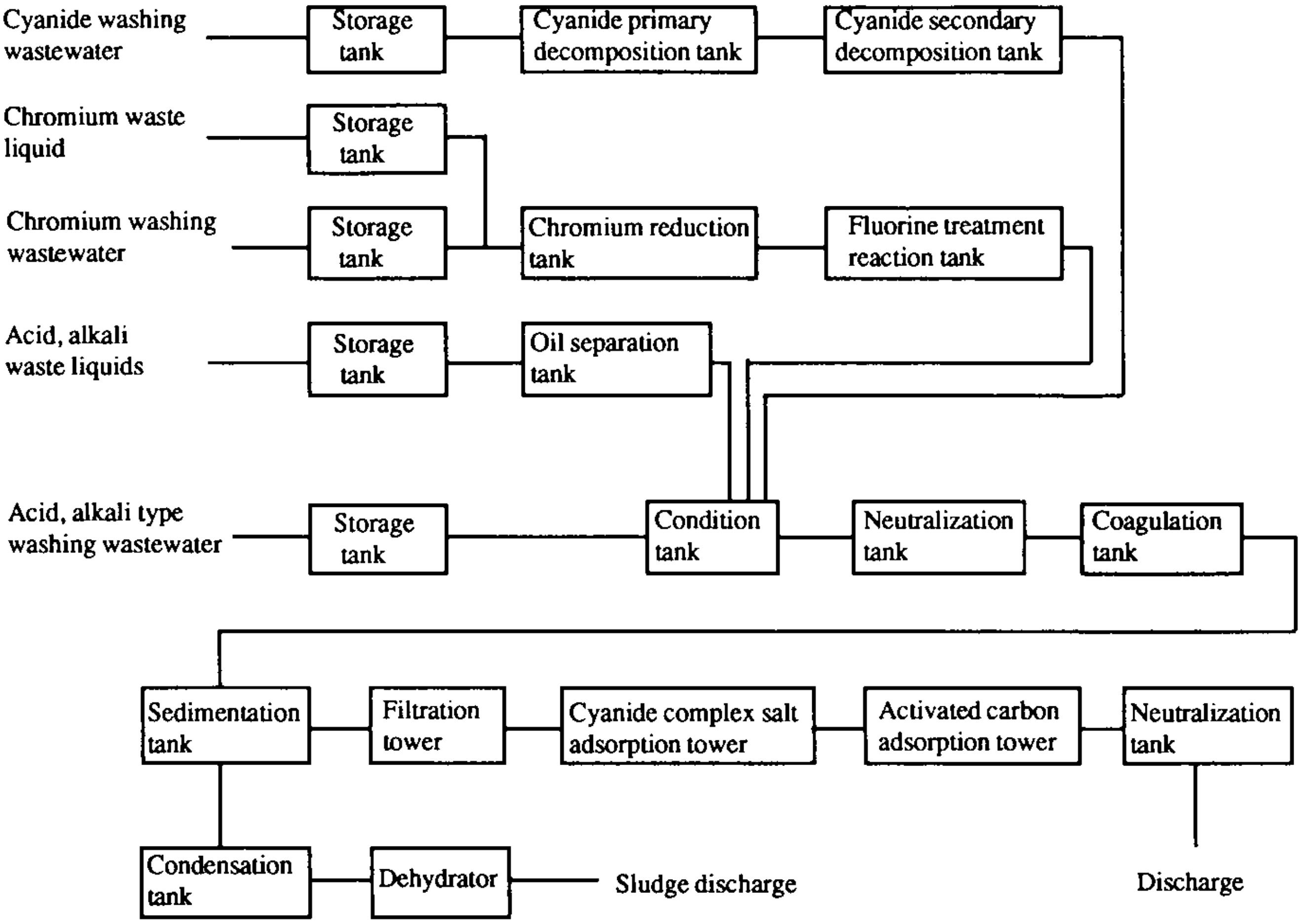
Item	CN washing water	Cr washing water	Cr waste liquid	Acid, alkali washing waters	Acid, alkali waste liquids
Wastewater amount m^3/day	57.8	61.2	0.7	115.4	2.8
pH	9 - 13	2 - 5	1 - 2	3 - 9	1 - 12
T-CN mg/L	177.1				
Zn mg/L	138.8			0.7	14.1
Fe mg/L	15.7		86.0	338.2	309.4
Cu mg/L	66.9				
T - Cr mg/L		266.0	7,800		
Cr^{6+} mg/L		2.7	5,700		
F mg/L		170.0			
Ni mg/L				13.3	
B mg/L				0.5	
NH_4 mg/L		92.6			
COD mg/L				6.4	1,300
n-Heane extract mg/L				65.4	902.7

Quality standards for treated waters

Item	Effluent standards	Remark
pH	5.8 - 8.6	
T - CN	≤ 1 mg/L	
Zn	≤ 5 mg/L	
Fe	≤ 10 mg/L	
Cu	≤ 3 mg/L	
T - Cr	≤ 2 mg/L	
Cr^{6+}	≤ 0.5 mg/L	
F	≤ 15 mg/L	
B	≤ 2 mg/L	Osaka city ordinance
Pb	≤ 1 mg/L	
BOD	≤ 20 (15) mg/L	Administrative guidance
COD	≤ 5 kg/day	Areawide total pollution load control
SS	≤ 65 (50) mg/L	Administrative guidance
n-Heane extract	≤ 4 mg/L	
P		Areawide total pollution load control

( ):per day average

Wastewater Treatment Process



State after Facility Completion

The joint wastewater treatment facility was smoothly operated and the wastewater was well treated, meeting the required standards.

When the facility was completed, to cope with the shortage of industrial water in this region, about half the amount of the treated water was recycled to each factory to be reused. But, the high salt concentration and high ammonia content in the treated water resulted in poor-quality product. As a countermeasure, reduction of ammonia content in the plating chemicals was tried.

The original plan called for resins in the cyanide complex salt adsorption tower to be regenerated under contract by an industrial waste management contractor. But because of the high cost, the regeneration treatment was changed, to be done by each corporation itself at a newly built facility where cyanide complex salt was treated by the zinc turbidity method.

Operation control of the wastewater treatment facility is carried out by a specific technician. Since the operation control and necessary maintenance have been done properly, each corporation can operate its plating process steadily with confidence.

Allotment of Initial Cost and Running Cost of the Facility

In the program for a joint-use facility, fair allotment of expenses must be decided first.

The initial costs (construction expenses) were allotted as follows:

1) Land and building owned by each corporation: each corporation bears total expenses by itself.
2) Road, jointly used land and joint wastewater treatment facility site: each corporation bears the expenses in a rate proportional to the land area it owns.
3) Joint wastewater treatment facility and joint-use equipment: each corporation bears equally allotted share of half the expenses, and further bears a share of the remaining half of the expenses at a rate proportional to the land area it owns.

On the other hand, running costs (wastewater treatment expenses) were allotted as follows:

Each corporation bears the cost A + B + C + D
where
A: Basic rate: specified amount for each corporation (together, these amounts make up about a third of the total expenses)
B: Expenses for total amounts of wastewater load: (total expenses minus basic rate) x 80% allotted to each corporation
C: Expenses for amount of water used: (total expenses minus basic rate) x 20% allotted to each corporation
D: Specially allotted money: holiday operation, concentration violation, share of extra expenses
"Total expenses" consist of monthly operation management cost, operation cost and facility maintenance cost.
"Total amounts of wastewater load" = (factor depending on kind and concentration divisions) x (wastewater amount)

Example of factors

Concentration mg/L	Cyanide concentration	Chromium concentration	SS after acid, alkali neutralization
< 50	2.4	1.2	1.0
< 100	3.0	1.4	1.2
100 - 150	3.4	2.0	1.3
150 - 200	4.0	2.5	1.5
200 - 300	5.0	3.0	1.8
300 - 400	6.0	3.5	2.0
400 - 500	7.0	5.0	2.2
500 - 1,000	Violation	Violation	2.4
1,000 - 2,000	Violation	Violation	2.6
2,000 - 3,000	Violation	Violation	3.0
3,000 - 4,000	Violation	Violation	4.0

The quality of wastewater discharged from each corporation must always be controlled, in order to fairly allot the each corporation's share of running cost of the joint wastewater treatment facility.

The average treatment cost for wastewater was about 600 yen/m³ wastewater (excluding depreciation cost of the facility).

Outcome of Project

The sites remaining after the cooperating corporations were transferred are being utilized as residential areas, and the pollution problems that arose while factories were located there have dissipated, improving the living environment.

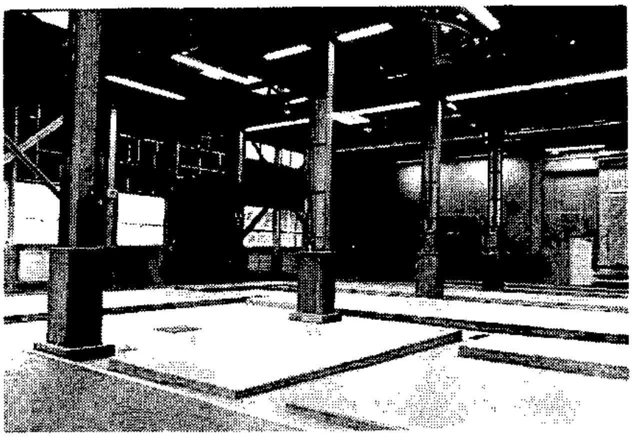
Constantly confronted by acutely competitive circumstances, small- and medium-scale corporations must always adapt themselves to varied management environment. In particular, the metal plating factories so notoriously involved with pollution must give first priority to improvement and expansion of the pollution control equipment rather lose business than to production equipment; otherwise they will be forced out of business.

Along with the factory transfer, each cooperative corporation was freed from locational restrictions such as neighbors' complaints about pollution, difficulty of factory expansion and urban area traffic obstruction. By installation of the complete wastewater treatment facility at the new site, it became possible for each plating corporation to manage its business without worrying about pollution problems. At the same time, introduction of modern production equipment and rational allocation of production lines were achieved and, consequently, the working environment was improved.

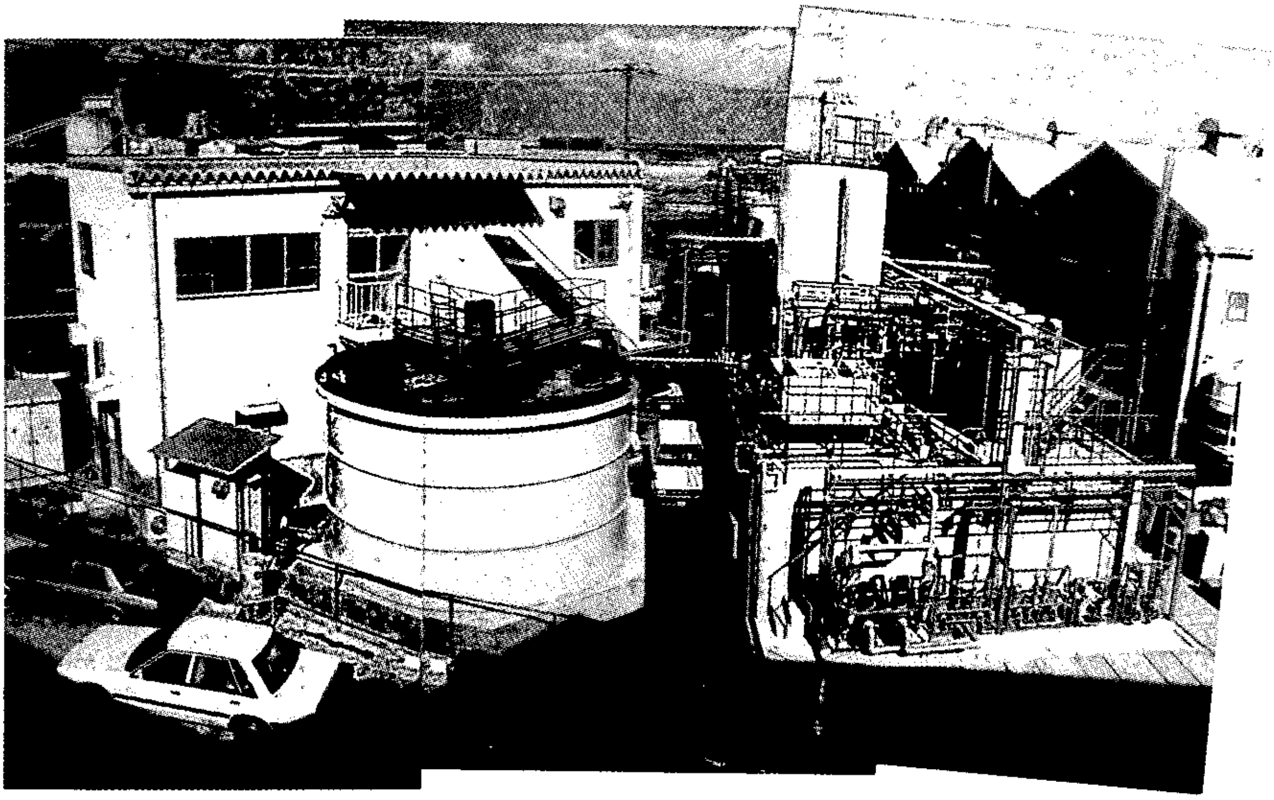
By obtaining locational advantages, the cooperative corporations increased their business reliability and facilitated labor power availability, resulting in improvement of productivity and product quality and reinforcement of business infrastructure.

Factory before transfer

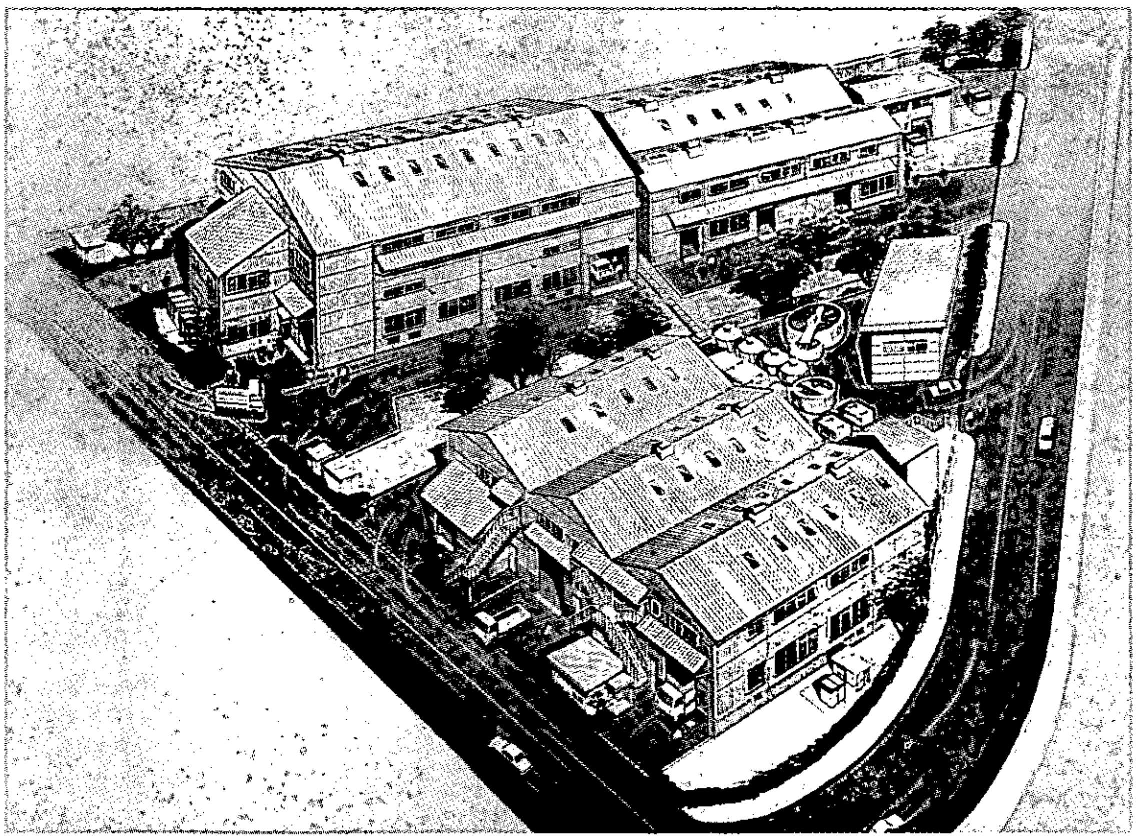
Factory after transfer



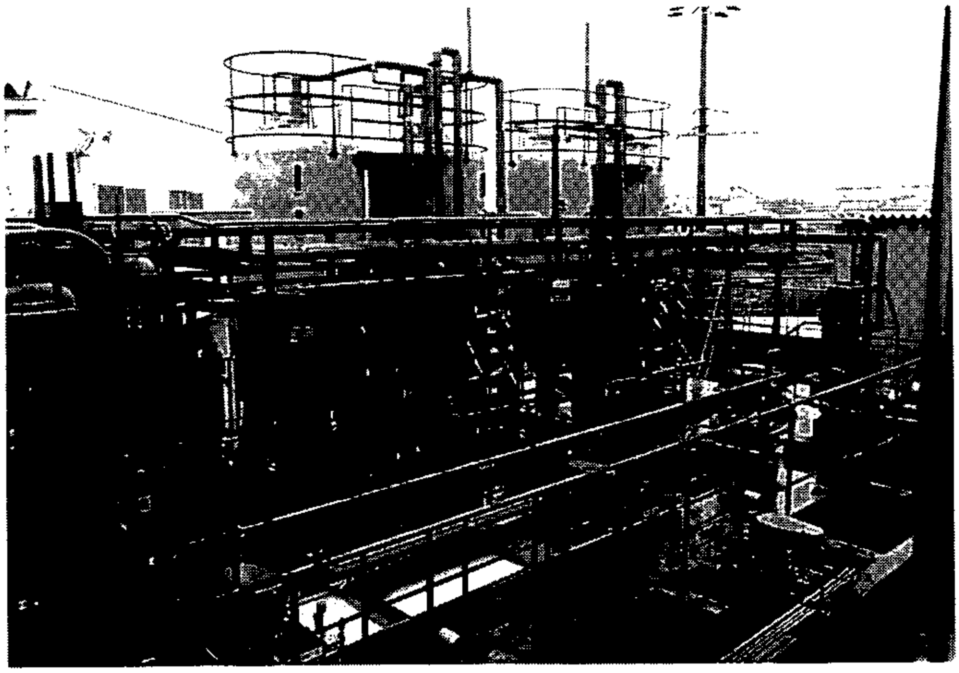
Factory after transfer



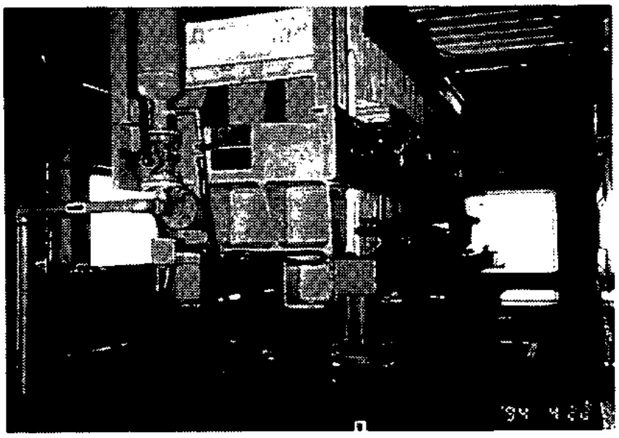
Wastewater treatment facility and office building



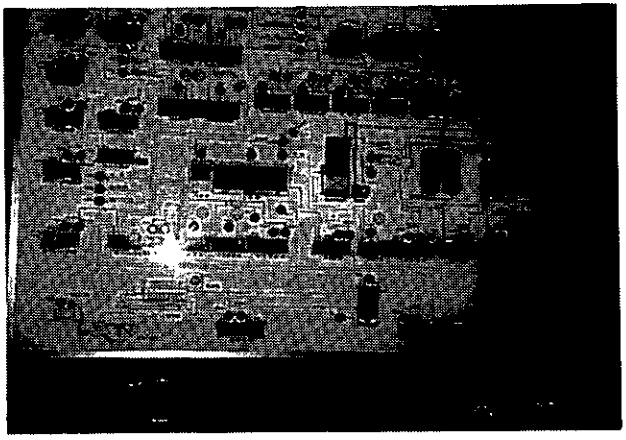
Bird's-eye view



Cyanide complex salt adsorption tower, activated carbon adsorption tower and reaction tank

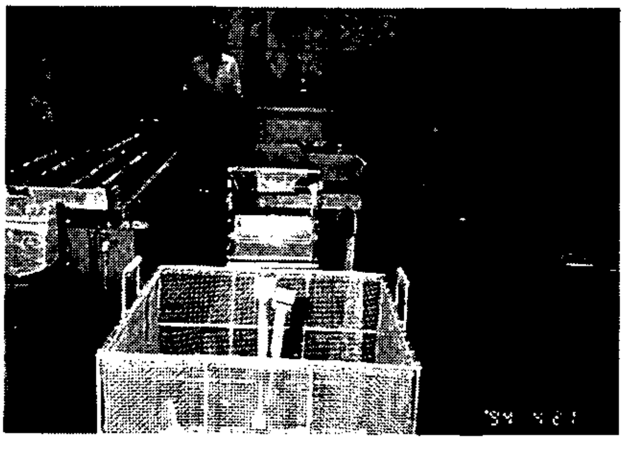


Dehydrator in wastewater treatment process



Control panel for wastewater treatment facility

Work place after transfer



Work place after transfer

4.1.17 JEC Loan Program Cases

JEC has provided funds for corporations that want to install facilities to control pollution. The objectives of this financing are the installation of facilities and, where necessary, the obtaining of sites for facility installation. But, expenses required for operating and managing each facility and expenses for repayment of already invested fund are excluded.

Among JEC's financing projects, the metal plating industry accounted for a large part of the financing funds, particularly in the early terms. Typical cases where funds were provided for pollution control facilities for the metal plating industry are shown in the following examples. Though ideal data have not always been accumulated, historical transformation of the pollution control measures and a trend toward cleaner production systems, i.e. "beginning from the arrangement of a terminal treatment facility and progressing to integrated drastic measures such as recycling and process improvement for breaking through the pollution problem" can be read from the data.

To assist in the analysis of these financing project records JEC handles the work of formation of standardized data sheets and their input into the data bases of personal computers.

Transfer and Joint Treatment (1970)

Among plating corporations (21) located in City A, majorcorporations (17) decided to jointly or individually install liquid-waste treatment facilities under guidance of the city authority and the remaining small-scale corporations (4) planned to transfer to an industrial park and construct a wastewater treatment facility there.

The wastewater discharged from these corporations (4), zinc-, nickel and chromium plating was collected according to type, i.e. cyanide-containing wastewater (15 m^3/hr), chromium-containing wastewater (5 m^3/hr) and acid, alkali wastewater (22 m^3/hr), and sent to the joint treatment facility to be treated. The cyanide-containing wasteater was treated with sodium hypochlorite, and the chromium-containing wastewater was treated with sodium bisulfite, then they were combained with acid, alkali wastewater to be neutralized. The discharged water quality was: pH 5.8-8.5, cyanide content $\leq$ 1 mg/L, chromium content $\leq$ 2 mg/L, SS $\leq$ 50 mg/L. The treated sludge was dehydrated and landfill disposal was done.

Production scale	Zinc-, nickel-, chromium plating factories (4) annual shipment ¥295 million
Cost for required improvement	¥50 million (JEC 80%, own funds 20%) ¥185 million (total transfer cost)

Construction cost percentages	Liquid-waste treatment facility (56.5%), water facility (31.5%), land purchase (9.5%)
Maintenance management cost	¥6.5 million/year

Expansion Improvement of Wastewater Treatment Facility (1971)

Among the wastewater (8,860 m^3/day) generated by zinc-, nickel-, chromium plating processes, only the comparatively high-concentration chromium wastewater (1,235 m^3/day) had been subjected to reduction treatment. But the factory was given administrative guidance and instructed to make improvements because the concentration exceeded the effluent standard. The improved treatment capacity of the system (9,600 m3/day) made it possible to treat the total plating wastewater by a chromium reducing, coagulation and settling. The wastewater quality before treatment, SS 200 mg/L and total chromium 5-10 mg/L, was improved to SS $\leq$ 40 mg/L and total chromium $\leq$1.5 mg/L after treatment. The settled sludge was dehydrated in vacuum and landfill disposal was done. (15-20 tons/day).

Production scale	Automobile parts plating, annual shipment ¥9,650 million
Cost for required improvement	¥149 million (JEC 50%, own funds 50%)
Construction cost percentages	Wastewater treatment facility (42%), drainage piping (8.4%), auxiliary equipment and others (49.6%)
Maintenance management cost	¥4.65 million/year (power cost ¥150,000, cost of chemicals ¥4 million, personnel expenses ¥100,000, sludge disposal cost ¥400,000)

Improvement of Wastewater Treatment Facility and Collection of Sulfuric Acid Mist (1971)

In corporation C, wastewater containing chromium and cyanide discharged from the plating process was insufficiently treated, so that the concentrations exceeded the effluent standards. Also, the sulfuric acid mist (including chromium mist) spattered from plating baths was discharged untreated. Though the concentration of this mist was not measured, the surrounding mulberry fields suffered considerable damage from the untreated mist and residents complained about it. For drastic improvement of the wastewater treatment, a scrubber and equipment for treating the sulfuric acid mist were installed.

Conventionally, wastewaters containing cyanide and chromium had been treated by sodium hypochlorite and sodium bisulfite respectively, and then discharged (typical discharged effluent quality: pH 6-7, cyanogen 2 mg/L, chromium 4.5 mg/L). In the new system, the treated water described above was combined with other wastewaters and neutralized, then coagulated and settled. The treatment capacity was 125 m^3/day. The discharged wastewater quality was pH 6-7, cyanide 0.01 mg/L, chromium 0.07 mg/L. The treated sludge was dried outside and landfill disposal was done.

The emission gas containing sulfuric acid mist is collected by ducts located above the plating baths and after water washing, released in the air. The collection efficiency is 80-90%, and the remaining solution can be reused in the process.

Production scale	Plating factory: annual shipment ¥103 million
Cost for required improvement	¥18 million (JEC 78%, own funds 22%)
Construction cost percentages	Improvement of existing equipment (15.3%), wastewater treatment facility (21.3%), piping (8.9%), sulfuric acid mist scrubber (9.5%), others (16.8%)
Maintenance management cost	¥501,000/month

Observance of Agreement on Environmental Pollution Control (1971)

The wastewater generated by the plating process had been treated to meet the effluent standards. But cadmium pollution of the surrounding agricultural products and fields occurred. Residents demanded damage compensation and soil replacement, and the problem was resolved by monetary compensation after negotiation. During negotiations, an agreement on environmental pollution control comprising, 1) abolishment of cadmium plating, 2) removal of sludge deposits from irrigation canals, 3) continuous measurement of cyanide and pH in effluent was concluded with the local government. In order to comply with this agreement, the wastewater treatment was intensified as follows:

The cadmium plating was eliminated from the production process, the wastewaters other than wastewaters containing cyanide and chromium were treated at the new facility and, after passing through the automatic water-quality monitoring equipment, were discharged to the public sewer.

Production scale	Automobile electrical parts, annual shipment ¥399,806 million
Cost for required improvement	¥69 million (JEC 49%, loan from bank 49%, own funds 2%)
Construction cost percentages	Wastewater treatment equipment (56.8%), piping and drainage canal (24.0%), miscellaneous wastewater treatment facility (5.1%), measuring instrument (14.1%)
Maintenance management cost	¥50/m^3 treated water (cost of chemicals)

Installation of Bag Filter (1973)

The considerable amount of white fumes released from the zinc hot dipping process contained zinc compound in excess of the local governments standard (20 mg/m^{3}N), as well as ammonium chloride which caused offensive odor. This consequently led to a deteriorated working environment in the factory as well as complaints by surrounding residents about trouble and damage to agricultural products, followed by administrative guidance requesting improvement, so that the measure of installing a mist collector was taken.

Zinc compound (35 mg/m^{3}N) and ammonium chloride (0.06 g/m^{3}N) contained in the white fume are collected by a filter type dust collector (bag filter) and treated. Concentrations in the treated emission gas have become 0.5 mg/m^{3}N and 0.004 g/m^{3}N, respectively. The collected dust is recycled and reused as flux.

Production scale	Zinc plating industry, annual shipment ¥3,727 million
Cost for required improvement	¥40 million (JEC 49.6%, own funds 50.4%)
Construction cost percentages	Bag filters and related equipment (64.5%), renovation of zinc plating bath (9.4%), dust recycling equipment (8.7%), others (17.4%)
Maintenance management cost	¥350,000/month (power cost ¥200,000, personnel expenses ¥150,000)

Treatment of Cyanide-containing Wastewater (Caston reaction)(1973)

Renewal of the facility was decided on, because wastewater from zinc electroplating process showed unsatisfactory values (CN 2.0 mg/L, pH 9.4, oil content 160 mg/L, Zn 30 mg/L), exceeding the standards (CN 1.0 mg/L, pH 5.8-8.6, oil content 5 mg/L, Zn 5 mg/L) according to the Water Pollution Control Law.

For cyanide-containing wastewater, after adjusting the pH value of the wastewater using the method of formalin oxidation (Caston reaction) by combining hydrogen peroxide and formalin, iron complex salt in the wastewater is removed and, after passing through the zinc coagulation sedimentation treatment, the supernatant liquid is filtered. For chromium-containing wastewater, after adjustment of the pH value by reduction reaction, the wastewater passes through coagulation sedimentation treatment and the supernatant liquid is filtered. For acid, alkali wastewater, after sedimentation, filtration and pH adjustment are done, it is mixed with other wastewaters and discharged (CN 0.2 mg/L, pH 7.2, oil content 0 mg/L, Zn 0.5 mg/L). The sludge is dried by a dehydrator and entrusted to an industrial waste management contractor for disposal (2 tons/day, water content 75%). Since the water content was 97% and amount disposed of was 4 tons/day before renewal of this facility, the sludge amount has been reduced to half.

Production scale	Plating finishing of automatic parts, sales amount ¥328 million/year
Cost for required improvement	¥80 million (JEC 74.9%, own funds 25.1%)
Construction cost percentages	Wastewater treatment equipment (80.1%), sludge dehydrator (9.1%), civil engineering (9.6%)
Maintenance management cost	¥1,200,000/month

Replacement by Non-Cyanide type Chemicals (1973)

To suppress the use of hazardous chemicals in the factory's zinc- and copper plating processes, the cyanide plating process was replaced by a non-cyanide plating process. Accordingly, the heavy metal content of the wastewater increased and the treatment process had to be changed.

The wastewater treatment facility was renewed, i.e., continuous automatic treatment equipment (capacity 34 m^3/hr) including a sludge dehydrator was set up in the facility to carry out neutralization and sedimentation treatment of the integrated plating wastewater and acid washing wastewater.

Production scale	Iron wire, wire manufacturing; annual shipment ¥7,140 million
Cost for required improvement	¥48 million (JEC 50%, own funds 50%)
Construction cost percentages	Wastewater treatment equipment (74.5%), renovation of existing tank, anti-acid work (4.6%), civil engineering (20.0%), others (0.9%)
Maintenance management cost	¥94/m^3 treated water (cost of chemicals ¥65, power cost ¥3, cost of consumables ¥14, personnel expenses ¥12)

Reuse of Treated Water (1973)

With stricter regulations by local governments, copper and chromium contents (Cu 0.5 mg/L, Cr 0.05 mg/L) in the plating effluent exceeded the standards and guidance was given directing reduction of the current effluent amount (1,100 m^3/day) to half, so that improvement and expansion of the wastewater treatment facility as well as recycling of the treated water were planned.

Chromium-containing wastewater was treated by reduction and sedimentation, and copper-containing wastewater was treated by neutralization and sedimentation. The copper sludge deposit (20 kg/month) was sold and chrome hydroxide (200 kg/month) was delivered to an industrial waste management contractor. After filtration of the treated water (Cu 0.2 mg/L, Cr 0.02 mg/L), half of it was discharged and the remaining half was returned to the process to be reused.

Production scale	Printed wiring board manufacturing; sales amount ¥900 million/year
Cost for required improvement	¥75 million (JEC 67.1%, prefectural subsidy 26.8%, own funds 6.1%)
Construction cost percentages	Neutralization equipment (10.1%), reduction sedimentation equipment (8.9%), filtration equipment (24.1%), receiving and effluent tanks (19.6%), tank work (11.8%), others (25.5%)
Maintenance management cost	¥276,000/month

Closed System for Wastewater (1973)

After the oxidation-reduction treatment, the wastewater from plating factory had previously soaked into the ground. But the infiltration of wastewater containing hazardous substance into ground was forbidden by prefectural ordinance, so that, when installing the fully automatic zinc plating equipment, a closed system was introduced for the wastewater and ion exchange equipment was installed so the wastewater could be re-used instead of discharged.

All wastewater was reused within the factory and no wastewater was discharged. The solid waste (75 kg/week) produced in the treatment process was, after evaporation and drying, stored at the factory site.

The effluent problem was entirely solved by applying the closed system, and the required amount of water consumption was reduced to 20% of the pevious amount by applying the water circulation method, resulting in considerable saving of the production cost.

Production scale	Plating finishing of communication equipment and household electric appliance parts, sales amount ¥64 million/year
Cost for required improvement	¥26 million (JEC 76.4%, own funds 23.6%)
Construction cost percentages	CN-containing wastewater treatment equipment (43.0%), Cr-containing wastewater treatment equipment (31.5%), piping (8.6%), others (16%)
Maintenance management cost	¥50,000/month

Closed System for Wastewater (1975)

After the oxidation treatment, the chromium plating wastewater was allowed to seep into the ground. But, because of possible contamination of the city water source and work to remove the chromium already infiltrated into the ground, transfer of the factory was recommended by the local governor. To cope with the situation, the factory was transferred and a closed-wastewater system was introduced at the new site.

In the new system, the wastewater (25-40 m^3/day, total chromium 80-100 mg/L) is, after reduction treatment, neutralized to remove sludge and then treated by an activated carbon filter and ion exchange equipment. The treated water is circulated to the cooling water tower and reused, so that no wastewater is discharged now. Chromium recovered by adsorption in the ion exchange equipment is reused in the plating process. The sludge, after being dehydrated and solidified, is stored at the factory site.

Since chromium was detected in the ground water of the old factory site, simple wells are being dug inside and around the factory and the water produced by these wells is treated.

Production scale	Chromium plating, sales amount ¥903 million/year
Cost for required improvement	¥23 million (JEC 87.3%, own funds 12.7%)(not including ground water treatment cost)
Construction cost percentages	Wastewater treatment tank (29.2%), ion exchange equipment (23.1%), countercurrent type washing equipment (21.8%), sludge treatment equipment (filter press 7.8%), others (18.1%)
Maintenance management cost	About ¥100,000/month (not including ground water treatment cost)

Joint Treatment of Sludge (1976)

Traditionally, landfill method was used for the disposal of sludge containing heavy metals and cyanide, produced during the treatment of plating wastewater. But, few disposal sites remained and there was concern about possible secondary pollution such as groundwater contamination, so a cooperative corporation was established by investments made by the corporations concerned and by the local government with the objective of doing steady treatment of the sludge.

The sludge generated by plating corporations was mixed with 15 weight% cement to solidify it. After curing, landfill method was used for the disposal of the solidified sludge, after passing the elution test and being classified as ordinary sludge. The operation cost was covered by collecting a sludge treatment fee.

Production scale	Sludge (4,878 tons) generated by zinc plating factories (164) was accepted. Treatment capacity 15 tons/day
Cost for required improvement	¥77 million (JEC 64.5%, loan from other organizations 25.8%, own funds 9.7%)
Construction cost percentages	Sludge treatment equipment (87.1%), shovel-loader (5.2%), measuring device (2.2%), analyzer (5.5%)
Maintenance management cost	¥15,000/ ton of sludge

Measures for Treatment of Emission Gas Evaporated from Plating Baths (1976)

Problems had occurred because of a deteriorated plating factory located in a residential area and cyanide content detected in water from peripheral wells. In accordance with the prefectural recommendation, countermeasures against emission gas evaporated from copper strike- and silver strike-silver plating treatment and other processees as well as transfer to a factory park and installation of a new wastewater treatment facility were carried out.

Emission gas evaporated from plating treatment is, after passing through the plating bath's hood, sent to the neutralization cleaning tower and then dispersed in the air (gas concentration at tower inlet: CN 150 mg.L; at tower outlet: CN 1.0 mg/L)

Production scale	Metal plating industry, metal dishes: 6,000 dishes/day
Cost for required improvement	¥6,800,000 (JEC 78.7%, prefectural subsidy 13%, own funds 8.2%)
Construction cost percentages	Neutralization cleaning tower (55.1%),ventilation fun (9.6%), exhaust duct piping support tower (35.2%)
Maintenance management cost	Unknown

4.1.18 JEC Survey and Research Reports

In order to establish pollution control techniques in fields where there were no technical precedents and to accumulate information for constructing pollution control facilities, JEC has continued its survey and research projects. With joint cooperative work between small- and medium-scale corporations as their main theme. These projects have been carried out with the objective of realizing technical development steps from basic research to practical factory construction. Such survey and research projects are highly evaluated as good examples of know-how application. Typical examples of projects concerning plating wastewater treatment are shown below. The contents and conclusions of these research projects reflect the situations of technical development when they were carried out, but it is necessary to be aware that they do not always reflect the present situations (1995).

(1) Report on Concentrated Cyanide Waste Liquid Treatment Technology (fiscal year 1971)

Background of Research

In the electroplating industry, cyanide wastewater is commonly generated. To treat diluted cyanide wastewater containing cyanide concentrations as low as 50-300 mg/L, the standard technique of cyanide decomposition by the hypochlorite method has been used and such treatment has been carried out jointly or by each corporation itself. However, for concentrated cyanide wastewater with cyanide concentrations as high as 30,000-50,000 mg/L, containing not only simple cyanide but also various complex salts, the hypochlorite method is not fully effective for treatment.

At present, small amounts of such wastewater is mixed with low-concentration cyanide wastewater, or a large amount of water is added to dilute the cyanide wastewater, which is then discharged to a public sewer. In the electroplating industry where there are many small- and medium-scale corporations, these treatments are sometimes not fully completed because of the high expense of treatment and difficulties in handling treatment, so that there have been some accidents.

JEC considered that development of treatment methods for concentrated cyanide wastewater discharged from the electroplating process must be established as an urgent project and decided to examine this problem in committee.

Outline of Research

The committee examined the current state of high-concentration cyanide waste liquid treatment and the following problems were pointed out:

1) The concentrated cyanide wastewater discharged from the electroplating process contains large amounts of metal cyanide complex iron and nickel salts. Use of the hypochlorite method, which is usually applied for treating low-concentration cyanide wastewater, is always expensive and also does not provide complete treatment of iron-cyanide salts.
2) Though traditionally the electroplating industry has not been held accountable for the treat ment of heavy metals, the industry is now obligated to do proper treatment of these discharged heavy metals to meet the stricter regulations.
3) Since the COD load in effluent is increasing as the costs of various chelating agents rise, complete treatment of small amounts (1 m3/month) of high-concentration cyanide waste liquid is very troublesome for the electroplating industry, which mainly consists of small-scale corporations, from the facility cost and treatment cost viewpoints, so that joint treatment systems will be adopted, even if some problems such as difficulties in collection of cargo and shipments are possible.

Based upon this understanding, the eligibility of various alternative methods was examined. The electrolytic oxidation method, combustion method and heating pressurized air oxidation method appear promising, but further demonstration research must be done using an experimental factory.

Conclusion of Research

The electrolytic oxidation method can be used at the present technical level, despite a problem concerning durability of the electrode as well as poor workability due to unfeasible automatic control in the heating oxidation process. Its running cost is about 4 times higher than either of the other two methods, but depending upon composition, particularly the content of iron-cyanide complex salt, the cost may be greatly reduced. The cost of the activated carbon used in the final filtration process may also be reduced. So, depending on wastewater composition, the cost is expected to approach that of other methods. In the electrolytic oxidation process, copper and zinc will deposit at the negative electrode. The advantages of this process are that the amount of sludge will be minimized and that the disposal cost is low; on the other hand, the chlorine content in the treated water is a disadvantage.

Techniques for the combustion method have been mostly, established except for sludge treatment. In the present system, careful safety measures for cyanide gas with high concentration (amounting to several %) must be taken . Where the iron-cyanide complex salt content in the high-concentration cyanide waste liquid is small, the cyanide concentration increases to about 1,000 mg/L after the neutralization and filtration processes and, consequently, the running cost of handling the succeeding processes becomes high.

The heating pressurized air oxidation method is advantageous in principle, because no chemicals are used in this main process to decompose cyanide (only heat and air are used) and the amount of sludge is small, causing no worrisome secondary pollution. However, further study on setup of the reaction conditions, removal of sludge and scale produced inside the reaction tower, choice and design of the equipment and materials for this method, will be needed.

These 3 treatment methods each have merits and demerits and an optimum method can not be recommended. Depending upon many factors, i.e. the components and concentration of high-concentration cyanide waste liquid, the location of the facility, e.g. where or not a non-metal refinery for sludge treatment is located in the neighborhood, and on the technical level of operators, the optimum treatment method must be selected after thorough pre-survey.

For satisfactory operation of the treatment facility, automatic devices for measuring high-concentration cyanide waste liquid are expected to be supplied soon by concerned makers.

For the electroplating industry which consists mainly of small- and medium-scale corporations, the fixed cost and running cost of these treatment facilities are a considerable load, so that positive assistance from central and local governments is needed.

(2) Survey of Actual Conditions of Industrial Waste (sludge) Treatment and Disposal (fiscal year 1973)

Research Survey of Joint Treatment System for Wastewater Treatment Sludge (fiscal year 1974)

Background of Research

Deciding "How to treat and dispose of industrial waste" is a social responsibility encountered in industry development. Since sludge generated by the wastewater treatment facility in a metal surface treatment factory contains hazardous heavy metals, satisfactory measures for environmental protection must be taken. However, obstructed by technical, economical and social systematic problems, practical measures have not yet been set up and deterioration of the living environment is now causing social problems. In particular, even the actual conditions of treatment techniques have not yet been fully clarified as yet. In a series of research projects, based on protection of the living environment and development of the industry, with the objectives of establishing economical, safe and reliable measures and to implement exemplary joint sludge treatment business, the proper treatment and disposal of hazardous sludge were examined.

Outline of Research

In the 1973 survey, a questionnaire survey was conducted involving corporations (71) which had wastewater treatment facilitis involved with JEC, and information about sludge disposal was collected. Furthermore, a field survey of some corporations was conducted to collect on-site hearing data and do sampling of sludge.

In the 1974 survey, a questionnaire survey of local governments (52) and on-site hearing survey of some local governments and joint treatment factories were conducted to examine and clarify the appropriate sludge treatment and disposal.

Almost all sludge generated by the wastewater treatment facility is accumulated at the factory site or temporarily stored in warehouse for sludge containing hazardous substances, to prevent secondary pollution. However, these are only temporary measures. Accordingly, administrative-level solution measures should be taken soon.

As part of the technical handling done to reduce the amount of sludge containing heavy metals, treatment of wastewaters is conducted separately depending on type. In many cases, the primary stage treatment is done by separating the wastewater according to type, but in the final stage, many types of wastewater are mixed together for treatment, so that large amounts of sludge are generated and treatment and disposal become complicated and difficult. If the treatment is effectively conducted from the primary stage to the final stage in individually classified series, the amount of sludge containing heavy metals is reduced and recovery of heavy metals is facilitated. In the final disposal of this kind of sludge care must be taken to prevent contamination of ground water by heavy-metal eluates. Research and development concerning methods for safe and economical land disposal or techniques of regeneration are expected.

In the ideal case, there is no wastewater discharge, and this can be attained by a closed production system. However, thorough transformation of production facilities is difficult, so that a compromise method is now being developed and applied, i.e. recovering valuable matters in the wastewater, and returning them to the production process to decrease the amounts of both wastewater and sludge. One example has shown that by applying such a circulation system, the amount of sludge discharged can be minimized, so this may be a milestone for the ideal wastewater treatment system yet to be developed.

However, for the metal plating industry, mainly consisting of small-scale corporations, even if persons responsible for pollution control are strongly urged to take countermeasures against pollution generation sources, such matters cannot be solved immediately because of financial load. Also, concerning the treatment and disposal of discharged sludge, proper measures have not been established, and also there are no disposal sites yet, so administrative bodies should be involved in this issue in some form. The present amalgamated treatment system is problematic from the pollution control and resource conservation viewpoints and is also expensive.

Research Conclusion

Based on the analysis described above, the following "basic program for plating sludge treatment and disposal system" was introduced.

To begin with, from the viwpoints of pollution control and environmental conservation, the sludge treatment and disposal techniques should aim at recycling and resource recovery. Simple disposal (landfill) will cause secondary pollution and interfere with the effective availability of resources. Since the present bottleneck preventing achievement of sludge-resource recovery is mixed sludge, the creation and collection system for sludge suitable for resource recovery is demanded including improvement of present wastewater treatment facility.

Secondly, a joint treatment system is not a simple assembly of sub-systems such as wastewater treatment techniques and sludge treatment techniques, but must be established as an integrated system. To establish the system, active consciousness of each person directly concerned and positive aid and support by administrative bodies are indispensable. When designing the system, the participation of chemical manufacturers, industrial waste management contractors and pollution control equipment manufacturers is desirable.

Thirdly, transformation of the industrial structure, must be done so that each plating technique is transferred to a "closed production system" and pollutants are not discharged from the system.

(3) Report on Advanced COD Treatment of Metal Plating Effluent (fiscal year 1982)

Background of Research

Since hazardous substances contained in the plating wastewater were not completely treated at the beginning, they became a social problem. But, as a result of enthusiastically striving to carry out pollution control measures under the strict guidance and control of local governments, plating corporations have been able to meet the effluent standards by installing and using wastewater treatment facilities, contributing to the improvement of water quality in rivers.

However, since 1984 area-wide COD load control was enforced to further improve the water quality in inter-prefectural closed water areas and the plating corporations which produce large amounts of effluent (≥ 50 m^3/day) and which are located within the designated areas, have been forced to adopt advanced treatment methods to lower the COD.

On the other hand, accompanying the progress of plating techniques, chemicals used for plating have become diversified and include items such as surfactants and chelating agents, which cause increase of the COD value. These substances have been traditionally treated by the activated carbon adsorption method, but the high cost is a large burden for plating corporations. In this research project, the advance treatment method for substances with high COD, substituted for the activated carbon adsorption method, was studied to determine its treatment efficiency and economic value.

Outline of Research

In this research, as the advanced treatment methods for substances with high COD to be substituted for the activated carbon adsorption method, the biological treatment method (catalytic oxidation method) and the chemical treatment method (oxidation decomposition method using ferric hydrogen peroxide) were selected. The results of their bench-scale experiments and of their pilot plant-scale operations were compared with those of the activated carbon adsorption method and their treatment efficiency and economical value were studied.

Results of Research

It has been clarified that in cases where is not necessary to keep the COD (Mn) value at less than 20 mg/L after treatment, the biological treatment method is the most inexpensive and advantageous method. However, if the COD (Mn) must be kept at ≤ 20 mg/L after treatment, the biological treatment method alone cannot meet this requirement, and the joint biological-hydrogen peroxide oxidation method is preferable, because, it was found that although this method is 30% higher in fixed cost, it is more than 50% lower in running cost compared to other methods, so it is a most economical method.

To achieve practical use, economic efficiency and simple workability must be improved, taking into account the many small-scale plating corporations concerned. But, to satisfy the more stringent regulations such as area-wide COD load control and nitrogen and phosphorus regulations, such an advanced treatmeent facility may possibly be adopted in plating corporations in the future.

In any case, effective measures must be taken at the pollutant source before treatment methods are examined. Possible measures are: cut down the use of chemicals that result in higher COD values, or replace the present chemicals by new ones that react at lower COD values or can be treated by the present treatment methods. Other useful measures are: cut down the use of chemicals by completely controlling the concentration of the plating bath when the solution is being prepared or supplemented, or by removing impurities from the solution to elongate its life, lower the concentration of the plating bath by replacing gluconic acid type chemicals with phosphoric acid type ones for use in the degreasing bath, and avoid discharging plating solution in the bath unnecessarily.

4.2 Marine Products-Processing Industry

4.2.1 Outline of Marine Products-Processing Industry

(1) Contents of the sector

Marine products-processing is the manufacturing of mainly foodstuffs, which conducts various kinds of processing for the purpose of storage or seasoning, using fish, shellfish and seaweed as raw materials, and ships processed marine products as finished commercial products.

Classified by manufactured items, marine products-processing can be divided into the following:

1) Marine food can/bottle-manufacturing

Principally using fish (including whale), shellfish and seaweed as raw materials, this sector of marine products-processing manufactures marine food cans and bottles. Main items include marine food cans/bottles, fish cans/bottles, crab cans, seaweed cans/bottles and bottles of marine foods boiled down in soy (tsukudani).

2) Marine food paste-manufacturing

This sector manufactures marine food paste (excluding fish-meat hams and sausages) or marine food paste-based products, such as boiled fish paste (kamaboko), cylinder-shaped toasted/boiled fish paste (yaki chikuwa), fried kamaboko and fish cake (hanpen).

3) Salted and dried products-manufacturing

This sector mainly produces dried, salted and dried, boiled and dried, salted-storage and smoke-dried products. Regarding principal items, dried products include dried devilfish, dried small sardines, dried herring, bar-shaped cod and dried flatfish; salted and dried products include dried small sardines, opened and dried sardines, salted and dried horse mackerel, salted and dried mackerel, salted and dried saury, opened and dried cod and straw-bound yellowtail; boiled and dried products include boiled and dried sardines, boiled and dried sand eel, dried ear shell and dried shrimps; salted-storage products are salted salmon, trout, mackerel, cod, walleye pollack, sardines, sauries, Atka mackerel, cod roe, herring roe and salmon roe. Among smoke-dried products are devilfish, salmon and trout smoked and dried.

4) Dried fish-manufacturing

This sector mainly produces dried bonito or mackerel.

5) Fish-meat ham/sausage-manufacturing

Chiefly using fish/shellfish (including whale), this sector produces fish-meat hams and sausages.

6) Seasoned/processed food-manufacturing

This sector principally manufactures fish boiled down in soy (tsukudani), dried mirin-seasoned marine foods, pickles and so-called "strange, tasty items" (chinmi). Principal items of marine foods boiled down in soy are those made of sand eel, young sardines, horse mackerel, bonito, tuna, pond smelts, gobies, crucian carps, shrimps, opossum shrimps, short-necked clams, clams, laver, sea tangle and sea lettuce. Further, these items are processed jointly with beans or meat. Dried mirin-seasoned marine foods include sardines, sauries, halfbeaks, sillaginoids, swellfish, sea breams and shrimps. Pickles are those seasoned with rice bran, sake lees, vinegar, soy paste (miso) and malted rice, including vinegared rice called "izushi." "Chinmi" items are salted fish guts, pickles, smoked foods, dishes dressed with various kinds of sauce and pressed/rolled foods.

7) Refrigerated marine products/refrigerated marine foods-manufacturing

Mainly using fish/shellfish (including whale) as raw materials, the refrigerated marine products-manufacturing industry manufactures refrigerated products by means of freezing facilities. The refrigerated marine foods-manufacturing industry, on the other hand, implements the preliminary treatment (cleaning, removal of guts, etc.) and rapid refrigeration, manufacturing packaged, refrigerated marine foods in the frozen condition. Products based on many processing methods, such as "round refrigeration products" (fish/shellfish are frozen as they are), "semi-dressed refrigeration products" (refrigeration is made after heads, guts and bones are removed), "dressed refrigeration products" and "filet refrigeration products," are manufactured for the same kind of fish.

8) Seaweed-processing industry

Principally utilizing seaweed as raw materials, this sector produces seaweed-processed foods (excluding agar-agar). Chief products are sea tangles, tangle shavings, vinegared tangles, parched laver, seasoned laver, "wakame" seaweed, edible seaweed, glue plants, etc.

9) Agar-agar-manufacturing

This sector principally produces agar-agar. Products manufactured through the method under which gelation, dehydration and drying are implemented, based on cold natural meteorological conditions, are called "natural agar-agar," while products manufactured through mechanical equipment are called "industrial agar-agar."

10) Non-food products-manufacturing

This sector mainly produces marine oil, fish meal, condensed fish protein, etc. Marine oil includes fish oil and cod-liver oil, and these products are utilized as shortenings for confectionery-manufacturing, industrial fuel and the raw material of edible oil, among others. Fish meal is used as a raw material for feed and fertilizer, while condensed fish protein is produced as feed, but it is also used as a material of seasonings for instant foods. These products are principally produced from the waste yielded in the course of marine food-processing.

Fish and shellfish, which are raw materials of these marine products, are liable to rapidly deteriorate in quality over time after their hauling, because protein- discomposing enzymes contained in the raw materials start to work. For this reason, two processing methods are adopted for them. One is the method of conducting, at the places of hauling, the relatively simple primary processing, such as drying, salted preservation and refrigeration, after removing bowels, heads, bones, etc. The other is the method in which the relatively advanced secondary processing, such as the production of paste and seasoned food, is carried out, with primary processed products utilized as raw materials.

It is a general trend to establish plants solely for primary processing or integrated processing that includes the secondary processing in places adjacent to fishing ports and the like. Even at present, this trend is maintained in plants designed to process fish and shellfish hauled from coast fishery, as well as processing that has developed as a localized industry.
In accordance with the development of deep-sea fishery, however, the proportion of marine products processed aboard (groups of) fishing boats or overseas is growing, so that the number of plants that engage principally in secondary processing without being affected by the aforementioned restriction is also increasing.

(2) Characteristics of the Japanese marine products-processing industry

Although fresh-water fish/shellfish are included in raw materials for Japanese marine products-processing, most of raw materials are sea water fish/shellfish, partly because Japan is surrounded by the sea. Also because the Japanese people have been dependent on marine protein resources since the ancient times, many marine products-processing enterprises have thrived as parts of a localized industry, based in areas adjoining hauling sites.

Kinds, size, taste and the like of fish/shellfish hauled differ considerably, depending on the season and area. Therefore, characteristics of business sectors are determined by raw materials used.

Marine food can/bottle-manufacturing, marine food paste-manufacturing, salted/dried products-manufacturing and seasoned food-manufacturing can change the kinds of fish/shellfish, depending on the season or local nature, and continue manufacturing. Of these, some of marine food paste-manufacturing, salted/dried products-manufacturing and seasoned food-manufacturing enterprises, which can operate with relatively simple facilities, have developed as localized businesses utilizing the characteristics of local areas, since old times. For this reason, there are many small-scale enterprises — this is a major characteristic of the sectors.

Meanwhile, large-scale plants in the aforementioned business sectors and enterprises in marine food can/bottle-manufacturing, fish-meat ham/sausage-manufacturing and refrigerated marine products/marine foods-manufacturing engage in integrated production starting with primary processing, in the season when fresh raw materials are available, and with secondary processing, in the season when such raw materials are not available, in order to perform stabilized operation throughout a year. Also, there is such a business sector as the marine food can/bottle products-manufacturing that processes fruits and other agricultural products in other seasons.

The processing industries that use limited kinds of raw materials, such as dried fish-manufacturing or agar-agar-manufacturing, similarly utilize refrigerated or salted materials in seasons when fresh materials are not available.

The production of natural agar-agar is implemented as he secondary business during winter by farm households in cold areas, such as Nagano Prefecture. For this reason, raw seaweed collected mainly in summer and stored as salted seaweed is transported and used in winter.

As shown in the following table, principal marine products-processing businesses in Japan are characteristically located in Hokkaido, Prefectures in the Tohoku area, Prefectures along the Pacific coast and those along the coasts of the Seto Inland Sea.

Table 4-2-1 Production Volume of the Marine Products-Processing Industry in Japan

Production volume in fiscal 1993

(1)

	Marine food paste-manufacturing								Dried fish-manufacturing	Seasoned/processed food-manufacturing		
	Food paste products	Fish-meat hams/sausages	Refrigerated food	Dried products	Salted and dried products	Boiled and dried products	Salted products	Smoke-dried products	Dried bonito or mackerel	Salted fish guts	Pickles	Marine foods boiled down with soy
Hokkaido	21,535	3,330	19,853	24,778	17,197	4,055	162,807	8,696	378	12,134	12,408	6,115
Aomori	17,886		23,351	3,129	837	1,073	14,044	744		4,800	10,486	236
Iwate	433	19	41,250	87	1,663	212	9,105	232	129	485	277	93
Miyagi	73,531	980	30,931	776	4,903	1,131	44,352	120	1,210	24,547	38,900	397
Akita	214	7	7	1,073	56	39	1,140	14			2,107	1,067
Yamagata	163		9	9	10		764	41		17	1,226	1,539
Fukushima	24,440	48	1,181		6,291	327		7	35		552	192
Ibaraki	2,331		12,092	962	15,189	4,303	5,311	985	86		1,832	3,196
Tochigi	340	7,635			4	6	10	2	23		3	1,398
Gunma	49			2	110		296		191		590	190
Saitama	2,804	868	1,000				591	7	407	10		1,846
Chiba	12,482	1,487	19,810	699	58,370	4,246	44,509	59	782	12	4,991	3,099
Tokyo	35,147	8,182	865	30	1,163	63	191	8	4,617	94	1,306	7,479
Kanagawa	25,805	228	4,062	249	8,302	87	6	288	834	947	2,488	49
Niigata	61,175	7,557	3,640	179	5,918	83	3,530	41	26	565	3,847	405
Toyama	9,839		2,664	1,446	1,623	1,109	64	15	462	718	407	2,291
Ishikawa	14,367	8	190	30	757	26	400	30	437	10	687	1,584
Fukui	4,489		1	777	2,591	46	630		35	18	891	270
Yamanashi	1		3	2,000			539	22			295	769
Nagano	3		1,476	7			109	5	28	8	1,493	381
Gifu	364			1				2	110	1	8	418
Shizuoka	41,305	5,149	19,469	1,057	38,075	4,242	3,207	53	40,028	2,134	3,578	4,171
Aichi	63,354		30,180	123	3,443	6,957	73	179	5,161		162	12,091
Mie	21,309	1,856	16,782	326	15,872	2,093	5,778	2	1,670	85	620	964
Shiga	8,371		309			5	71	389	36		67	2,311

(2)

	Marine food paste-manufacturing								Dried fish-manufacturing	Seasoned/processed food-manufacturing		
	Food paste products	Fish-meat hams/sausages	Refrigerated food	Dried products	Salted and dried products	Boiled and dried products	Salted products	Smoke-dried products	Dried bonito or mackerel	Salted fish guts	Pickles	Marine foods boiled down with soy
Kyoto	8,894			70	579	951	317		1,160	2	28	1,381
Osaka	41,319	7,240	2,316	123	84	612	629	263	8,549	151	128	6,813
Hyogo	64,045	4	3,663	3,280	7,702	6,976	282	420	3,442	596	4,579	22,346
Nara	285								143			11
Wakayama	5,445		1,075	53	3,462	5,322	317		2,027	3	50	38
Tottori	2,931		18,603	456	2,739	5,126	169	240		32	2,579	185
Shimane	12,612	5	9,070	310	6,405	155	454		51	12	56	346
Okayama	14,234		30	35		59	800	142	3,205	226	322	2,142
Hiroshima	19,844		6,556	493	371	2,904	4	3	1,701	35	233	25,312
Yamaguchi	39,664	10,010	5,741	692	4,834	4,923	1,322	6	93	864	11	67
Tokushima	5,523		10,019	26	907	1,848	43		206	2		9
Kagawa	8,040		28,671	2	11	2,052			265		27	14,515
Ehime	14,536	650	17,311	15	593	3,393	30		8,656	22	2	399
Kochi	6,468		2,282	60	2,818	1,757	3		3,863	92		13
Fukuoka	26,867	5,579	14,692	31	2,913	974	2,180	11	857	1,161	1,044	1,166
Saga	7,696	5,656	4,877	14	5,640	727	613		54	178	909	342
Nagasaki	12,430	5	6,781	513	4,708	12,194	1,055		189	610	13	137
Kumamoto	8,516	319	4,094	2	170	4,046	125	47	11,291	135	7	670
Oita	5,007		4,452	57	4,919	2,787		110	25	220	21	993
Miyazaki	3,477		388	106	1,972	1,751	4	23	1,215	8	11	34
Kagoshima	10,224	6	12,342	12	13,141	1,979	411	25	25,882	177	391	419
Okinawa	3,238			1				53	334	56		29

(3)

	Seasoned/processed food-manufacturing		Agar-agar manufacturing		Marine oil/fat-manufacturing	Feed/fertilizer-manufacturing				Marine food can/bottle-manufacturing
	Dried/parched/ fried-processing	Others	Agar-agar	Seasoned laver	Marine oils/fats	Fish meal, etc.	Fish soluble	Fresh marine products	Refrigerated ground fish meat	Cans
Hokkaido	38,258	15,799		68,031	16,227	99,370	9,683	252,975	111,889	11,547
Aomori	16,396	776			18,242	46,372	10,284	78,855	5,457	16,466
Iwate	1,291	243		8,813	6,296	8,521	1,989	141,754	194	9,020
Miyagi	9,809	11,409	38	231,438	13,709	122,464	2,048	322,033	12,031	15,828
Akita	267	28				0		2,847		
Yamagata	245	553				0		217		993
Fukushima	653	525		77,641	175	8,077		82,320	421	12
Ibaraki	2,283	100		318,377	2,644	7,299		229,811		10,574
Tochigi	54			89,520		0		185		
Gunma	78	1,173		101,548		0		2		
Saitama	860	719		111,697		0		40		51
Chiba	2,638	1,078		245,128	3,007	43,535	395	279,006	1,652	10,955
Tokyo	3,062	362	180	951,655		0		256		
Kanagawa	3			113,083		4,082	1	1,405		238
Niigata	2,298	990		102,869	1,898	5,165		499		
Toyama	1,872	19		4,060	134	4,868	77	1,542	4	46
Ishikawa	533	163	54	1,433	6,184	13,476		8,355	15	99
Fukui	878	72				1		2,609		1,706
Yamanashi	2,156	8				0		0		
Nagano	101	394	925	41,108		0		225		
Gifu	24	185	395	28,276		0		2		
Shizuoka	8,965	50	23	365,058	3,113	84,395	5,694	5,242	386	79,976
Aichi	2,537	2,770		1,108,516		11,476		16,835		1,563
Mie	4,543	11,977		339,405		181		106,118		
Shiga		42				0		648		

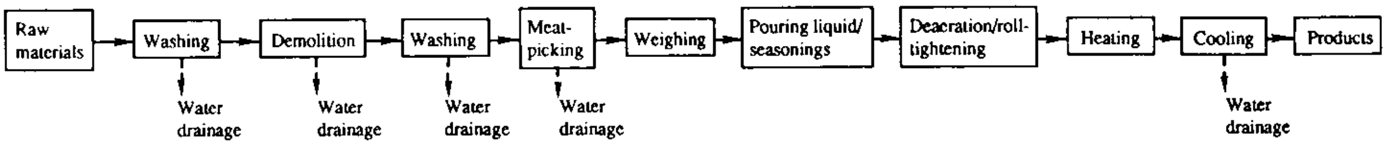
(4)

	Seasoned/processed food-manufacturing		Agar-agar manufacturing		Marine oil/fat-manufacturing	Feed/fertilizer-manufacturing				Marine food can/bottle-manufacturing
	Dried/parched/ fried-processing	Others	Agar-agar	Seasoned laver	Marine oils/fats	Fish meal, etc.	Fish soluble	Fresh marine products	Refrigerated ground fish meat	Cans
Kyoto	437	81	4	57,268	360	2,500		9,211	495	186
Osaka	1,276	4,291	5	1,294,360	1,440	7,400	3,000	3,481	9	
Hyogo	5,191	3,729	25	344,110	473	2,542	140	18,342		
Nara						0		0		
Wakayama	496			21,600		217		19,713	50	349
Tottori	152	1,094			18,809	43,734	2,820	454,311	37	16,228
Shimane	4,440	635		53,468	4,137	11,198	1,028	58,283	138	
Okayama	1,772	104		391,855	77	33,266		1,703		
Hiroshima	11,672			149,296	1,200	91,256		3,960	1	102
Yamaguchi	11,858	4,937		54,576	2,919	8,671		23,890	1,845	
Tokushima	64	57		64,500		322		17,273		
Kagawa	332			19,798		433		5,275		1
Ehime	10,332	245		12,000		65,355		16,704	16	
Kochi	204	36		827,387	113	5,044	113	4,178	60	
Fukuoka	1,991	19,829		155,370	1,274	2,912	322	10,854	200	1,997
Saga	1,182	201		188,799	3,450	19,867	2,152	116,607	5,653	860
Nagasaki	4,298	665		808,832		11,792	9,177	184,046	48	7,090
Kumamoto	105	726		43,152		1,587		15,486		2,915
Oita	129	46			100	763		38,831	176	445
Miyazaki	127	103				207		10,548	212	
Kagoshima	565	400			733	12,510	3,227	112,784	12	
Okinawa	377	115			5	840		156		

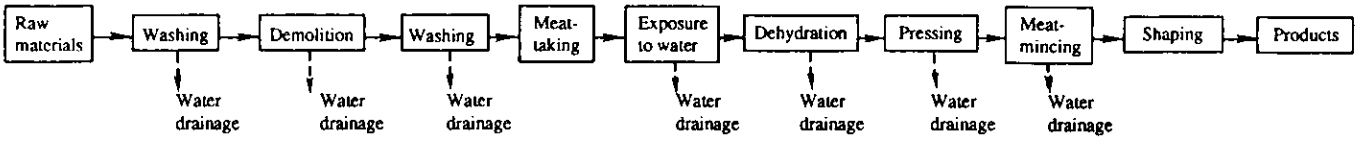
4.2.2 Basic Processes

Basic processes of marine products-processing, classified by production item, are shown below:

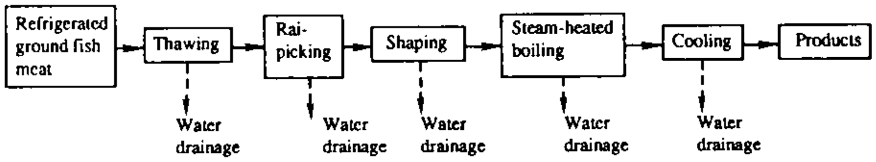
(1) Marine food can/bottle-manufacturing



(2) Marine food paste-manufacturing

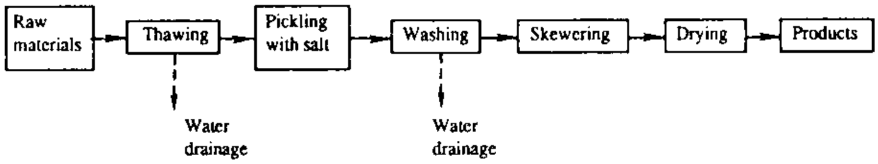


Boiled fish paste (kamaboko) (If produced from raw fish, the grounding process will be added prior to process.)

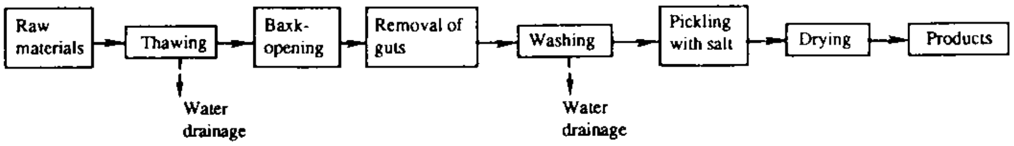


(3) Salted and dried product-manufacturing

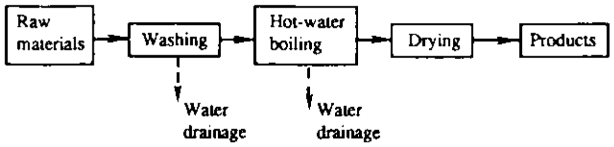
Dried sardines/sun-dried small fish



Salted mackerel

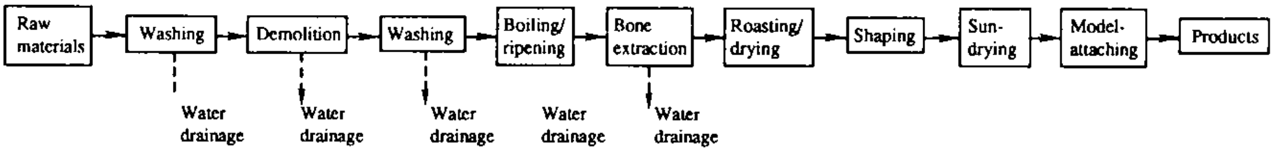


Dried small sardines

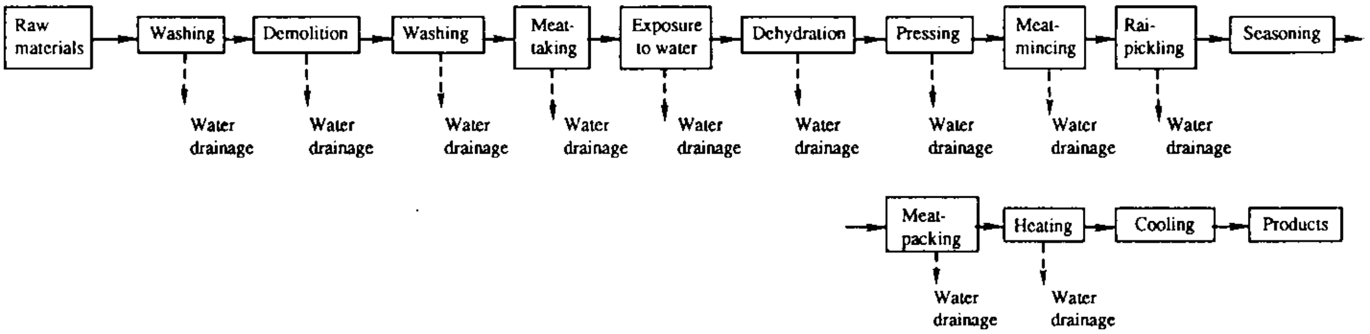


(4) Dried bonito/mackerel

Dried bonito

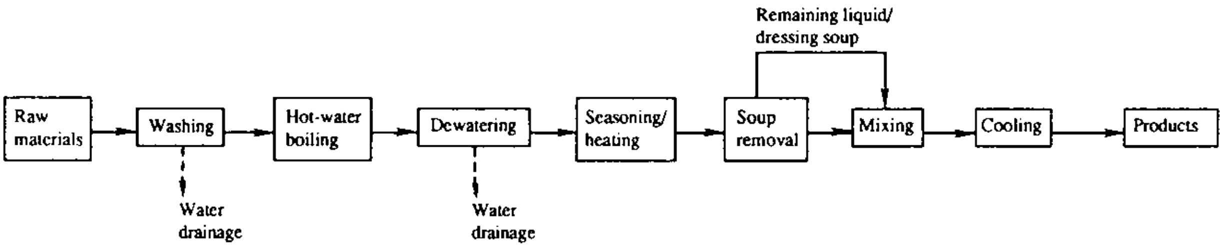


(5) Fish-meat ham-manufacturing

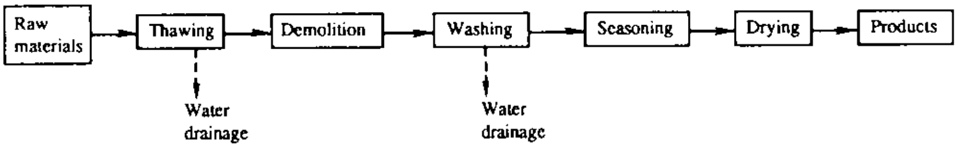


(6) Seasoned/processed food-manufacturing

Marine foods boiled down with soy

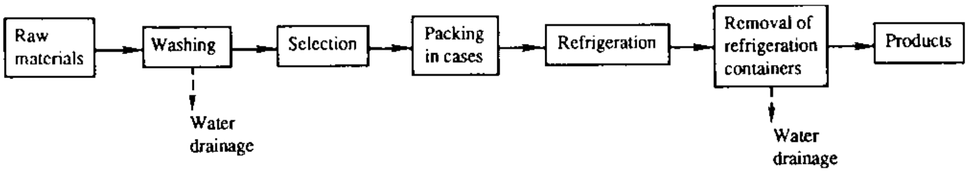


Dried “mirin-seasoned” fish

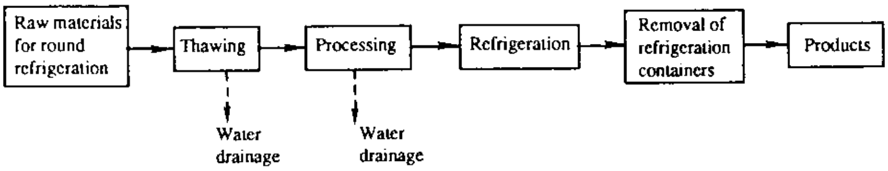


(7) Refrigerated marine products/foods-manufacturing

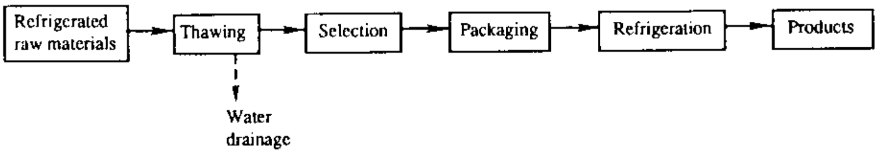
Round refrigeration



Processed refrigeration (Dressed, semi-dressed and filet refrigeration)

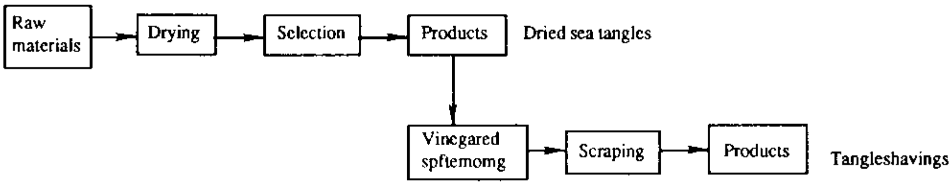


Repacking

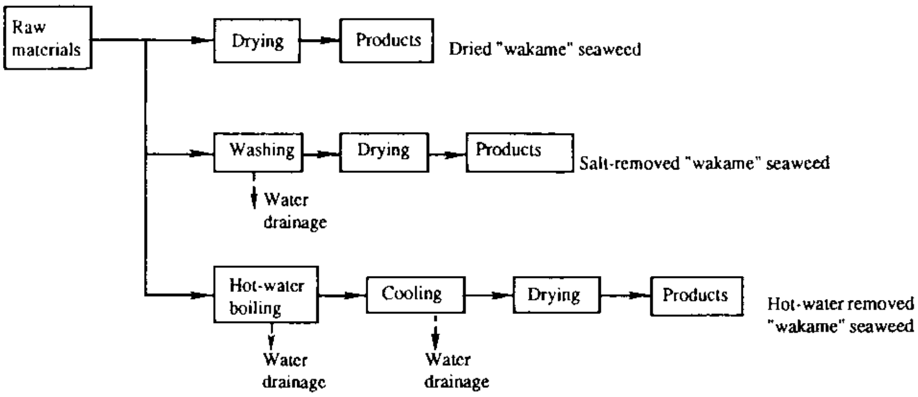


(8) Seaweed-processing industry

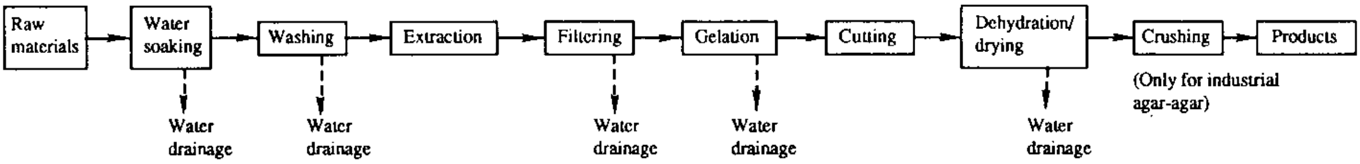
Sea tangle



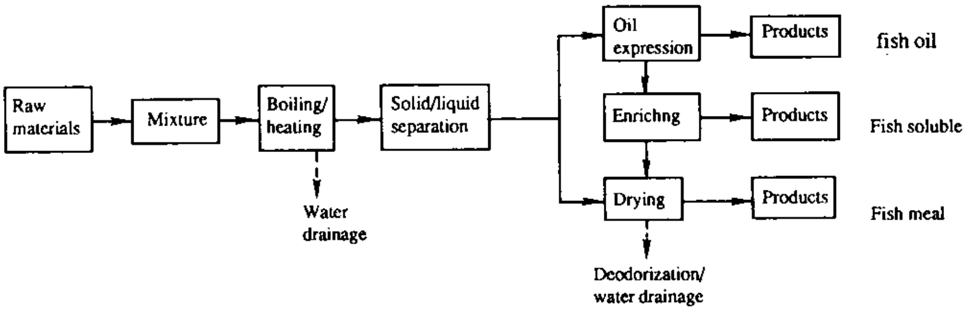
"Wakame" seaweed



(9) Agar-agar-manufacturing



(10) Non-food products-manufacturing



4.2.3 Sources and Properties of Pollution and Waste

(1) Main Sources of Wastewater

Sources of wastewater in principal manufacturing processes are shown in the preceding section. If attention is paid to pollution load, principal generation sources can be summarized as follows:

1) Preliminary treatment process of raw fish and seaweed
This process corresponds to the thawing, demolition and washing of raw fish; and the washing and desalting of raw seaweed. Because the blood, protein, fat and carbohydrate of raw fish, as well as carbohydrate, protein, etc., of raw seaweed, are discharged, wastewater that has a high concentration of BOD, COD (Mn), SS, N and P is discharged.

2) Processes of hot-water boiling, steam-heated boiling and seasoning
This process corresponds to the heating treatment process that closely follows the parliamentary treatment process. In this process, residual liquid abounding in protein and fat that eluted as a result of heating, and residual liquid after seasoning/processing are discarded as they are, and then washed away. As such, wastewater that contains highly dense BOD, COD (Mn), SS, N and P is discharged.

3) The process of washing manufacturing equipment, floor, etc.
This corresponds to the process of washing the utilized equipment, containers, plant floor, etc., after the end of the manufacturing process. Products or their like attached to equipment or containers are removed by washing, and they are discharged as effluent.

(2) Properties of wastewater

Cases of wastewater conditions, measured for individual sectors and processes, are shown below. Because such water-quality measurement was performed mainly as part of steps to deal with wastewater treatment, it was implemented in the processes characterized by relatively high wastewater concentration.

Because products, kinds of raw materials and the handling of measured data vary depending on measurement classification, they are shown as separate, individual examples. However, characteristics of marine products-processing wastewater can be summarized as follows:

1) Regarding wastewater from the processes of thawing, demolishing and cleaning raw fish to manufacture cans, boiled bonito/mackerel and refrigerated marine products, BOD amounts to 1,000-10,000 mg/l; COD (Mn) totals 1/3 of the BOD level; SS totals 1,000-2,000 mg/l;

and oil content reaches 200-2,000 mg/l. The wastewater is high-density, organic wastewater containing blood, soluble protein and oil/fat.

2) With regard to wastewater from steam-heated boiling and boiling/ripening processes, BOD totals 10,000-20,000 mg/l; COD (Mn) amounts to 1/2 of the BOD level; and both SS and oil content reach 1,000-10,000 mg/l. Thus, it is high-density, organic wastewater, containing flowed-out protein and oil/fat.

3) In wastewater from the fish-meat exposure and dehydration processes in ground fish- or fish-meat ham/sausage-manufacturing, BOD amounts to 1,000-3,000 mg/l; COD (Mn) and SS are at the levels of 500-2,000 mg/l.

4) Concerning wastewater from the processes of washing and soaking raw seaweed to manufacture agar-agar, BOD and COD (Mn) are at the levels of 2,000-4,000 mg/l; and SS totals 1,000-2,000 mg/l.

5) As for wastewater from the process of washing manufacturing equipment, floor, etc., BOD amounts to 400-2,000 mg/l; COD (Mn) totals 100-1,000 mg/l; and SS is at the level of 300-3,000 mg/l.

Generally, water quality measurement data indicated in the table are extensively dispersed. This is considered to be due to diversity in the kinds of raw fish handled, etc., or the method of water usage. Furthermore, attention should be paid to the fact that the data indicated the values at the time when contamination load reduction steps, including the recovery of dense wastewater, in "cleaner production" arrangements, were not yet positively implemented in the manufacturing process.

Table 4-2-2 Cases of Monitoring Regarding Marine Food Can-Related Wastewater

Case No.	Business sector	Process	Classification	Drainage volume (m3/day)	pH	BOD (mg/L)	COD (mg/L)	SS (mg/L)	N (mg/L)	P (mg/L)	Oil content (mg/L)
1	Tuna cans	Thawing		277	6.6	890	465	76			214
		Demolitionwashing		239	7.1	813	424	255			317
		Steam-heatedboiling wastewater		6	6.2	87,114	20,465	17,133			4,538
		Can-washing		-	7.0	349	113	74			173
		Cooling		178	7.0	7	3	15			139
		Plant-washing		51	-	5,598	2,740	3,410			3,058
		Overall		894	6.9	689	286	255			146
2	Mackerel cans	Thawing	min	-	6.6	3,343	1,680	810			-
			max	-	6.7	4,663	2,573	1,117			-
		Raw fish-washing		20	6.7	1,440	384	432			260
		Demolition	min	3	6.2	6,012	267	1,899			401
			max	3	6.6	15,407	3,126	4,115			3,126
		Fish meat-washing	min	20	6.4	2,454	990	1,899			216
			max	30	6.6	7,799	2,348	4,115			4,172
		Meat-packing	min	15	6.6	5,777	1,669	1,260			186
			max	20	6.7	17,796	4,175	8,268			4,372
		Steam-heated boiling	min	-	6.4	26,750	17,900	11,965			6,850
			max	-	6.6	41,150	23,950	28,000			12,000
		Can-washing	min	-	6.4	874	362	530			204
			max	-	7.1	2,316	1,121	1,741			474
		Plant-washing	min	60	5.3	421	163	332			342
			max	60	8.4	2,418	1,010	3,778			484
		Overall	min	975	6.5	2,895	1,177	1,391			1,595
			max	975	6.8	3,597	1,630	3,343			1,595
3	Mackerel cans	Raw material-washing			6.8	1,440	384	432			260
		Demolition/washing			6.5	12,572	3,677	4,444			1,631
		Cut meat-washing			6.4	8,573	2,482	2,919			2,096
		Fish meat-washing			6.3	6,179	1,886	2,946			1,527
		Meat-packing wastewater			6.3	23,132	6,045	7,825			1,734
		Box-washing			6.7	5,060	1,727	705			539
		Broth wastewater			6.1	75,357	22,109	29,807			27,990
		Can-washing wastewater			5.9	929	501	279			331
		Can-washing machine wastewater			8.9	1,012	493	108			1,457
		Water jet			8.8	290	52	386			243
4	Crab cans	Boiling/ripening				3,170	2,983	367	800		
		Boiling/ripening cooling				130	913	514	40		
		Overall				690	1,236	274	140		
5	Tuna cans	Steam-heated boiling	min		6.0	720	100	130			22
		Steam-heated boiling	max		6.9	13,300	7,770	2,830			3,240
		Demolition/washing	min		7.1	74	9	44			26
		Demolition/washing	max		7.3	210	74	186			260
		Overall	min		6.3	96	155	230			3
		Overall	max		6.7	920	820	582			120
		Demolition/washing	min		6.3	495	216	352			50
		Demolition/washing	max		6.5	1,350	540	770			764

Table 4-2-3 Cases of Monitoring Regarding Marine Food Paste-Related Wastewater

Case No.	Business sector	Process	Classification	Drainage volume (m³/day)	pH	BOD (mg/L)	COD (mg/L)	SS (mg/L)	N (mg/L)	P (mg/L)	Oil content (mg/L)
6	Boiled fish paste (kamaboko)	Exposure to water	1			2,150	890	920			
		Exposure to water	2			2,500	883	968			
		Exposure to water	3			1,920	670	500			
		Exposure to water	4			1,440	596	360			
		Exposure to water	5			2,000	543	528			
		Centrifugal dehydration				4,090	1,300	2,480			
7	Refrigerated ground fish meat	Storage in tanks		40	7.1		2,420	3,390	570		1,910
		Washing		40	7.1		1,180	3,200	666		740
		1st sieving		90	7.2		6,380	6,900	2,750		420
		1st dehydration		1.5	7.2		5,690	1,240	2,730		400
		2nd sieving		69	7.4		3,320	1,500	516		450
		3rd sieving		69	7.4		3,320	1,500	516		450
		4th sieving		69	7.1		1,140	1,400	433		30
		2nd dehudration		1.5	7.2		10,800	23,400	4,340		90
		Recovery sieving 1			7.2		5,420	3,700	2,120		390
		Recovery sieving 2			7.3		1,110	950	375		60
		Overall		380	7.1		2,180	2,310	939		640
8	Ground fish meamanufacturing	Exposure wastewater	A		7.4	2,010	490	514	247		
		Exposure wastewater	A		6.6	9,600	1,260	418	210		
		Exposure wastewater	B		6.6	7,200	870	1,010	320		
		Exposure wastewater	C		6.6	12,300	1,642	1,020	700		
		Exposure wastewater	D		6.6	5,800	650	337	160		
		Exposure wastewater	E		7.9	12,200	1,600	289	660		
		Exposure wastewater	E		6.7	8,200	790	370	130		
9	Marine food paste products	Thawing/cutting	min		6.9	313	125	104			
		Thawing/cutting	max		9.4	1,690	610	4,290			
		Content-taking/ exposure	min		6.8	128	38	162			
		Content-taking exposure	max		7.1	318	490	317			
		Rai-pickling	min		6.7	218	71	60			
		Rai-pickling	max		7.2	582	230	818			
		Shaping/steam-heated boiling	min		6.3	852	340	763			
		Shaping/steam-heated boiling	max		6.9	3,250	1,460	4,110			
		Overall	min		6.9	212	70	196			
		Overall	max		8.2	670	300	812			

Table 4-2-4 Cases of Monitoring Regarding Fish-Meat Ham/Sausage Wastewater

Case No.	Business sector	Process	Classification	Drainage volume (m³/day)	pH	BOD (mg/L)	COD_{Mn} (mg/L)	SS (mg/L)	N (mg/L)	P (mg/L)	Oil content (mg/L)
10	Fish-meat hams/sausages	Raw material treatment			6.5		1,400	740			140
		Miscellaneous wastewater			6.8		105	60			50

Table 4-2-5 Cases of Monitoring Regarding Dried Bonito/Mackerel-Manufacturing Wastewater

Case No.	Business sector	Process	Classification	Drainage volume (m³/day)	pH	BOD (mg/L)	CODMn (mg/L)	SS (mg/L)	N (mg/L)	P (mg/L)	Oil content (mg/L)
11	Dried mackerel	Thawing/ventral parts-opening		0.50	7.1	520	230	350			220
		Boiling/ripening		1.95	6.4	17,500	6,100	2,100			1,550
		Pressing		0.44	6.6	185,000	115,000	30,200			107,000
		Oil-separation recovery		0.39	6.6	98,500	41,300	29,000			17,300
		Overall		0.85	6.7	25,600	9,900	5,490			3,480

Table 4-2-6 Cases of Monitoring Regarding Marine Products Refrigeration-Related Wastewater

Case No.	Business sector	Process	Classification	Drainage volume (m³/day)	pH	BOD (mg/L)	CODMn (mg/L)	SS (mg/L)	N (mg/L)	P (mg/L)	Oil content (mg/L)
12	Refrigerated marine products	Saury-washing	min			155	104	117			
			max			2,290	849	860			
		Sardine-washing	min				58	32			8
			max				328	432			52
		Anchovy-washing	min				90	8			24
			max				960	714			130
		Mackerel-washing	min			676	142	120			30
			max			2,309	554	810			472
		Smelt-washing	min			25	78	7			
			max			1,203	283	149			
		Flatfish-washing	min			288	77	13			
			max			940	485	192			
		Herring-washing	min			874	123	6			
			max			6,420	2,000	2,140			
		Devilfish-washing	min			1,014	324				
			max			1,168	445				
		Red spider crabs	min			140	136	14			
			max			3,500	1,194	1,120			
13	Refrigerated marine foods	Sardine storage in tanks			6.4	3,300	1,600	600			75
		Sardine-washing			7.3	460	120	150			42
		Sardine head-cutting			7.2	170	150	150			53
		Container removal			7.5	21	170	27			7
		Cooling in refrigerators	1		7.6	10	7	10			3
		Cooling in refrigerators	2		7.7	17	5	14			5
14	Refrigeratored marine foods	Refrigerated sauries	1	12		38	15				
		Refrigerated sauries	2	12		115	45				
		Refrigerated sauries	3	12			6				
		Refrigerated sauries	4	12		115	45				
		Refrigerated sauries	5	12		115	45				

Table 4-2-7 Cases of Monitoring Regarding Agar-agar-Related Wastewater

Case No.	Business sector	Process	Classification	drainage volume (m³/day)	pH	BOD (mg/L)	CODMn (mg/L)	SS (mg/L)	N (mg/L)	P (mg/L)	Oil content (mg/L)
3	Agar-agar	Alkali washing		340	12.2	4,350	3,505	1,970			
3	Agar-agar	Liquid soaking		180	11.0	2,900	1,321	755			
3	Agar-agar	Rubbing/twisting		7	7.3	2,300	765	260			
3	Agar-agar	Washing		15	7.4	460	129	1,063			
3	Agar-agar	Pressured dehydration		7	7.0	385	310	40			
3	Agar-agar	Freezing/thawing		12	6.2	2,350	1,118	755			
3	Agar-agar			200	7.2	140	52	67			

(3) Generation of offensive odor

Generation sources of offensive odor in marine products-processing plants are as shown below:

1) Waste placement sites or raw material storages Bowels of fish, particularly digestive organs, contain many bacteria, and they corrupt quickly. If waste is left within uncapped containers in a sunny place, whose temperature easily rises, corruption progresses rapidly, generating offensive odor or septic smell due to volatile fatty acids and organic acids that include nitro gen and sulfur contents. Because such waste is used as raw materials for plants of non-food products, such as fish meal or marine oil, offensive order generates from storages of raw materials at these plants.

2) Boiling/ripening, roasting and frying processes
When boiling/ripening fish or shellfish, volatile organic substances contained in fish or shellfish or volatile organic materials that are newly produced as a result of heating generate as offensive odor. In the course of roasting, fish are burned after they are coated with special sauces, particularly during the "kabayaki" and "sugatayaki" processes, so that odor arises from the burning of sauces or from amino acids, including fish oil and sulfuric contents. In the frying process, ground fish meat is fried using sesame oil, etc., and oil-oxidized objects and fat-decomposed objects produced due to high temperature create offensive odor.

3) Drying process
As in the boiling/ripening process, offensive odor arises in the drying process. Particularly in the case of high-temperature machine drying, odor is generated from volatile organic substances contained in fish bodies or due to odor contents arising out of lowered freshness and oil decomposition.

4) Wastewater and Its Treatment
If wastewater is stored, or if floating particles contained in the wastewater precipitates on the water course, etc., corruption progresses, causing the generation of offensive odor. Ofen-sive odor may sometimes be generated due to aeration in the wastewater treatment process.

5) Fixed plant odor
Volatile fatty acid or volatile carbonyl, characterized by relatively high boiling points, are liable to be deposited if, in a gassified condition, it touches something cold. For this reason, some fixed odor unique to a specific plant is liable to be attached to its walls and ceilings.

4.2.4 Discharge Control Regulations and Trend

(1) Trend of effluent control regulations

In Japan, high economic growth was attained in the 1960s and 1970s after World War II. On the other hand, industrial pollution caused damage on human health and living environments, and destruction of nature due to non-principled development actions occurred in various parts of the country. As a result, the deterioration of environments progressed rapidly.

In December 1958, a law for the control of factory effluent and another law for the protection of the water quality in public water areas were enacted for the first time in Japan. Because these laws — "Industrial Effluent Water Law" and "Water Quality Preservation Law" — were enacted at the same time, they are referred to as the "two former water-quality laws."

Subsequently in the mid-1960s, increased social concerns were directed to water pollution and air contamination, resulting from the high economic growth. Accordingly, the Basic Law for Environmental Pollution Control was enacted in 1967 to curb pollutants, etc., for the principal purpose of preventing pollutions caused by business enterprises.

In the law, pollutions and public nuisances were classified in six categories, i.e. air pollution, water pollution, offensive odor, noise, vibration and ground subsidence (Underground water contamination was added later).

With regard to water pollution, which affects marine products-processing most seriously, the Water Pollution Control Law was instituted in December 1970. Main contents of this law are as follows:

1) It abolished the designated water area-limiting system, provided for in the two old water-quality laws, so total public water areas have come to be covered by the new law.

2) To reinforce observance of effluent standards, it introduced the direct punishment system.

3) While transferring powers to the Metropolitan, Hokkaido and Prefectural Governments, it enables Prefectural Governors to set more rigorous standards (higher additional standards) than national standards based on their own administrative powers.

4) It improved the water quality monitoring/measurement setups for public water areas.

5) It instituted on-site inspection rights for effluent quality monitoring/measurement purposes.

6) It unified arrangements for effluent standard setting and adoption of steps for forcible observance of effluent standards into those based on the Water Pollution Control Law, in principle.

As noted later, the Water Pollution Control Law designates 74 specific facilities in its enforcement ordinance. It also specifies seven items, such as cyanide and hexavalent chromium, as substances that may cause damage to human health (hazardous substances), and 14 items, including pH, BOD, COD and SS, as those that may cause damage related to the living environment (living environment items).

The effluent standards regarding living environment items, which concerns marine products-processing wastewater, is not applied to small-scale business establishments with a drainage volume of less than 50 m^3/day.

Soon after the enforcement of the Water Pollution Control Law, a provisional standard was set for the business sector that was unable to technically observe the effluent standard for a period of five years. This provisional standard was also applied to the marine products-processing industry. The provisional standard is explained later.

Concerning offensive odor, which has a great bearing on marine products-processing, the Offensive Odor Control Law was instituted in June 1971. At that time, restriction was implemented on five substances — ammonia, methyl mercaptan, hydrogen sulfide, methyl sulfide and methyl disulfide. In 1989, seven substances, such as trimethylamine and acetaldehyde, were added as restriction items, and in 1994, ten substances, including toluene, were added. At present, therefore, restriction is imposed on a total of 22 substances.

The Offensive Odor Control Law stipulates the following restriction standard in accordance with offensive odor emission forms and human sensitivity. Unlike the Water Pollution Control Law, it does not implement facilities-specified regulations.

1) Concentration in the on-ground air exactly above the border line of a site
Concentration is set for each substance having an offensive odor, based on odor intensity that can be sensed by man.

2) Concentration of gas emitted from smokestacks and other gaseous outlets
Emission concentration is set for each substance having offensive odor, based on emission gas flow-rate ranks determined by the height of the smokestack, etc.

3) Concentration in effluent at effluent outlets
The regulation of this concentration was instituted through the law amendment in 1994.

A specific concentration level was set for each flow-rate of effluent regarding sulfuric substances, such as hydrogen sulfide.

4) Odor index
This index is set, without specifying substances, for areas where the regulation for each odorous substance is not sufficient to protect the living environment. The index is set for a) air, b) stacks, etc., and c) effluent outlet.

Today, a mood in favor of shifting the viewpoint from pollution control to environmental conservation is heightening. On the occasion of the Earth Summit held in 1992, the Environment Basic Law was instituted in 1993. In accordance with this, the Basic Law for Environmental Pollution Control was abolished.

Under present water pollution control arrangements, it is mainly necessary for business enterprises to take required steps, in order to achieve and maintain the environmental quality standard in accordance with the Basic Environment Plan prepared, based on the Environment Basic Law. This is also the same regarding offensive odor.

As such, the study of resources-saving, energy-saving, water-use rationalization and other countermeasures in the discharge courses of individual pollutants is positioned as a more important environmental step than water pollution/ offensive odor prevention based on effluent/offensive odor treatment technology, which has been stressed thus far.

(2) Current Water Pollution Control Law

(a) Specific facilities

Under the present Water Pollution Control Law, facilities that discharge such an effluent as containing cadmium and other hazardous substances, as well as index items of the living environment, including COD (Mn), are designated as specific facilities, and effluent that is discharged from specific facilities is legally regulated as specified effluent.

In connection with marine products-processing, the following facilities are regulated as specific facilities:

3. Facilities that are provided for use in marine food-manufacturing, which are as shown below:
   a. Marine animal raw-material treatment facilities
   b. Washing facilities

c. Dehydration facilities
d. Filtering facilities
e. Hot-water boiling facilities

11. Facilities that are used for the manufacturing of animal feed or organic fertilizer, which are as follows:
    a. Raw-material treatment facilities
    b. Washing facilities
    c. Pressing facilities
    d. Vacuum enrichment facilities
    e. Washing-type deodorization facilities

12. Facilities that are provided for use in animal/plant oil/fat-manufacturing, which are as follows:
    a. Raw-material treatment facilities
    b. Washing facilities
    c. Pressing facilities
    d. Separation facilities

(b) Uniform effluent standards

The uniform effluent standard is shown in Tables 4-2-8 and 4-2-9.

Principal pollutants contained in marine products-processing wastewater are organic ingredients, and the uniform standard value for them is 160 mg/l (diurnal average 120 mg/l) for BOD and COD (Mn), 200 mg/l (150 mg/l) for SS and 30 mg/l for oil content (normal-hexane extracts).

Concerning the sea area specified by the Director General of the Environment Agency as the area where there is the possibility of great multiplication of maritime plankton, the uniform effluent standards of 120 mg/l (diurnal average 60 mg/l) for nitrogen and 16 mg/l (8 mg/l) for phosphorus are applied.

Table 4-2-8 Uniform Effluent Standard (Hazardous Substances Such as Cadmium <Related to Article 1>) Amended in 1993

Substances	Allowable limits
Cadmium and its compounds	0.1 (mg/L)
Cyanide compounds	1 (mg/L)
Organic phosphorus compounds (limited to parathion, methyl parathion, methyldemeton and EPN)	1 (mg/L)
Lead and its compounds	0.1 (mg/L)
Chromium (VI) compounds	0.5 (mg/L)
Arsenic and its compounds	0.1 (mg/L)
Mercury, arkyl mercury and other mercury compounds	0.005 (mg/L)
Arkyl mercury compounds	Not to be detected.
PCB	0.003 (mg/L)
Trichloroethylene	0.3 (mg/L)
Tetrachloroethylene	0.1 (mg/L)
Dichloromethane	0.2 (mg/L)
Carbon tetrachloride	0.02 (mg/L)
1•2-dichloroethane	0.04 (mg/L)
1•1-dichloroethylene	0.2 (mg/L)
Cis-1•2-dischloroethylene	0.4 (mg/L)
1•1•1-Trichloroethane	3 (mg/L)
1•1•2-trichloroethane	0.06 (mg/L)
1•3-dichloropropene	0.02 (mg/L)
Thiuram	0.06 (mg/L)
Simazin	0.03 (mg/L)
Thibencarb	0.2 (mg/L)
Benzene	0.1 (mg/L)
Selenium and its compounds	0.1 (mg/L)

Table 4-2-9 Uniform Effluent Standard (Living Environment Items) Amended in 1993

Parameters	Allowable limits
pH	Drainage to be discharged to public waters excluding sea areas 5.8 - 8.6 Drainage to be discharged to sea areas 5.0 - 9.0
BOD	160 (diurnal average 120) (mg/L)
COD-Mn	160 (diurnal average 120) (mg/L)
SS	200 (diurnal average 150) (mg/L)
Normal-hezane extracts (mineral oil containment volume)	5 (mg/L)
Normal-hexane extracts (animal/plant oil/fat containment volume)	30 (mg/L)
Phenol content	5 (mg/L)
Copper content	3 (mg/L)
Zinc content	5 (mg/L)
Soluble iron content	10 (mg/L)
Soluble Mn content	10 (mg/L)
Chrome content	2 (mg/L)
Fluoric content	15 (mg/L)
No. of coliform bacilli	Diurnal average 3,000 (bacilli/mL)
Nitric content	120 (diurnal average 60) (mg/L)
Phosphoric content	16 (diurnal average 8) (mg/L)

(c) Provisional standards

For five years from June 24, 1971, when the Water Pollution Control Law was put into effect, the provisional standard — 390-1,800 mg/l for BOD, 260-1,600 mg/l for COD (Mn), 330 mg/l for SS and 70 mg/l for oil content — was applied for various classes of industrial sectors that discharged marine products-processing effluent. The provisional standard for individual business sectors at that time is shown in the table below.

For sea areas specified by the Director General of the Environment Agency as areas that have a possibility of marine plankton multiplication, furthermore, a provisional standard — 140-460 mg/l for nitrogen and 60-340 mg/l for phosphorus — has been applied for five years from Oct. 1, 1993, as shown in the table.

The marine products-processing industry was obligated to promote effluent countermeasures during the period of the tentative standard, so that it can shift to the uniform standard following the end of the period.

Table 4-2-10 Provisional Standard (1) (For five years from June 24, 1971)

Parameters	Business sectors	Allowable limits
BOD (mg/L)	Marine food-manufacturing (excluding marine food can-manufacturing (including marine food bottle/ceramic pot-manufacturing; hereinafter the same), seaweed-processing, fish-meat ham/sausage-manufacturing, marine food paste products-manufacturing, refrigerated marine products-manufacturing and ground raw fish product-manufacturing)	390 (diurnal average 300)
	Marine food can-manufacturing and refrigerated marine product-manufacturing (excluding refrigerated ground fish-manufacturing)	780 up to June 23, 1973 (diurnal average 600) 260 up to June 24, 1973 (diurnal average 200)
	Fish meal feed-manufacturing (including fish soluble-manufacturing)	780 (diurnal average 600)
	Refrigerated ground fish-manufacturing and raw ground fish-manufacturing	1,800 up to June 23, 1973 (diurnal average 1,400) 780 from June 23, 1973 (diurnal average 600)
COD-Mn (mg/L)	Marine food-manufacturing (excluding marine food can-manufacturing, seaweed-manufacturing, agar-agar-manufacturing, fish-meat ham/sausage manufacturing, marine paste products-manufacturing, refrigerated marine products-manufacturing and raw ground fish-manufacturing)	260 (diurnal average 200)
	Marine food can-manufacturing and refrigerated marine product-manufacturing (excluding refrigerated ground fish-manufacturing)	650 up to June 23, 1973 (diurnal average 500) 260 from June 23, 1973 (diurnal average 200)
	Agar-agar-manufacturing	390 (diurnal average 300)
	Fish meal feed-manufacturing (including fish soluble-manufacturing)	780 (diurnal average 600)
	Refrigerated ground fish-manufacturing and raw ground fish-manufacturing	1,600 up to June 23, 1973 (diurnal average 1,200) 780 from June 23, 1973 (diurnal average 600)
SS(mg/L)	Agar-agar-manufacturing, refrigerated marine product-manufacturing, fish meal-manufacturing (including fish soluble-manufacturing)	330 (diurnal average 250)
Normal-hexan extracts (mg/L)	Marine food-manufacturing (excluding agar-agar-manufacturing and seaweed-processing) and fish meal-manufacturing (including fish soluble-manufacturing)	70

Note: Normal-hexane extracts concern animal/plant oil/fat contents.

Table 4-2-11 Provisional Standard (2) (For five years from Oct. 1, 1993)

Parameters	Business sectors and other classifications	Allowable limit
Nitrogen (mg/L)	Seaweed-processing and animal oil/fat-manufacturing	180 (diurnal average 70)
	Fish-meat ham/sausage-manufacturing	260 (diurnal average 130)
	Single-unit feed-manufacturing	320 (diurnal average 160)
	Refrigerated marine product-manufacturing	360 (diurnal average 180)
	Marine food-manufacturing (excluding marine food can/bottle-manufacturing, seaweed-processing, agar-agar-manufacturing, fish-meat ham/sausage-manufacturing, marine food paste-manufacturing, refrigerated marine product-manufacturing and refrigerated marine food-manufacturing)	380 (diurnal average 190)
	Marine food can/bottle-manufacturing	440 (diurnal average 220)
	Marine food paste-manufacturing and refrigerated marine food-manufacturing	460 (diurnal average 230)
Phosphorus (mg/L)	Seaweed-processing	60 (diurnal average 30)
	Marine food can/bottle-manufacturing and animal oil/fat-manufacturing	100 (diurnal average 50)
	Refrigerated marine product-manufacturing	140 (diurnal average 70)
	Fish-meat ham/sausage-manufacturing	160 (diurnal average 80)
	Marine food paste-manufacturing and refrigerated marine food-manufacturing	320 (diurnal average 160)
	Marine food-manufacturing (excluding marine food can/bottle-manufacturing, seaweed-processing, agar-agar-manufacturing, fish-meat ham/sausage-manufacturing, marine food paste-manufacturing, refrigerated marine product-manufacturing and refrigerated marine food-manufacturing)	340 (diurnal average 170)

(d) Areawide total pollutant load control

The areawide pollutant load control system, instituted in fiscal 1979, is designed to make the control of effluent from specific business establishments in the related areaigorous, in order to protect water quality in closed water areas in Tokyo Bay, Ise Bay and the Seto Inland Sea.

Under the system, a process effluent volume to be notified to administrative offices (notification effluent volume) is set for each business sector based on industrial activities, and the amount of emission-permitted pollution load (pollution loading amount) is set for specific COD concentration determined by the Prefectural Governor. Each business establishment is required to report its observance of these permission standards, based on its own load volume measurements.

The areawide pollution load control system has been strengthened three times in the past. It is planned to be strengthened for the fourth time in the near future.

The permissible pollution load volume is calculated as

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

Herein, L: Emission-allowed pollution load volume

C_j, C_i, C_o: Fixed COD concentration (mg/l) to be set by the Prefectural Governor (referred to as the "value of C, etc.") (j, i, o show that they are set based on the year/month/day of the establishment.)

Q_j, Q_i, Q_o: Notified process effluent volumes corresponding to C_j, C_i and C_o

In the third round of areawide total pollutant load control, the following "value of C, etc.," has been applied after April 1, 1994, depending on the date of establishment.

(1) Establishment on June 30, 1980 or earlier: C_o
(2) Establishment between July 1, 1980 and March 31, 1989: C_i
(3) Establishment after April 1, 1989: C_j

The table in the Enforcement Regulation of the Water Pollution Control Law stipulates the scope for the "value of C, etc.," for the marine products-processing, as shown below, and in accordance with the scope, the Prefectural Governor sets a specific value for each business establishment.

Table 4-2-12 Value of C, etc., Related to the Fisheny Processing Industry

Business sectors and other classifications		COD (mg/L)						Remarks
		Co		Ci		Cj		
		Lower limit	Upper limit	Lower limit	Upper limit	Lower limit	Upper limit	
8	Marine food can/bottle-manufacturing	40	80	40	70	30	60	
9	Agar-agar-manufacturing	80	120	80	100	80	100	
10	Fish-meat ham/sausage-manufacturing	30	60	30	60	20	50	
11	Marine food paste product-manufacturing	30	80	30	60	20	50	Regarding the ground fish-manufacturing process C_o shall be set at 40-110, C_i shall be set at 40-80, and C_j at 30-70.
12	Refrigerated marine product-manufacturing	30	70	30	60	20	50	
13	Refrigerated marine food-manufacturing	40	80	40	70	30	60	
14	Marine food-manufacturing (excluding those shown in items 8 to 13)	40	80	40	70	30	60	
30	Plant oil/fat-manufacturing	40	80	40	70	30	60	
31	Animal oil/fat-manufacturing	40	80	40	70	30	60	
48	Single-unit feed-manufacturing	20	100	20	60	20	60	
49	Organic fertilizer-manufacturing	20	70	20	50	20	40	

(3) More stringent prefectural control for water pollution control

Marine products-processing enterprises, in particular those engaged in the primary processing, are largely located in the vicinity of fishing ports, and water areas into which their wastewater is discharged are mainly considered to be almost-enclosed bays and the like. As such, if the capacity of the environment is small, and if high-level regulation is required for water quality conservation, the Prefectural Government may impose more stringent control than the national uniform standards.

Some additional regulations specify public water areas for wastewater discharge and the discharge volume.

Cases of more stringent prefectural control are shown below.

Table 4-2-13 Cases of More Stringent Prefectural Control for Water Pollution Control

Prefecture	Business sector (manufacturing)	Water area	BOD	COD_{Mn}	SS	n-hexane extracts	Remarks (Figures represent per-day discharge volumes.)
Hokkaido	Marine food products	Wakkanai, Monbetsu, Abashiri, Nemuro, Kushiro	1,300 (1,000)				• 20 m^3 - Less than 50 m^3 • Sea areas
	Marine food products	Wakkanai	1,300 (1,000)				• Less than 20 m^3 • Sea areas
	Fish-meal feed (including fish soluble)	Wakkanai	780 (600)				• Less than 50 m^3 • Sea areas
	Fish-meal feed (including fish soluble)	Monbetsu, Abashiri, Nemuro, Kushiro	780 (600)				• 20 m^3 -Less than 50 m^3 • Sea areas
Aomori Prefecture	Refrigerated ground fish and raw ground fish		130 (100)	100 (80)	150 (120)	20	
	Fish-meal feed (including fish soluble) and organic fertilizer		130 (100)	100 (80)	150 (120)		
Miyagi Prefecture	Marine food products, fish-meal feed	Matsushima Bay		130 (100)			10 m^3 or more
Shizuoka Prefecture	Marine food products (excluding fish soluble)	Shita water area	50(40)	50 (40)	70 (50)	30	2,000 m^3 or more
			80 (60)	80 (60)	90 (70)	30	1,000 m^3- Less than 2,000m^3
			120 (90)	120 (90)	120 (100)	30	150 m^3 - Less than 1,000 m^3
			160(120)	160(120)	200(150)	30	50 m^3 - Less than 150 m^3
			390(300)	390(300)	330(250)		Less than 50 m^3
	Organic fertilizer (including fish soluble)	Shita water area	40 (30)	40 (30)	50 (40)	30	1,000 m^3 or more
			80 (60)	80 (60)	90 (70)	30	50 m^3 - Less than 1,000 m^3
			390(300)	390(300)	330(250)		Less than 50 m^3

Note: • Unit: mg/L

• ( ) : Diurnal average

(4) Offensive Odor Control Law

(a) Regulation standards for concentrations at site boundaries

The regulation standards for on-ground aerial concentrations upon site boundaries are set as shown below. Specific standard values are determined within this scope under Prefectural ordinances, etc.

Table 4-2-14 Regulation Standard on Site Boundaries

	Offensive odor substances	Concentration in the air (ppm)
1	Ammonia	1 - 5
2	Methyl mercaptan	0.002 - 0.01
3	Hydrogen sulfide	0.02 - 0.2
4	Methyl fulfide	0.01 - 0.2
5	Methyl disulfide	0.009 - 0.1
6	Trimethylamine	0.005 - 0.07
7	Acetaldehyde	0.05 - 0.5
8	Propionaldehyde	0.05 - 0.5
9	Normal-butylaldehyde	0.009 - 0.08
10	Isobutylaldehyde	0.02 - 0.2
11	Normal-valeraldehyde	0.009 - 0.05
12	Isovaleraldehyde	0.003 - 0.01
13	Isobutanol	0.9 - 20
14	Ethyl acetate	3 - 20
15	Methyl isobutylketone	1 - 6
16	Toluene	10 - 60
17	Styrene	0.4 - 2
18	Xylene	1 - 5
19	Propionic acid	0.03 - 0.2
20	Normal-butyric	0.001 - 0.006
21	Normal-valeric acid	0.0009 - 0.004
22	Iso-valeric acid	0.001 - 0.01

(b) Regulation standards for concentrations at discharge outlets

The regulation standards at discharge outlets for offensive odor substances, excluding methyl mercaptan, methyl sulfide, methyl disulfide, acetaldehyde, styrene, propionic acid, normal-butyric acid, normal-valeric acid and isovaleric acid, are based on the following flow-rate calculation formula. However, this formula shall not be applied if the corrected height of a discharge outlet is less than 5 m.

$q = 0.108 \times H_e^2 \bullet C_m$

Herein,

q: Flow rate (unit: m^3/sec converted into the condition of 0 degree temperature and 1 atmospheric pressure)

H_e: Corrected discharge outlet height (unit: m)

C_m: Regulation standard value for odorous substance (same as the value on site boundaries)

$$H_e = H_0 + 0.65(H_m + H_t)$$

$$H_m = \frac{0.975\sqrt{Q \cdot V}}{1 + \frac{2.58}{V}}$$

$$H_t = 2.01 \times 10^{-3} \cdot Q \cdot (T - 288) \cdot (2.30 \log J + \frac{1}{J} - 1)$$

$$J = \frac{1}{\sqrt{Q \cdot V}} - (1460 - 296 \times \frac{V}{T - 288}) + 1$$

Herein,

H_e: Compensated discharge outlet height (unit: m)

H_o: Height of the discharge outlet (unit: m)

Q: Flow rate of emission gas at a temperature of 15°C (unit: m^3/sec)

V: Emission speed of exhaust gas (unit: m/sec)

T: Temperature of emission gas (unit: absolute temperature)

(c) Regulation standards for concentration in effluents

The regulation standards for methyl mercaptan, hydrogen sulfide, methyl sulfide and methyl disulfide in effluents shall be calculated under the following formula:

$C_{Lm} = KC_m$

Herein,

C_{Lm}: Allowable limit for offensive odor substances in effluent (unit: mg/L)

k: Constant

C_m: Regulation standard value on the site border

The constant k is as shown in the following table:

Table 4-2-15 Value of Constant K

		k	
Name of substance	$Q \leq 10^{-3}$	$10^{-3} < Q \leq 10^{-1}$	$10^{-1} < Q$
Methl mercaptan	16	3.4	0.71
Hydrogen sulfide	5.6	1.2	0.26
Methyl sulfide	32	6.9	1.4
Methyl disulfide	63	14	2.9

Note: Q (m^3/sec)

(d) Regulation standards based on the allowable limit for the odor index

The odor index represents the odor intensity determined by a method based on human olfaction, without specifying the content of the odor.

The measurement method, called the triangular odor bag method, is a method under which a qualified odor judge examines the degree of dilution by which the odor can no longer be sensed, while comparingly smelling a bag that contains the odor sample and two other bags that do not contain it.

For classes (a) - (c) shown above, suitable sample collection methods and odor index calculation methods have been set, to establish corresponding combinations.

4.2.5 Response of Industry and Role of JEC

The marine products-processing industry was hardly conscious of the need for effluent pollution control, because small-scale plants conventionally accounted for a major proportion, because pollutants in effluent were originally organic substances that occurred naturally and because seasonal changes of effluent were substantial. Accordingly, the adoption of pollution countermeasures was delayed. As the institutional arrangement continued for industrial pollution control in the 1970s, however, enterprises in the industry were forced to establish effluent treatment facilities and take appropriate corrective steps.

At first, many marine products-processing plants tried to cope with the matter by externally adding wastewater treatment equipment, based on existing organic wastewater treatment technology, to plant facilities. However, the enforcement of these measures was frequently entrusted in its entirety to wastewater treatment plant manufacturers, and more often schematic designs prepared by plant manufacturers were handed over to construction companies that have no technological experiences, for installment/ construction. In such cases, no study was made of the production process which generate the pollution, nor were the designs worked out with the sufficient consideration to wastewater characteristics or operational conditions; accordingly, these facilities could not display their functions sufficiently.

These problems could never be solved merely by wastewater treatment technology, so a drastic change in problem-solving efforts was necessary. Therefore, the enterprises thoroughly enforced the preliminary treatment or positively recovered substances with residual values for the purposes of eliminating pollutants at points as close to their generation source as possible and reducing the load imposed on wastewater treatment facilities. The state in which these enterprises gradually started undertaking integrated source control measures can be seen in the examples of loan cases (4.2.14).

The Japan Environment Corporation has played a leading role in fund procurement for such activities, as a financial institution. At the same time, it has implemented technologically and methodically advanced pollution control projects, thereby providing models for pollution control activities for private enterprises. Representative cases of "Construction-Transfer Programs" by the Japan Environment Corporation are shown in 4.2.13. Particularly, the case of the Corporation's project in Shiogama since 1967 is a typical example of pioneering activities. Initially, there was such a problem as non-functioning of treatment facilities in this project. As a result of trial-and-error improvement efforts, however, a new plant which attracted much expectation from the marine products-processing industry throughout the nation was completed in 1972, and this plant has long occupied the position of the standard treatment technology for the industry's effluent. The Corporation tackled the manufacturing of fish meal in Shiogama, to develop better measures to treat marine product waste and to deal with offensive odor, and based on related experience, it improved production processes and deodorant mechanisms, establishing plants at various places. Through the joint venture with the Tokyo Metropolitan Government, etc., the Corporation was eventually able to establish the standard for a plant free from offensive odor, to be used subsequently.

Survey and research programs of the Japan Environment Corporation, which recorded remarkable achievements in various fields later, were originally started, mainly to study the methods of improving facilities in Shiogama. After the original purpose was achieved in Shiogama, many survey and research programs were implemented to establish pollution control technologies in previously unprecedented areas and to use such technologies as the basis for the construction of joint pollution control facilities. As seen in 4.2.15, these research programs led to the suggestions that, for appropriate treatment of marine products-processing wastewater and waste, it is necessary not only to technically deal with the wastewater at treatment facilities but also to take overall pollution control measures at source that include the recovery and re-use of resources and improvement of production processes, and that, if the pollutant load for final treatment facility can be limited below a certain level through source control or preliminary treatment, various kinds of biological treatment can effectively function.

These suggestions subsequently served as guidelines for pollution countermeasures to be adopted by the marine products-processing industry.

4.2.6 Basic Policy for Pollution Control and Program

(1) Viewpoint for target-setting

(a) Pollution control

Since the Pollution Control Basic Law was instituted in 1967, this country specified (1) air pollution, (2) water pollution, (3) noise, (4) vibration, (5) offensive odor and (6) ground subsidence (subsequently, (7) underground water contamination was added) as pollution, improving the legal regulation system and promoting technological countermeasures based on close cooperations between governmental and private sectors.

Of the aforementioned pollution, (2) water pollution and (3) offensive odor principally require the enforcement of countermeasures in marine products-processing industry. Particularly because effluent from this industry is organic wastewater containing nutrient salts, such as nitrogen and phosphorus, water pollution control measures are greatly important.

The most essential target in the environmental conservation program is to abide by related legal requirements and to meet the discharge standards, such as water quality standards.

(b) Cleaner production

The effectiveness of the "cleaner production" approach — promotion of energy-saving measures, resources-saving steps and water use rationalization mainly within manufacturing processes — in reducing air and water pollution was stated in 3.3.3. Especially in newly established plants, overall manufacturing costs are remarkably lowered in many cases, by implementing resources-saving and energy-saving countermeasures and pollution load curtailment steps in parallel, from the stage of manufacturing facility planning onward.

The "cleaner production" approach, targeted at the simultaneous attainment of pollution control and resources-saving/production cost curtailment, is even more effective in developing countries, which have to seek sustainable development based on limited resources. In order to make this possible, it is of course a premise to implement sophisticated manufacturing process control and product quality control.

Of marine products-processing industry, manufacturing of non-food items such as oils/fats, fish meal and condensed fish protein utilize guts and bones, which are solid waste discharged from the same fishery. From viewpoint surpassing individual enterprise, these activities can also be considered "cleaner production" in a broader sense.

(c) Environmental management

It is important to combine pollution control under the legal system, and manufacturing process control under the "cleaner production" approach, and to enforce production activities that can coexist with environment preservation. To attain these purposes, management program involving planning, implementation, evaluation and review should be in place in each corporation. Such activities are called environmental management.

(2) Matters to be considered in the formation of pollution control program options

(a) In-process improvement steps

In the marine products-processing industry, development has been made for (1) recovery of guts and their sales as value-retained objects, (2) purchase and utilization of primary processing-finished materials, (3) improvement of washing methods and increase of yield, (4) separation/recovery of high concentration wastewater, such as broth and (5) development of methods for the recovery and re-utilization of seasoning liquid. Steps for such in-process improvement have already been spread in the industry.

It is desirable to enforce these steps, beginning with those possible to be immediately adopted, while giving consideration to the circumstances of individual companies, such as the content of processing activities and existing facilities.

(b) Wastewater treatment

Regarding wastewater treatment measures, the adoption of the unit treatment formula or its combination method is determined based on the condition of wastewater, treatment targets, wastewater treatment costs and sludge disposal methods.

Because the marine products-processing effluent is organic wastewater including protein and oil content, it is basically suitable for biological treatment. At the initial stage in which wastewater treatment technology started to spread, and the provisional standard was applied, however, coagulation treatment that put stress on the removal of oil and protein contents was implemented. This was because more advanced technology was considered to be needed for biological treatment at that time. Due to subsequent technological development and also to the shift to the uniform standard, the method was changed to the biological treatment formula.

Even at present, however, some companies conduct coagulation treatment as preliminary treatment, in order to reduce the load on the biological treatment at the subsequent stage.

(c) Offensive odor control

In the marine products-processing industry, unique odor may arise, depending on the contents of operations. Furthermore, offensive odor is generated if the storage of raw materials is insufficiently controlled or if abandoned guts are left unattended nearby.

It is necessary to maintain the working environment in good conditions and to control odor at its source in consideration of its effect on the surrounding environment. Depending on cases, measures such as the introduction of deodorant technology may even become necessary.

(d) Waste management

In working out efficient waste management, it is necessary to study whether the waste concerned can be sold as value-retained objects or whether it should be disposed of as industrial waste.

If it is disposed of as industrial waste, generally the disposal will be entrusted to specialized subcontractors. It is essential, however, that the generator of the waste take responsibility up to the stage of final disposal, in accordance with legal regulations or procedures regulated by Waste Disposal and Public Cleansing Law, etc.

(3) Setting up of pollution control programs
(a) Grasping of the current status

The necessary thing at the initial stage of plan preparation is to grasp the existing state of the corporation or the factory. Therefore, the present status of operation and the real situation of its effects on the environment should be evaluated to extract points of improvement.

It is vital to grasp the existing condition accurately. If it is grasped incorrectly, there may be cases in which subsequent plans will become meaningless.

(b) Setting of the target

In setting the target, it is desirable to put priority on "cleaner production," approach which aims, to give consideration to the environment and to seek productivity improvement in the entire range of the work.

Regarding steps to improve manufacturing processes, it is rational to implement such steps on the occasion of the renewal of existing facilities. What should be done in this connection is not to follow general principles or earlier cases as they are but to introduce such systems as matching the plant or process concerned. It is important for the person in charge of introducing the principle of "clearer production" to understand the process and method well, to accurately grasp and analyze the prevailing situation in his own plant and to work out reasonable plans.

It is true that, even if a high target is set, it does not necessarily follow that the target can be achieved in a short period of time. However, setting a low-level target will reduce the significance of target-setting. As such, a sense of attainment can be easily obtained if a long-term target is set, and it is raised by stages.

(c) Selection from program options

Together with the extraction of individual control options, such as cleaner production, wastewater treatment technology and odor control measures, conceivable measures should be screened and the step to attain the target should be selected, with consideration of consistency within the entire project or activities.

(d) Evaluation of economic efficiency

It is also important to compare various programs in the light of economy.

However, multi-facet comparison and study are necessary because the steps involve various items, including one-time disbursement expenses, such as installation expenses; continual disbursement items, such as maintenance and control expenses; value-retained objects that allow recovery of expenses; processing whose profit increase can be expected through process improvement; and processing for which certain fund assistance or loan extension system can be utilized.

(e) Decision of program

It is necessary to compile results of aforementioned activities in the form of an environment control program. As mentioned earlier, it is desirable to uphold a long-term target and implement it by stages.

(f) Implementation system

It is also desirable for the environment control program to call for the establishment of necessary organizational structures, such as the implementation and evaluation system.

(4) Monitoring of effect of the program

(a) Evaluation of effect

It is important to evaluate the enforcement status of the environment control program and its effects in the light of the target set.

If the attainment of the target is insufficient, study should be made as to whether the cause is attributable to the implementation system or to the environment control program itself.

To grasp or measure effects of the implementation of the plan, a variety of data, ranging from data in ledgers to automatically measured effluent quality, are required, because they must be closely analyzed. As such, overall evaluation, in addition to the evaluation of individual steps, will become necessary.

Because of a situation in which evaluation at one establishment may be difficult, it is recommendable to utilize organizations such as associations or unions.

(b) Review of the plan

If effects of control programs are insufficient, it will be necessary to review the implementation plan, based on the cause of the insufficient attainment, and to perform the control work to achieve the target. It is desired that the final objective is approached by stages through the repetition of such a series of work.

4.2.7 In-process Improvement Measures

(1) Appropriate layout of manufacturing facilities and improvement of discharge canals

Operations of marine products-processing are extensive, but effluent systems can be generally divided into raw material-receiving facilities; demolishers, cutters and similar facilities; steam-heated boiling and frying equipment and floor cleaning.

Usually, a discharge canal is provided to collect wastewater from these facilities or work processes. However, if facilities are laid in accordance with individual systems, such as manufacturing processes, and discharge canals are formed for individual systems, it will be easier to recover, re-use or separately handle value-retained objects or waste, based on their respective characteristics.

It is necessary to install screens before the entry of wastewater into a discharge canal or in the middle of the canal, to prevent the corruption of effluent or solubilization of protein. As a result of the installation of screens, the reinforcement of the manufacturing process control and the reduction of pollution load will be attained at the same time.

(2) Study of accepted raw materials

If raw materials that include nonfresh substances or foreign matter, such as sand, are brought into a plant, wastewater or waste that is discharged from the preliminary treatment process will increase. On the other hand, if post-primary processing raw materials, such as on-board ground fish or refrigerated marine products, are purchased, it will become possible to reduce pollution load.

First, it is necessary to strictly implement the quality control of accepted raw materials.

In connection with the purchase of primary processing-finished raw materials, it is desirable to adequately compare and study content and quality of operations, as well as the manufacturing cost and the wastewater treatment cost, and take necessary steps, if any.

(3) Improvement of washing methods

(a) Washing raw materials

In the case of washing raw materials, including the thawing of refrigerated raw materials, the reduction of washing water shall be sought by installing several tanks for washing application and implementing multi-stage, counter-flow washing.

(b) Washing manufacturing equipment

Before washing manufacturing equipment, the reduction of pollution load and the improvement of product yield should be sought by recovering residual processed products as much as possible through a rubber spatula, etc., storing them in refrigerated state and utilizing them on the following day.

Further, if steam washing is implemented, sanitary washing with a small volume of water will become possible. On this occasion, products contained in wastewater should be recovered as much as possible, stored in refrigerated conditions and effectively used for other products.

(c) Washing the floor

In washing the floor, the method of flowing water only during washing should be adopted using a hose equipped with a tap at hand.

As for hand-washing, water-saving can be achieved by installing an automatic tap.

(4) Converting waste into resources

(a) Dense wastewater

Because dense wastewater from the steam-heated/boiling process and aged seasoning liquids contain essences, etc., their effective utilization, such as extraction of essences for re-use as seasoning materials or mixture with rice bran for use as feed, is possible.

Although such dense wastewater is little in volume, its pollution load is heavy. Further, means of its effective utilization have been developed. As such, it is desirable to separate and recover essences from such wastewater as much as possible.

(b) Guts

Demolition residues of fish (heads, guts, bones and scales) discharged from the processes of fish demolition and shaping are high-pollution load waste, but because feed/fertilizer enterprise employees regularly recover them every day, their separation from wastewater and separate treatment/disposal are considered to have been attained to a considerable degree thus far.

Placing such demolition residues in tightly closed containers and carefully keeping them in cold/dark places will be effective in preventing the generation of offensive odor or leakage of waste liquids.

In the case of fresh guts, their sales as high-added-value goods, including raw materials for cod-liver oil and "chinmi" (rare tasty foods), may become possible.

(c) Others

Waste oil used for frying is sometimes used as high-added value resources to manufacture soap. It is also effectively utilized as supplementary fuel for waste oil boilers. In the latter case, if it is used jointly with dense wastewater, both wastewater treatment and energy recovery will become possible.

Furthermore, it is desirable to recover thermal energy emitted in the form of steam, warm wind, warm wastewater etc., through heat exchangers or heat pumps.

(5) Rationalization of cooling water utilization

Wastewater that was used as cooling water is discharged without being contaminated, although its temperature is increased. Because it affects the water environment in the discharged area as warm wastewater, it is desirable to study the method of recovering thermal energy through heat exchangers as mentioned earlier, that of circulating the wastewater based on a cooling tower to be introduced and the method of reducing cooling water by installing refrigerators. It is also hoped to rationalize the use of cooling water based on the results of such study.

4.2.8 Wastewater Treatment Techniques

(1) Selection of suitable wastewater treatment technology

(a) Preliminary treatment

Depending on the content of marine products-processing, objects contained in wastewater differ greatly. If processing is started with primary processing, unrecovered objects, such as scales, fish meat pieces, oil and fat discharged from the process of raw fish demolition, as well as dust attached to original seaweed, enter wastewater treatment facilities as impurities. For this reason, it is desirable to install screens and oil/water separation tanks as preliminary treatment equipment.

If bioremediation is implemented, there are cases in which a regulating tank, designed to smooth out the time-series changes of wastewater, is installed.

These preliminary treatment facilities require maintenance and control activities, such as removing screen residues or floating scum and conducting agitation or aeration in the regulating tank to prevent conversion into anaerobiocis.

(b) Removal of oils and fats

Oils and fats, contained in marine products-processing wastewater are liable to coagulate at normal temperature, and they sometimes cause such problems as adhering to walls of discharge canals or wastewater treatment facilities and forming films there or reducing the efficiency of bioremediation. They are also liable to catch meat pieces or protein, to convert into scums and to float, thereby not only preventing smooth wastewater treatment but also generating offensive odor.

(c) Removal of organic contents

As removal technology for organic contents in marine products-processing wastewater, bioremediation is effective. At the initial stage of bioremediation introduction, it was considered difficult to attain stabilized treatment effects, because water temperature was too low in Hokkaido and the Tohoku district, and also because the bulking of activated sludge was liable to occur as wastewater had a high concentration of soluble organic substances.

However, technology to combine bioremediation with coagulation treatment and technology based on biological membranes have been developed, while effluent concentration tends to decline as a result of the spread of "cleaner production." As such, bioremediation is currently considered suitable for the removal of organic substances.

Organic substance removal through bioremediation is based on design conditions, planned for the stage in which nitrification has not yet progressed.

(d) Advanced treatment

Advanced treatment refers to raising treatment effects of bioremediation for the removal of organic substances, or to implementing new process-added treatment in order to obtain higher treatment-water-quality than the uniform effluent standard or to remove COD, nitrogen or phosphorus.

As technologies to add a new treatment process to conventional bioremediation for organic substance removal, coagulation treatment, sand filtration and activated carbon adsorption are generally adopted. In coagulating treatment, colloidal SS can be removed, and phosphorus removal is also possible, if metallic salt coagulants are used. Sand filtration is mainly utilized to supplement coagulating treatment. Activated carbon adsorption, on the other hand, is effective in removing refractory organics (COD) that remain even after bioremediation.

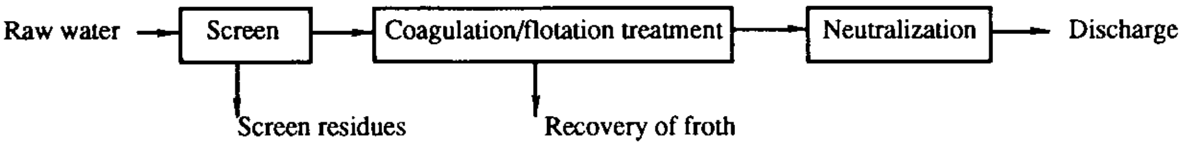
The technologies that have raised the treatment efficiency of bioremediation include technology to remove even nitrogen and phosphorus through bioremediation by combining anaerobic and aerobic treatment steps. Because technological development in this field is progressing at a rapid pace, the introduction of new technologies into marine products-processing effluent is expected to accelerate in the future.

(2) Coagulation treatment

Coagulation treatment of marine products-processing wastewater is mainly aimed at removing oils and fats, as well as protein. To coagulate these substances, operations to lower pH or to add high molecular coagulants to promote coagulation of generated colloidal particles are implemented. Because coagulated substances are prone to float in normal circumstances, the separation on solid bodies and liquids is carried out under the pressure flotation method.

Some of high molecular coagulants have been designated as food additives. If such coagulants are utilized, recovered substances can be effectively utilized as feed, etc.

An example of coagulation treatment is shown below:



(3) Bioremediation for the removal of organics

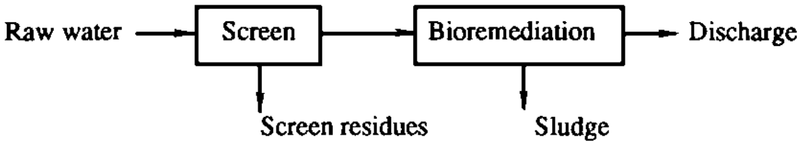
This treatment utilizes the functions of microorganisms to take in organic substances to multiply themselves. In the case of high concentration, the anaerobic treatment may be used, but usually aerobic treatment is utilized.

Depending on whether microorganisms are multiplied in the state of being floated or being attached to a plastic plate, it is called the floating organism process or biofilm process.
A representative treatment method of the former process is the activated sludge method, while a corresponding method of the latter process is the contact oxidation method.

Because microorganisms are utilized, care is required when the water temperature is low, if pH greatly deviates from the neutrality range, if the change of salt concentration due to sea water is considerable or if wastewater load alteration is substantial. Accordingly, in the case of low water temperature, lowered load operation is implemented; as for pH, neutralization is sometimes required; and in the event of load changes, a regulating tank is sometimes utilized. Salt concentration changes are dealt with through sufficient acclimatization.

In the case of treating wastewater containing much soluble organics under the activated sludge method, furthermore, the separation of activated sludge from treatment water sometimes becomes difficult due to the occurrence of bulking. In many cases, it is hard to find a decisive step to deal with bulking, but in some instances the anaerobic-aerobic activated sludge process for removing nitrogen, to be explained later, is effective.

An example of bioremediation flow is shown below:



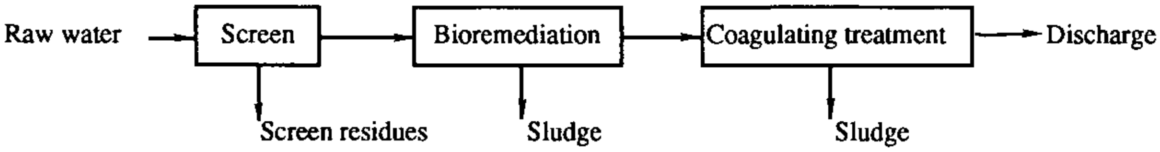
(4) Advanced treatment based on the addition of coagulating treatment process

The coagulating treatment of bioremediation treatment-water is implemented for the purpose of removing residual SS particles or phosphorus. Facilities for the objective are sometimes installed in addition to normal bioremediation facilities at business establishments that are subject to the regulation of nitrogen/phosphorus or to the regulation of total emission.

In many cases, high-molecular coagulating agents are employed to remove SS particles, while metallic salts, such as iron salts or aluminum salts, or slaked lime is used to remove phosphorus. In this case, coagulating sedimentation is usually implemented. Further, the activated sludge process is also adopted for the purpose, and there is also a simplified method to directly put mineral salt coagulants, such as iron salts, into an aeration tank, if the removal of phosphorus is the objective.

If sludge is reduced to farmland as fertilizer, the use of aluminum salts as coagulants will make it difficult for plants to absorb phosphoric acid. Adequate care is required in this regard.

An example of the treatment flow in which coagulating treatment is added to bioremediation is shown below:



(5) Advanced treatment based on bioremediation

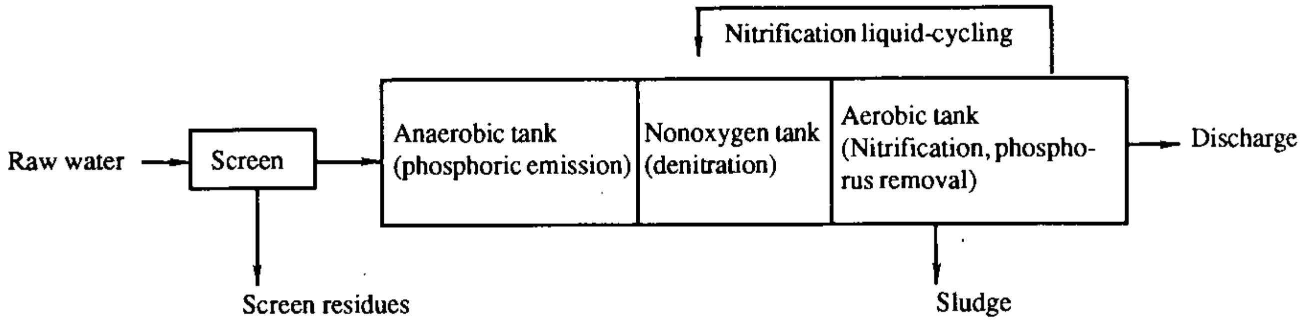
Technology to remove nitrogen and phosphorus, in addition to organic objects, was developed, and its utilization has spread considerably thus far.

Technology to remove nitrogen through bioremediation is referred to as biological nitration denitrification process. Its method is divided into the stage in which nitrogen that is contained in organic substances as amino acid ingredients is converted into ammonia-type nitrogen free from amino acid, and then it is nitrified into nitric acid-type nitrogen, and another stage in which it is converted into nitric gas for nitric removal. The nitrification is implemented under aerobic conditions, so no organic objects are required. However, denitration is carried out under non-oxygen conditions (the condition without any dissolved oxygen), and organic objects are required. Because treatment raw water is used for organic objects for denitration under the recent technology, methods of recycling wastewater that has reached the stage of nitrification into the inflow portion or pouring some portion of raw water into the latter-half section of the reaction tank, where nitrification has progressed considerably, have been developed.

Technology to remove phosphorus through bioremediation is called the biological phosphorus removal process. This process can be divided into a phase in which bacteria effuse phosphoric acid to obtain energy to take in organic substances under the anaerobic conditions, and another phase in which they excessively take in phosphorus to store energy under aerobic conditions. Accordingly, the inflow portion of the reaction tank is made anaerobic, and then aerobic.

Thus, technology to remove nitrogen and phosphorus based on bioremediation is based on the combination of anaerobic and aerobic conditions. Recently, technology to simultaneously remove nitrogen and phosphorus through bioremediation treatment has been developed.

An example of the treatment flow of the anaerobic-nonoxygen-aerobic process is shown below:



(6) Treatment technologies designed for small-scale business establishments

Treatment technologies considered to be easily implemented in small-scale plants include the sequencing batch reactor process and the contact aeration process.

The sequencing batch reactor process calls for conducting each operation of wastewater acceptance, aeration and sedimentation separation sequentially in a single tank.
It features simple operation movement, and it is considered to be able to attain advanced treatment, such as nitrogen removal, depending on the load rate setting or the aeration method.

The contact aeration process is characterized by easy operation movement, non affection by load changes and expectancy of nitrogen removal without special operation, depending on the setting of the load rate.

(7) Combination of unit operation movements

Marine products-processing wastewater treatment is basically suitable for bioremediation. However, operation time differences are sometimes great, and in some cases wastewater abounding in oils and fats is discharged, depending on the season.

For these reasons, it requires preliminary treatment facilities, such as a screen, an oil separator and a flow controlling tank. Also, if wastewater concentration is at a high level, and if oils and facts are contained in large quantities, it is also appropriate to implement bioremediation treatment after enforcing coagulating treatment.

(8) Wastewater treatment cost and a case of its trial calculation

A case of wastewater treatment cost calculation, based on guidelines prepared by the Environment Agency for the removal of nitrogen and phosphorus from wastewater, is shown below (an example of the marine food paste product-manufacturing):

[Preconditions]

i. Treatment technology

Existing technology: Coagulating flotation + Bioremediation
Phosphorus countermeasure: Addition of coagulating sedimentation
Nitrogen countermeasure: Coagulation treatment + Biological nitration denitrification process

ii. Treatment effects

		Raw water quality		Treated water quality		
		Range	Average	Existing technology	Phosphorus countermeasure	Nitrogen countermeasure
BOD	(mg/L)	200 - 5,800	800	50	20	6
COD	(mg/L)	200 - 6,000	600	50	25	30
SS	(mg/L)	400 - 3,700	500	30	10	20
T-N	(mg/L)	- 1,000	150	45	38	18
T-P	(mg/L)	34 - 140	50	12	2	12

[Treatment cost] (Effluent volume: 100 m^3 / day)

		Existing technology	Phosphorus countermeasure	Nitrogen countermeasure
Facilities expenses,	(1000/m^3 x day)	280	599	455
Operation expenses	(¥/m^3)	31	34	227
Sludge treatment expenses	(¥/m^3)	24	27	24

(9) Sludge treatment

Because sludge discharged from wastewater treatment facilities contain much moisture, its handling will be difficult and require much treatment expenses, if it is carried out and disposed of as it is. For this reason, it is a generally adopted practice to dehydrate sludge to the degree that no water will leak out even if the sludge is put on a truck, and then to carry it out.

Sludge dehydration methods are in several kinds, and technological development is in progress. Among such methods, dehydration through a beltpress dehydrator is presumably spreading rapidly, because it allows automatic operation, because it is suitable for excess sludge and because it can be easily introduced into small-scale plants.

Sludge treatment can be implemented without being affected by the operating condition so much as in the case of wastewater treatment, if an appropriate-capacity storage tank is installed.

In the case of small-scale plants, it is sometimes more realistic and practical to carry out sludge by vacuum car rather than implementing sludge treatment.

Dehydrated sludge can be reduced to farmland as fertilizer.

4.2.9 Treatment and Disposal of Waste

(1) Effective utilization as value-retained objects

As explained thus far, waste that is discharged out of the manufacturing processes of the marine products-processing industry can be effectively utilized as various kinds of value-retained objects. Further, sludge that is discharged out of wastewater treatment facilities can be reduced to farmland as fertilizer.

For the effective utilization of waste, however, treatment matching its respective application is enforced. In this connection, enforcement of corruption prevention measures or adjustment with work hours of recovery enterprises, for instance, may become necessary.

(2) Disposal of sludge

Waste that cannot be effectively utilized and solid waste, such as sludge that is generated as a result of wastewater treatment, are defined as industrial waste under the Waste Disposal and Public Cleansing Law (Waste Law).

Industrial waste shall be appropriately disposed of by enterprises on their own responsibility, in principle.

In implementing the treatment and disposal of industrial waste, enterprises concerned are obligated to enforce them in accordance with legally-determined technological standards, designed to prevent the leakage of hazardous objects to the environment, and also to indicate their law-adhering enforcement of the treatment/disposal.

However, it is generally difficult for enterprises to implement the treatment/disposal by themselves; therefore, it becomes necessary to entrust the work to specialized businesses. In this case, it is essential to confirm beforehand that the specialized enterprise to be entrusted with the work has legally obtained the licenses of industrial waste collection/transport business and industrial waste disposal business in connection with the handling of industrial waste.

It is also essential to properly manage manifests that verify that treatment and disposal were implemented in the appropriate manner. Manifests are to be stored by three parties — discharge enterprises, collection/transport businesses and disposal enterprises, and discharge enterprises are to keep two kinds of manifests — the forwarding slip and the slip that verifies the final disposal of the waste. The number of slips for the single industrial waste is four.

The final disposal methods are of two kinds: Landfill disposal and ocean disposal. As a result of the amendment of the London Convention, however, it has become virtually impossible to enforce ocean disposal in the future.

Landfill disposal sites can be divided into the least controlled, controlled, and strictly controlled ones, and disposal values are distributed among these three types depending on the kinds of waste. However, it has recently become difficult to secure disposal sites, partly because past environmental protection measures regarding the disposal of industrial waste were inadequate, so that the trust of residents could hardly be obtained. Currently, the construction of a disposal site requires government permission, and before the start of its use, undergoing inspection is obligated.

The Japan Environment Corporation has newly started projects related to the construction and transfer of final disposal sites.

4.2.10 Control of Offensive Odor

Generation sources of offensive odor in marine products-processing industry can be grouped into two: Insufficient control of waste, such as raw materials and guts, and the manufacturing processes themselves, such as the steam-heated boiling and heat treatment.

With regard to offensive odor countermeasures of the industry, there are countermeasures for manufacturing processes and other generation sources, and countermeasures mainly based on treatment technology. In connection with the former, steps to improve storage places are required to prevent the dispersion of corruption and offensive odor.

(1) Measures for generation sources of offensive odor

Measures for generation sources of offensive order for principal business sectors of the marine products-processing industry are as follows:

1) Ground fish-manufacturing

Objects that require odor countermeasures are scum and sludge from waste/wastewater treatment facilities. These are liable to corrupt at places whose temperature easily rises or sunny places, and to emit offensive odor.

The principal measures to prevent offensive odor are to put these objects in tightly-closed containers, to get specialized collection/transport enterprises to carry these objects out of the plant as soon as possible and to thereby shorten their storage period at the plant as much as possible.

2) Paste product plants/manufacturing enterprises

In plants engaged in the production of paste products, such as steamed/boiled fish paste (kamaboko), fried kamaboko, toasted/boiled fish paste (yaki chikuwa) and fish-meat ham/sausage products, offensive odor is generated in steaming, roasting and frying processes. Becausethe materials were exposed to water several times in the grounding process, volatile base substances that emit offensive order, such as amines, and volatile fatty acid are extremely little. No major problems are expected to occur, therefore, if attention is paid to air outlets used for ventilation or to aging of oil.

3) Dried bonito/mackerel-manufacturing

With regard to odor from waste or wastewater treatment facilities, the same countermeasures as those for ground fish-manufacturing can apply. Other major odor generation sources are the boiling/ripening process and roasting/drying process. Concerning odor from the boiling/ripening process, if a ventilating fan is installed on a wall, for instance, odor will be blown to adjacent or neighboring houses; accordingly, it is desired to discharge air from the ceiling. Odor from the roasting/drying process is discharged through a stack, together with smoke. Adequate consideration should be given to the wind direction and the falling location of odor in this regard.

4) Salted and dried products-manufacturing

Principal odor generation processes are the drying process in the case of manufacturing dried products, and the boiling/ripening process and drying process for manufacturing boiled and dried products. The chief countermeasure for them is to effect ventilation while giving sufficient consideration to the air outlet.

5) Seasoned/processed food-manufacturing

In manufacturing marine food boiled down in soy (tsukudani) or strange, tasty foods (chinmi), odor is generated from the processes of boiling/ripening, drying, roasting and smoking/drying. The main countermeasure is to effect ventilation while giving consideration to air outlets.

6) Marine can-manufacturing

Concerning odor from the waste or wastewater treatment processes, the same countermeasures as those for ground fish odor apply. The principal measure for odor from the boiling/ripening process and the eel/saury-broiling process is to effect ventilation while giving attention to air outlets, as in the case of other business sectors.

7) Wastewater treatment facilities

As indicated in the section of ground fish- manufacturing, scum or sludge discharged from wastewater treatment facilities is accompanied by odor in many cases. In particular, scum from the preliminary treatment process, screen residues, oil/water separation residues and scum from pressure flotation treatment is characterized by enormously offensive odor. They must be carried out as promptly as possible. In some cases, furthermore, deodorant facilities may become necessary.

8) If it is difficult for technological or economical reasons to cope with odor at individual plants, it may be one approach to unify their wastewater treatment systems, for better arrangements.

(2) Deodorization technologies

Deodorization technologies for treatment of offensive odor can be classified as follows, in accordance with principles used as the base:

Fig. 4-2-16 Classification of Deodorant Technologies

- Physical methods
  - Washing process — Washing the object concerned with water and removing odor by dissolving it.
  - Adsorption process — Effecting adsorption and removal, using activated carbon, zeolite and other objects with high-gas adsorption capacity.
  - Cooling and condensation process — Removing odorous objects by cooling and condensing them.
  - Diluting process — Diffusing the odorous gas into the air and diluting the odor.
- Chemical methods
  - Pharmaceutical liquid absorption process
    - Oxidation absorption process
      - Gas phase oxidation process: Decomposing odor, using ozone, chloric gas, etc.
      - Liquid phase oxidation process: Decomposing odor, using pharmaceutical liquids, such as sodium hypochlorite.
    - Acid/alkali absorption process — Pharmaceutically dissolving odor based on acid or alkali, making the odor change chemically and removing it.
  - Chemical adsorption process — Removing odor by adsorbing it with ion exchange resin or gas adsorption agents.
  - Combustion process
    - Direct combustion process — Making combustion decomposition of odor, using a high temperature of more than 800°C.
    - Indirect combustion process — If the combustible content is little, achieving combustion decomposition at a low temperature, using platinum or vanasium as a catalyst.
  - Neutralization process — Masking process — Covering up offensive odor using the masking agent, etc.

- Biological methods
  - Soil adsorption process — Decomposing and removing odorous content based on the biochemical activities of soil bacteria.
  - Biological deodorization process — Based on a reaction tower filled with bacteria-fixed carriers, decomposing and removing odorous content biochemically.
  - Enzymatic process — Decomposing and removing odorous content using enzymatic agents.

As technologies to remove offensive odor from marine products-processing, pharmaceutical liquid absorption process and the activated carbon adsorption process are suitable.

Of various marine products-processing operations, the sector that requires offensive odor countermeasures to the utmost extent is fish meal-manufacturing. In this sector, it is a generally-adopted practice to subject odor from cookers, etc., to dehumidification and heat exchanges, and then to treat the odor under the direct combustion process. For direct combustion, there are two methods: The method to use a specialized furnace and the other to utilize a boiler, etc.

An example of deodorant-facility effects in a fish meal manufacturing plant, where offensive odor content is washed with water, and boiler-used combustion treatment is implemented subsequently, is shown below:

Table 4-2-17 Case of Deodorant Effects in a Fish Meal Plant

	Volatile base (ppm)	Hydrogen sulfide (ppm)	Mercaptan (ppm)
Primary odor	350	18	24
After washing with water	20 - 75	Tr.	5 - 10
After direct combustion treatment	0	0	0

4.2.11 Operation of Wastewater Treatment Facilities

(1) Matching the treatment capacity of wastewater treatment facilities and effluent

The operation content, scale and pharmaceuticals of wastewater treatment facilities adopted or planned at the time of their installation sometimes change in accordance with alteration of times or changes in the requirement of product quality. It is possible that, as a result, projected volume, planned water quality and changed composition of effluent after such alteration sometimes surpass the capacity of wastewater treatment facilities or the application range of treatment technologies concerned.

If the drainage volume increases as a result of business development, and wastewater treatment capacity becomes short of, enlargement or remodeling of treatment facilities will become necessary.

It is necessary to review the state of matching of wastewater treatment facilities' capacity and effluent after the lapse of a certain period of time, after seasonal changes of operations or upon the alteration of manufacturing items/methods. At that time, it is also important, in connection with the analysis of wastewater quality, to give consideration to the execution of testing regarding soluble contents and nitrogen in various forms and phosphorus, so that changes in ingredients of wastewater can be easily grasped.

(2) Arrangement and maintenance/inspection of wastewater treatment facilities

It is necessary to keep conducting maintenance and inspection to confirm that wastewater treatment facilities are operating smoothly and to check if some problems have occurred. In this process, maintenance and inspection work can be implemented surely and easily, if it is possible to make a round of the wastewater treatment facilities in the order of the treatment flow.

It is considered that wastewater treatment facilities are frequently installed in a limited site area. Because circulating maintenance and inspection work, in addition to the data-checking of automatic control equipment and water-quality monitoring equipment, is important, adequate thought should be given to the arrangement of wastewater treatment facilities.

(3) Unit operation functions of various wastewater treatment facilities

Wastewater treatment operations are sometimes composed of manipulation of a screen, oil/fat separation equipment and other preliminary treatment units, as well as unit operations such as coagulating sedimentation and biological treatment. If related constituent treatment functions are incomplete, excellent effluent quality that meets the standard cannot be obtained.

Causes of such incompleteness may be, as stated earlier, the volume or water quality that surpasses the treatment capacity range of effluent treatment facilities. In these cases, the study of operation control, including the work content of the manufacturing process, is required.

Other causes include inability to perform the intended functions despite the matching of treatment technologies, because there are defects in the structure or specifications of treatment facilities. In the case of a reaction tank designed for coagulating reaction, for instance, the shape of the tank, agitating method, agitating capacity, the flow of wastewater and the spot of pharmaceutical liquid injection affect treatment effects.

In conducting wastewater treatment effect testing, it is important to check the functions of unit treatment devices, in addition to examining operation control. If there are defects in equipment, the problems may be solved through relatively slight improvement, so it is necessary to take corrective measures promptly.

(4) Maintenance control of sensors

Sensors used for monitoring and automatic control of wastewater treatment facilities, such as the pH meter, ORP meter and water level gauge, are liable to show erroneous values, if oil content or scum in the wastewater adheres to such sensors.

Regular cleaning, calibration and functional checking of meter-indicated values are necessary. It is important to record such results in daily operational-control record books to continually utilize the results in operational control.

(5) COD, BOD, phosphorus and nitrogen countermeasures

In some plants discharging wastewater to closed water areas, such as lakes, bonds and nearly-closed bays, countermeasures for COD, BOD, phosphorus or nitrogen may be required. In such cases, bioremediation primarily designed for removing conventional organics cannot be expected to have sufficient treatment effects. Therefore, adoption of the method of combining the conventional process with coagulating treatment or bioremediation characterized by advanced treatment functions will be necessary.

If there is some room in bioremediation facilities, due to effects of water-use rationalization or load curtailment steps within the process, it may become possible to improve nitrogen or phosphorus removal effects, depending on the operation method.

(6) Simple analysis of wastewater and treatment water

In order to surely enforce wastewater treatment, it is important to conduct water-quality tests of wastewater from each process, treated water, discharged water and post-treatment water after the operation of each treatment unit, depending on cases, and to grasp the real state of treatment effects.

The method of analyzing the water quality of effluent is legally set by the notice of the Environment Agency or Japanese Industrial Standards (JIS). If data obligated to be reported are to be collected, it is necessary to follow this method or to entrust the work to an analysis organization engaged in environment measurement work.
Generally, however, this will require considerable labor and expenses.

For water-quality testing to be implemented as part of the operation control of wastewater treatment, it is important to promptly obtain results and to frequently carry out testing. In some cases, therefore, it may be more desirable to implement it in a simplified manner. In this case, it is recommended that correlations between the simplified and formal analysis methods be checked.

In bioremediation, changes in the treatment state are slow, and it is significant in the control of wastewater treatment to record water-quality alteration in daily processes and to grasp the trends of changes.

(7) Improvement of control records regarding wastewater treatment equipment

Wastewater treatment is implemented for the purpose of observing the legally-stipulated effluent standard.

It is important to systematically record and control actually-exerted efforts, treatment effects, electric power and expense achievements in the form of daily and monthly control reports on the operation control status of wastewater treatment equipment, maintenance and inspection, utilized pharmaceuticals and power volume.

Further, it is significant to sort out and analyze such results based on their relations with the kinds of products, treatment volume and the processing work of pharmaceuticals used.

Through such work, it becomes possible to clarify the wastewater treatment cost regarding marine products-processing. This enables the enforcement and control of steps for the realization of cleaner production, based on energy-saving, resources-saving and manufacturing cost rationalization.

(8) Securing spare parts of wastewater treatment equipment

It is essential to always secure and keep basic parts and spare components of wastewater treatment equipment.

In particular, automatic control sensors and their components, including electrodes of pH meters, are precise and liable to break down. In some cases, they are erroneously damaged even during earnest maintenance and inspection work, such as cleaning. Also, there are parts that protect the equipment proper through their breakdown, such as fuses and thermal switches.

As is stated in operation manuals for various kinds of equipment, it is important to check daily operating records and secure spare parts for portions that frequently wear out or break down. It is also necessary to pay attention to the durable period and storage methods of parts.

4.2.12 Benefits from Pollution Control Activities

It is a rigorous fact that pollution control necessitate investment. However, the enforcement of pollution control measures may be accompanied by various secondary benefits. These benefits contribute to future corporate management directly and indirectly, so if this is taken into account, pollution control expenses can never be considered "waste of money" that is meaningless in terms of corporate management.

For instance, the enforcement of environment control steps that put emphasis on cleaner production makes it possible to streamline raw material usage and to convert waste into value-retained objects. Further, its resultant reduction of technological and economic burden required for wastewater and waste treatment contributes to production cost curtailment and product quality improvement, in addition to environmental conservation.

In addition, the reduction of adverse effects on the external environment based on these steps, together with active publicity of such efforts help maintain excellent corporate image and lead to the improvement of corporate status. Now that the concepts of ecological investments and greenery procurement are spreading, these contributions are expected to work favorably in the realms of securing investments, selling products and enlisting staff members.

Representative benefits are as follows:

1) Benefits due to cleaner production
   - Quality stability and improvement, resulting from technological control
   - Improvement of yield
     Raising yield through the curtailment of raw material and product loss
   - Production of value-retained objects as by-products
     Turning what previously was waste into value-retained objects or reducing treatment/disposal costs

- Rationalization of water usage
  Saving water costs and wastewater treatment expenses
- Energy-saving
  Recovering energy from discharged heat, warm wastewater and high calorie waste
- Reduction of pollution load on wastewater treatment
  Not only reducing pollution objects to be treated but also diminishing those difficult to treat
- Reduction of waste treatment
  Decreasing surplus sludge from wastewater treatment, as well as other waste
- Improvement of economy
  Virtually leading to the improvement of economy even if expenses for equipment buildup and labor requirement for cleaner production are taken into account

2) Benefits from wastewater treatment
  - Water quality maintenance in wastewater-discharged water areas
  - Curtailment of offensive odor generation
  - Control and extermination of hazardous insects

3) Benefits from deodorization measures
  - Conservation of the work environment
  - Prevention and control of offensive odor around plants

4.2.13 Construction and Transfer Programs by JEC

Industrial pollution control projects of the Japan Environment Corporation for the benefits of small and medium-sized enterprises include the following:

1) Construction of joint pollution prevention facilities, such as wastewater treatment facilities to be jointly used by enterprises

2) Preparation of plant sites and construction of buildings for the transfer of pollution-responsible urban facilities in densely populated sections to areas having no possibilities of pollution

In the case of small and medium-sized enterprises having little experience of pollution and small self-governing entities, the construction and improvement of pollution control facilities by themselves are often difficult not only due to the lack of necessary funds but also because of technological competence required. In such cases, if enterprises jointly undertake pollution countermeasures, the Japan Environment Corporation constructs pollution control facilities on behalf of these enterprises, and transfer completed facilities to them. Expenses required in the construction are to be repaid in 10 to 20 years. In many cases, construction/transfer projects are based on good offices of the self-governing bodies in charge of environmental administration in related areas.

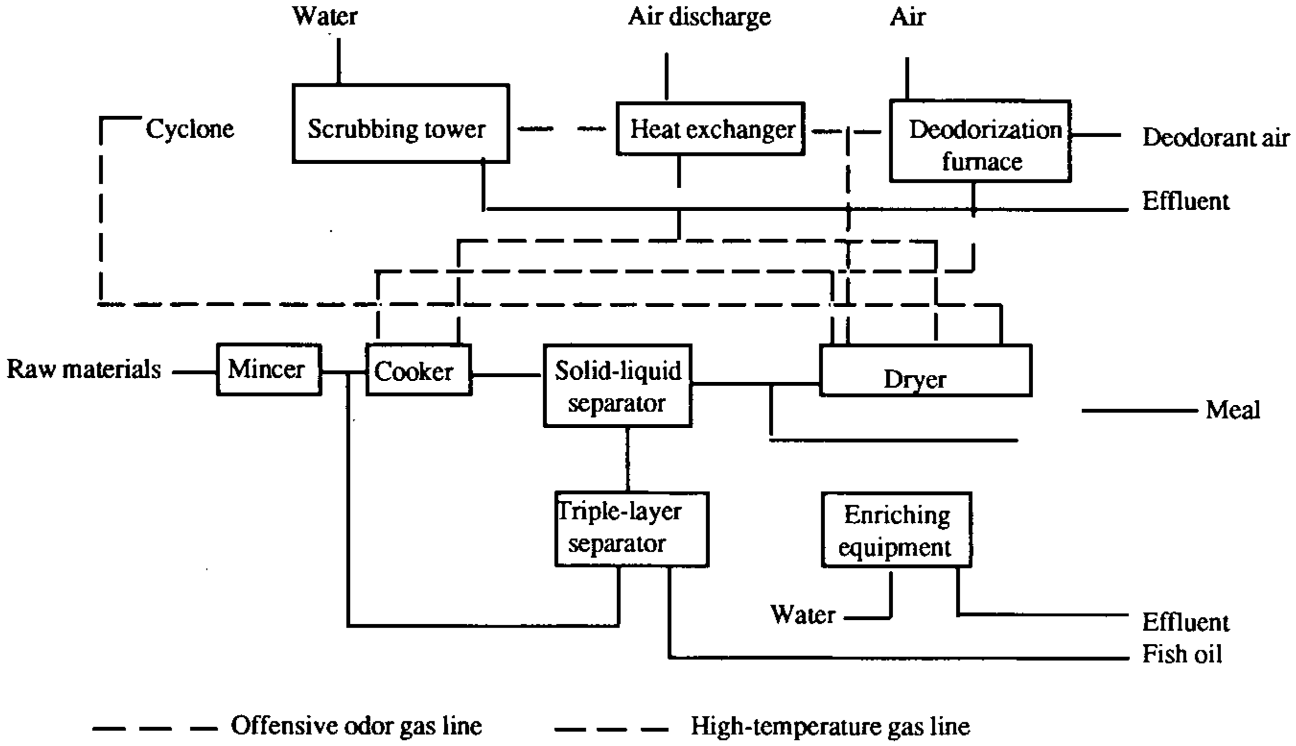
Concerning pollution countermeasures to be taken by the marine products-processing industry, drastic plant remodeling, such as the installation of wastewater treatment facilities and incorporation of deodorization equipment in production facilities, is required in many cases. Under all of its projects for the marine products-processing industry, therefore, the Corporation implemented (1) and (2) above at the same time.

In 1967, the Corporation started the construction of an industrial housing complex for marine products-manufacturing plants and joint wastewater treatment facilities for pollution control in the city of Shiogama, a representative fishing and marine products-processing base in Japan. Because full-scale treatment of marine products-processing wastewater was the first attempt in Japan, the Corporation was faced by various problems. However, the process of its technological development made great contributions to the progress of treating technologies regarding marine products-processing wastewater. The joint wastewater treatment facilities in the Shiogama industrial housing complex for marine products-processing plants are described in Detailed Case Explanation (1) below.

Out of fish residues (guts, bones) stemming from marine products-processing, fish meal or fish oil can be manufactured at residue treatment plants. However, offensive odor pollution also poses serious problems. In the case of Shiogama, offensive odor countermeasures were taken, but their effects were not complete.

In 1969, the Corporation established a treatment plant for urban fish residues (fish/guts/bones treatment grounds; treatment volume 100 tons/day), stemming from fish markets and fish stores, at the request of the Tokyo Metropolitan Government. The construction of this plant was Japan's first project designed to cope with offensive odor. The deodorization mechanism is based on the washing/combustion method, and the completely-sealed production machinery and a deodorization mechanism incorporated in the production machinery could be termed an excellent example of "cleaner production." The production system was installed based on fish meal production machine technology in Northern Europe, where the technology had a long history and was advanced. This "production system, based on the premise of pollution control," was unprecedented at that time, and for that reason there were not a few problems. However, the process for their solution provided valuable actual-research opportunities for the study of odor by the Tokyo Metropolitan Government and other organizations throughout Japan. As such, it not only made great contributions toward the development of residue treatment and deodorization technologies but also served as a basis for subsequent facilities planning of the same kind.

[Manufacturing Process and Deodorization Process]



[Deodorization Mechanism]

The heat source of the cooker and dryer is high-temperature gas at about 400°C, generated in a deodorization furnace. To reduce the generation volume of offensive odor gas, indirect heating is implemented. Equipment is completely sealed to prevent the leakage of malodor gas, and such gas that generated from the cooker or dryer is collected at one place.

In deodorizing the offensive gas line, water-soluble malodor contents, such as ammonia and trimethylamine, are removed by taking out meal powder that has entered the malodor gas, through a cyclone, and washing meal powder in a scrubbing tower, while moisture is removed from the offensive odor gas. Next, in the heat exchanger, this gas is heated with another gas that had been heated in the cooker or dryer (150 - 200°C). It is then recycled as a ventilation gas for the dryer, and part of the recycled malodor gas is also employed as a secondary combustion-use air for the deodorization furnace; by combusting this gas at about 1,200 - 1,500°C for one second, offensive odor substances, such as hydrogen sulfide, mercaptan, indole and fat, are decomposed.

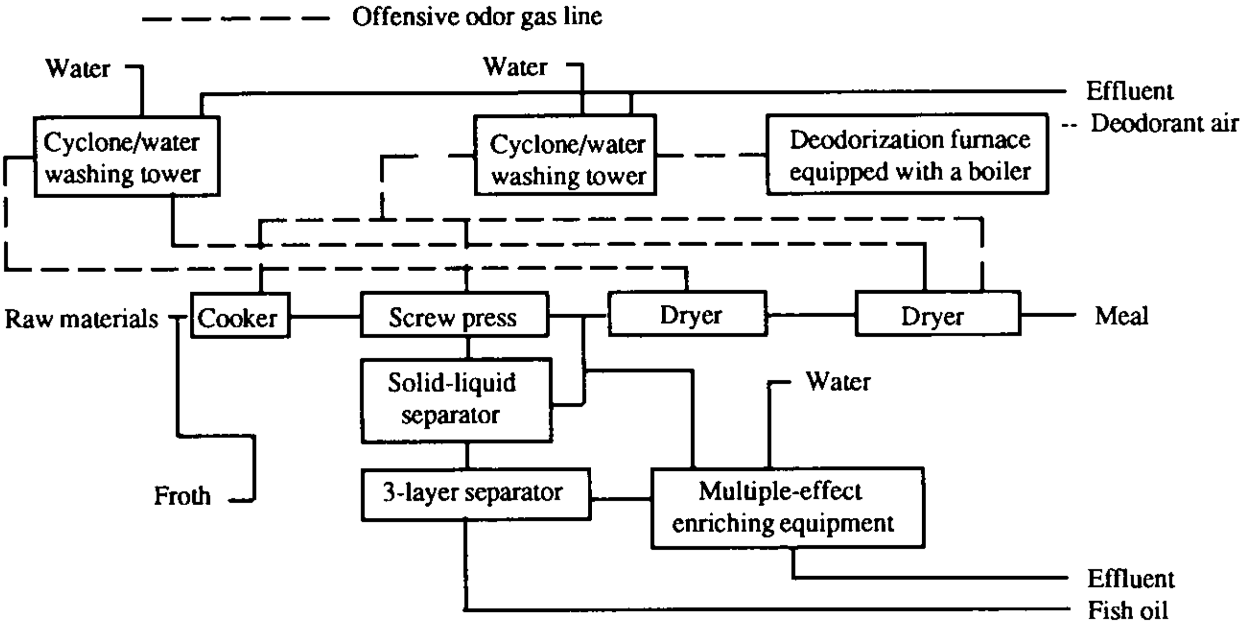
The high-temperature gas, generated at the deodorization furnace, is used as heat source for the cooker and dryer, so that no excess energy is consumed for deodorization.

Generally, most malodor substances are decomposed at about 750 - 800°C. In this system, the temperature can always be maintained at more than 1,000°C, by using a small deodorization furnace. Therefore, offensive odor substances can be decomposed instantly.

Concerning wastewater, because its discharge into public sewer networks is possible, it is not treated but discharged into the sewer system.

Because deodorizing functions of the washing/combustion method were technologically confirmed, the Corporation founded a joint fish guts/bone treatment plant, in which the deodorizing mechanism was incorporated in its production machinery, in principal fishing port bases, such as Kushiro, Nagasaki, Hakodate and Otaru, thereby seeking the establishment and spread of the universal technology.

Kushiro Joint Fish Guts/Bone Treatment Plant (Kushiro High Meal) (Raw material treatment volume: 600 tons/day. Completed in 1972)
[Manufacturing Process and Deodorization Process]

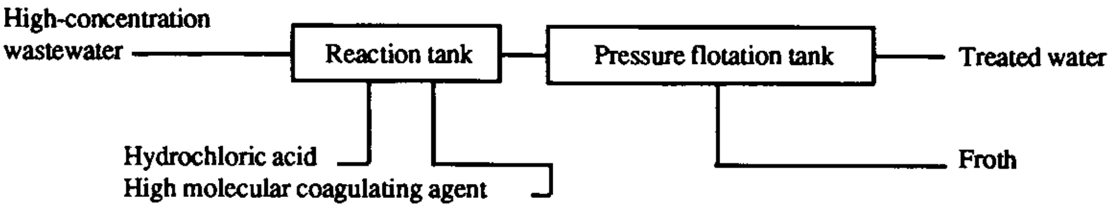


With equipment completely sealed, offensive gas leakage is prevented. Water-soluble malodorous content of offensive odor gas that generated from the cooker and dryer is removed in the water-washing tower, with dehumidification and bulk reduction implemented at the same time. Subsequently, the gas is heated to about 800°C in the deodorization furnace to oxidize and decompose remaining malodorous content.

The deodorization furnace body should be designed to be so long that much time is necessary for the high-temperature combustion of offensive gas. In the later stage of the furnace, a steam boiler is installed to recover heat, which is subsequently used as the thermal source for the cooker and dryer. Water used in the water-washing tower and water utilized for vacuum enrichment application are discharged without treatment, because their contamination concentration is below the discharge standard.

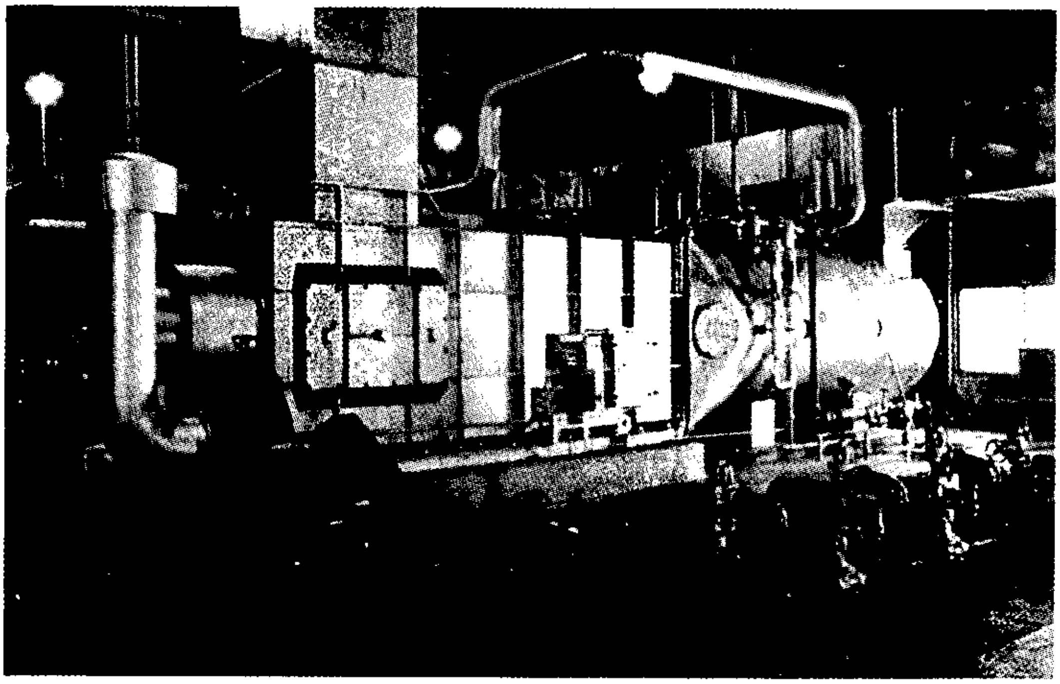
High-concentration wastewater, which was generated by washing machines, is subject to the following wastewater treatment. Froth that is generated here is recovered as the raw material for meal through the use of nonhazardous coagulating agents for foods. Related wastewater is discharged after being mixed with other wastewater. The wastewater treatment volume is 90 m^3/day.

[Wastewater Treatment Flowchart]



	Raw water concentration ppm	Treated water concentration ppm
BOD	12,000	2,000
SS	6,000	300
Oil content	8,000	50

Photo 4-2-18 Specialized Malodor Combustion Furnace in the Kushiro Joint Fish Guts/ Bone Treatment Plant



In 1976, effluent control was reinforced through new legislation. Small and medium-sized enterprises, however, were not sure about technological steps to deal with the stricter regulation, and they were not certain whether they could endure the increased economic burden.

The Hakodate Joint Marine Products-Processing Treatment/Joint Utilization Plant was planned to serve as model facilities to be referred to by small and medium-sized enterprises in the Hakodate area in dealing with the stricter legal regulation. At the time when the establish ment of marine products-processing technology was hoped for, the plant provided many technological knowledge to not only marine products-processing companies but local governments and wastewater treatment manufacturers as well. The plant is expounded in Detailed Case Explanation (2) below.

In the following cases, money figures are indicated in nominal values during the project enforcement. If they are to be converted into present values, refer to the separate table shown at the end of this publication.

Detailed Case Explanation (1) Joint Wastewater Treatment Facilities in the Shiogama Industrial Complex for Marine Products-Processing (in 1968, 1972 and 1974)

"Japan's First Treatment Facilities for Marine Products-Processing Wastewater"

Background for the Construction of Facilities

The Shiogama Port in Miyagi Prefecture is located at 38°N. Lat. Since old times, it has developed as a key port in maritime traffic. The port has also developed as an important fishery base, and there have been many small and medium-sized marine products-processing enterprises in the city of Shiogama. In particular, Shiogama is the greatest production site of marine food paste products, represented by boiled food paste (kamaboko), in Japan. Thus, marine products-processing is the principal industry in the city.

Meanwhile, the Matsushima Bay, on whose coast the city of Shiogama is situated, is an excellent sight-seeing place abounding in many beautiful islands. It is one of the few, most famous tourist spots in Japan.

Along with Japan's high economic growth since the second half of the 1950s, fishing techniques and marine products-processing technologies attained an impressive development, causing sharp growth in Japan's total haul. In accordance with this, marine products-processing enterprises prosperedgreatly, but at the same time, water contamination in the bay due to plant effluent deteriorated rapidly.

Within the bay, oyster cultivation has been implemented in its shallow waters. In intra-bay sections where contamination became serious, oyster cultivation was replaced with laver culture, but because red tides frequently occurred in summer, laver culture was also damaged. Furthermore, water quality deterioration in the Matsushima Bay has seriously undermined the value of tourist resources in the Bay, thereby posing a major social problem.

Outline of the Project

The Shiogama municipal authorities considered that, if the solution of the water contamination issue and the development of the marine products-processing were to be attained at the same time, the location and conditions of marine products-processing businesses, which had developed in a disorderly manner, must be rectified. Thus, the authorities planned to relocate these businesses to a new place — a new industrial housing complex.

After obtaining the cooperation of the Miyagi Prefectural Government, the Shiogama Municipal Government decided to reclaim part of the Matsushima Bay to secure the land for the industrial housing complex. With a view to promoting plant relocation, further, the Municipal Government established a pollution control ordinance in 1965 ahead of the central government, beginning the control of effluent.

In order to smoothly promote plant relocation, the Municipal Government arranged the formation of a cooperative association, aimed at plant relocation and management/control, by marine products-processing enterprises within the city (The Shiogama Industrial Housing Complex-Located Marine Products-Processing Cooperative Association). The Municipal Government specifically projected two-phase plant relocation and worked out plans for each phase.

The first-phase plan called for constructing a joint utilization plant equipped with complete treatment facilities, to be directly managed by the cooperative association in a 1.5-hectare site. Many small enterprises with weak financial bases were to utilize this plant under the plan.

In its second-phase plan, the Municipal Government envisioned the development of a 12-hectare tract for industrial site application and individual relocation of plants by enterprises. Effluent that would come out of individual plants were to be treated in joint treatment facilities to be established subsequently.

The Municipal Government intended to relocate most marine products-processing plants in the city, to arrange for new development of the marine products-processing industry there and to solve the water contamination issue simultaneously under these plans.

The Japan Environment Corporation's Enforcement of Business Activities

It was agreed that these relocation plans be implemented based on (1) construction of joint utilization plants, (2) establishment of joint pollution control facilities and (3) development of plant relocation sites, all by the Japan Environment Corporation, in line with the entrustment by the Shiogama Municipal Government, and also based on (4) the Corporation's extension of loans, necessary for the establishment of joint pollution control facilities.

The first-phase relocation plan called for the Corporation to construct all facilities and to assign them to the municipality, and for the Municipal Government to lend these facilities to the

Shiogama Industrial Housing Complex-Located Marine Products-Processing Cooperative Association. The reason for the Municipal Government's intermediation, instead of the direct assignment of the facilities to relocating enterprises, was that, if assignment agreements are directly concluded between the Corporation and enterprises, such enterprises were expected to be limited to powerful ones that have the ability to repay loans; this would lead to the situation in which only a limited number of enterprises would move to the complex industrial site. Should small enterprises remain in the urban area of the city, city administrators' plan for the control of fish-processing pollution and environmental improvement in the urban area might not be achieved.

Construction of Facilities (1968)

The Japan Environment Corporation undertook the enforcement of the first relocation project for 70 small-sized enterprises and constructed the following facilities:

1) The first processing plant to be utilized by primary processing enterprises that will demolish fish bodies (raw fish treatment volume: 320 tons/day)

2) Fish-grinding plant to be directly managed by the cooperative association (production volume: 15 tons/day)

3) Refrigeration storage to keep processing-use raw materials and products

4) Fish residue treatment plant, designed to manufacture feed and fish oil, using fish residues (guts, bones) (treatment volume: 9.5 tons/hour)

5) Joint wastewater treatment facilities to treat effluent that will be discharged from the aforementioned plants (treatment volume: 680 m^3/day)

With regard to the treatment method for the joint wastewater treatment facilities, the Corporation adopted the sequencing batch reactor process, which is characterized by relatively low construction cost. The Corporation also decided to use post-treatment water as coolant for fish residue treatment facilities, and to dry excess sludge to be produced as a result of wastewater treatment at the fish residue treatment plant after its dehydration in order to utilize it as fertilizer.

The construction cost was ¥274 million for the plant building and refrigerating storage, ¥83 million for fish residue treatment facilities and ¥51 million for wastewater treatment facilities.

Operation and Problems of the Facilities

The facilities began their operation in January 1969, but it turned out soon that wastewater treatment facilities were virtually not functioning. The reason was that water quality of actual effluent was substantially different from the quality set during the design of wastewater treatment facilities.

During the designing period, the Corporation examined pre-relocation marine products-processing plants in Shiogama. At that time, the average BOD concentration was 2,300 mg/l, so this figure was used as the base for designing.

After relocation, operation was started, and actual effluent was measured. The measured BOD concentration was 15,000 - 20,000 mg/l for primary processing wastewater, about 3,500 mg/l for ground fish manufacturing wastewater and approximately 10,000 mg/l for overall (combined) wastewater. Such high concentration by far surpassed the concentration limit that could be treated based on the ordinary activated sludge method.

Further, the adoption of the sequential batch reactor formula for activated sludge treatment facilities eventually damaged their adjustment functions in the case of water quality changes.

Causes of the problem (difference between the design water quality and actual quality) can be pointed out as follows:

1) At that time, when full-fledged wastewater treatment was not yet experienced, general knowledge about the conditions of marine products-processing wastewater was insufficient.

2) The Corporation had little recognition of the importance of water quality, which would be the design basis, and of its changes, for the functional and design requirements of treatment facilities.

3) The period for the collection of effluent was the off-season period regarding the haul of walleye pollack, which was the main raw material for processed food products.

4) The Shiogama Port was located at the southernmost limit area for ports of walleye pollack-fishing boats that were engaged in fishery in northern waters. As such, walleye pollack kept there was less fresh than general raw materials, and the volume of protein and oil that effused into wastewater was much.

5) Because the water quality examination was conducted in a short period of time, sufficient time and money were not spent to previously examine differences in water quality among individual plants or manufacturing processes, time-series changes, seasonal alteration, changes depending on kinds of fish and manufacturing method or changes due to the mechanization of manufacturing processes at the new plant.

This served as a significant lesson, which reminded us that previous investigation, includ ing the examination of raw materials and production processes, was most important.

Attitude toward the Problem

Non-smooth operation of wastewater treatment facilities was taken up not only in the Shiogama Municipal Assembly but also in the Diet. This led to the agreement to develop technologies to treat marine products-processing wastewater in a national effort.

Principal research themes related to the development were as follows:

1) Treatment tests based on the putrefactive method
2) Treatment tests based on coagulating flotation equipment
3) Centrifugal dehydrator-used treatment and sludge dehydration testing
4) Inner-froth oil content separation tests based on oil-water separators
5) Testing of the effects of rotary screens
6) Treatment testing based on lagoons
7) Treatment testing based on the activated sludge method

Emergency Countermeasures and Improvement Steps

As emergency countermeasures for the unsatisfactory functioning of wastewater treatment facilities, a lagoon (retention tank having a capacity of about three-day portions) was tentatively installed, and solid ingredients and oil contents within the wastewater were left to naturally deposit or float. The wastewater was discharged after these ingredients/contents were removed. In 1970, it became possible, because of a progress in treatment technology, to treat high-concentration primary fish-processing effluent satisfactorily, based on the activated sludge method, by first removing rough solid pieces through a rotary screen and then separating small solid particles and oil/protein contents through coagulating flotation equipment. Thus, prospects for clearing the regulation value for effluent appeared.

Further in 1971, research on the treatment of froth that arises as a consequence of coagulating flotation treatment was implemented by the central Government and the Miyagi Prefectural Government. As a result, governmental researchers developed technologies to decompose froth by adding enzymatic agents, to separate oil contents through a centrifugal separator after heating the remaining liquid and to utilize residual liquid, which contains protein, for feed as fish soluble, by enriching the liquid through concentrating equipment.

Improvement of Facilities (1972)

Because prospects for a technological breakthrough appeared, the Corporation implemented the remodeling of the facilities.

With regard to wastewater, related mechanisms were unified into a single treatment system, which had a capacity of 1,000 per day. The treatment system was designed to remove soild contents through a static screen, characterized by nonfrequent occurrence of blinding, at the first stage of the process. After adjusting pH to about 5 to coagulate protein in wastewater and adding high molecular coagulating agents to form blocks of such protein, oil contents and mall solid particles in the wastewater, the system was designed to eliminate such blocks in the form of froth through pressure flotation equipment. As a result of this arrangement, we were able to change effluent with the concentration of 10,000 mg/l in BOD, 7,000 mg/l in oil/fat and 9,000 mg/l in SS to the liquid with the concentration of 1,000 - 1,500 mg/l and 50 mg/l in oil/fat and SS, respectively.

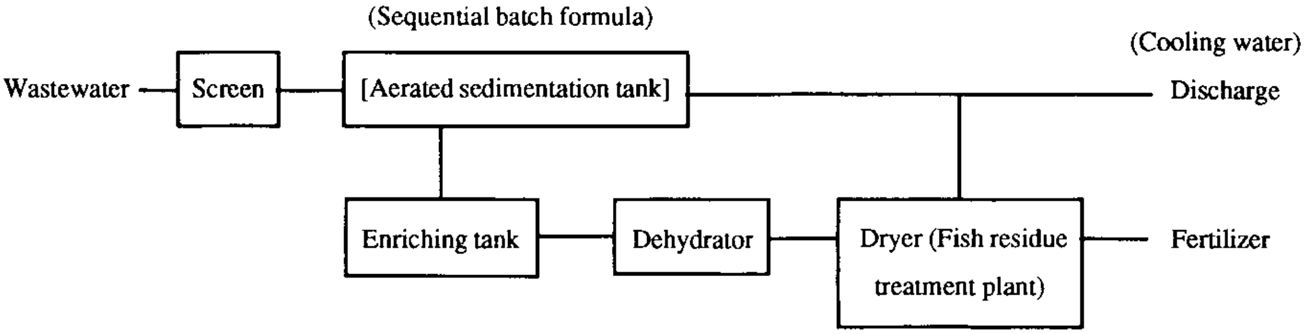
As the second stage, treatment under the two-stage continuous activated sludge method was carried out. Based on this method, the water quality of effluent could be improved so that its BOD was 50 mg/l. (The analysis value of COD(Mn) for the effluent was about half of the BOD value.)

Out of froth that arose at the rate of 30 m^3 per day, protein and fish oil were recovered under the enzymatic decomposition method, while surplus sludge was dried and recovered for use as fertilizer. Regarding coagulating agents, those recognized as food additives were used. Furthermore, the floor of the plant was remodeled so that fish residues dropped onto the floor would be smoothly dehydrated, and contamination load substances would not mix with effluent.

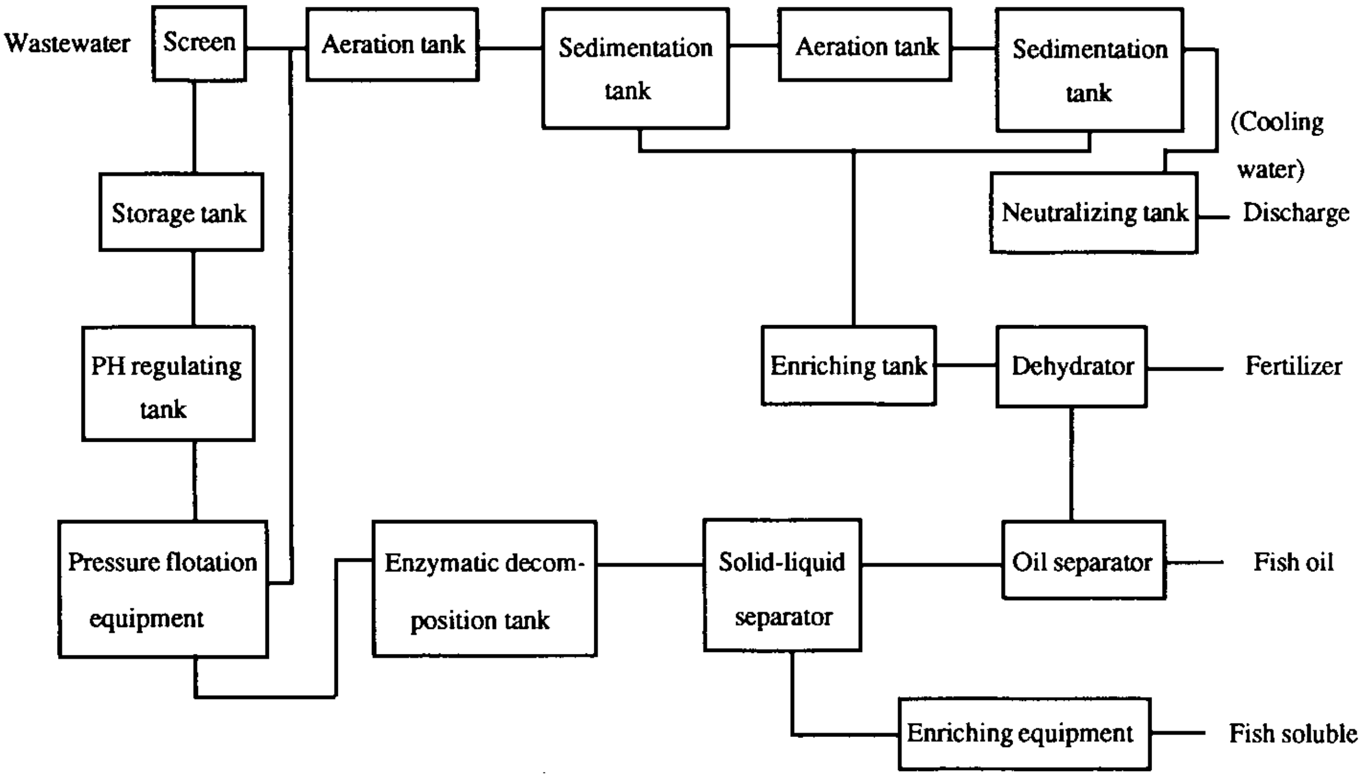
A total sum of ¥219 million was required for the remodeling of these facilities.

Effluent Treatment Process

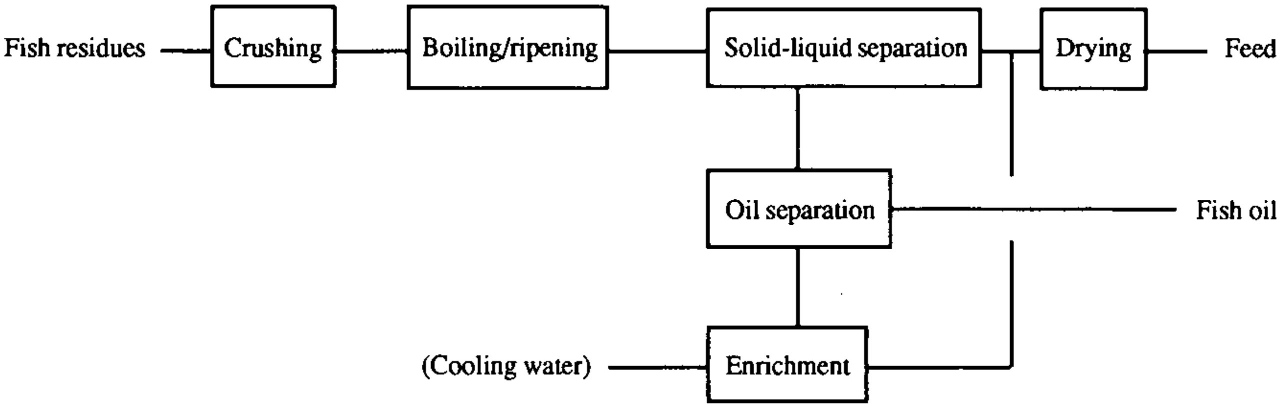
[At the Initial Stage]



[After Remodeling]



[Fish Residue Treatment Process]



[Wastewater Treatment Design Values]

Item	At the initial stage	After remodeling	Treated water (standard)
Water volume m^3/day	680	1,000	
BOD mg/l	2,130	20,000	120 or less
Oil/fat content mg/l		7,000	30 or less
SS mg/l		9,000	150 or less
Aeration tank BOD Volume load kg/m^{3}d	Sequential batch formula 2.1	Continuous formula 0.8	

The standard for discharge into the sea regarding COD (Mn) shall be 120 mg/l or less.

Promotion of the Secondary Relocation Plan

With aforementioned technological problems solved, the second phase of industrial housing complex development was undertaken. Subsequently, the Corporation completed the development of a complex plant relocation site and assigned the site to the Shiogama Municipal Government. To the said site, 144 processing enterprises that had plants within the city, moved their plants

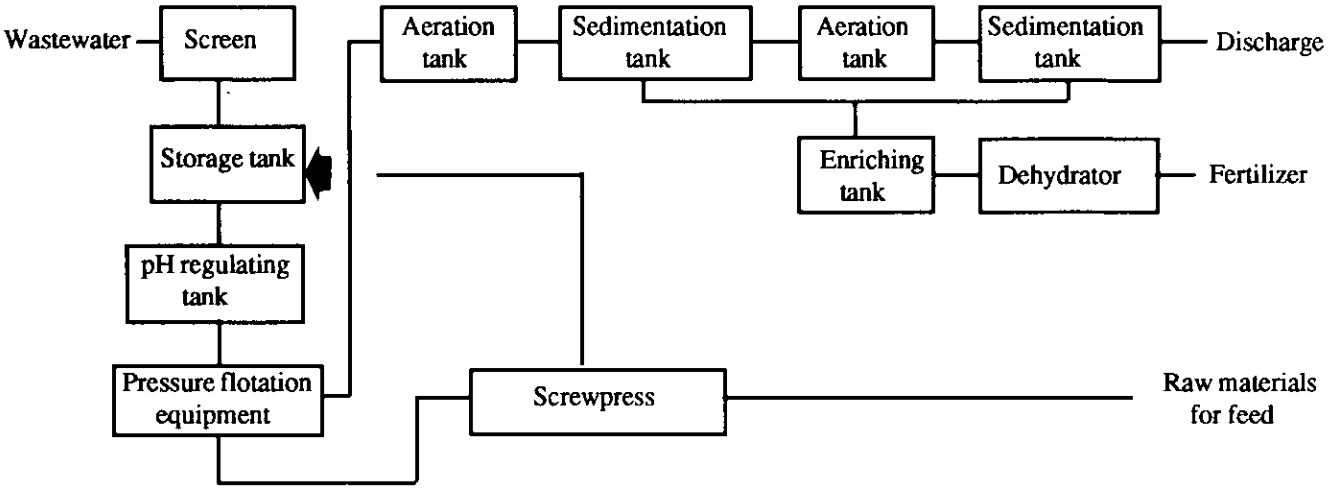
In connection with the construction of joint wastewater treatment facilities in the second phase, the Corporation cooperated with the Municipal Government by extending loans for the construction fund. The per-day wastewater treatment capacity of the facilities was 3,000 m^3 at the initial stage of construction, but in line with the increase of fishing haul, treatment facilities with a daily capacity of 2,000 m^3 were added. The construction cost for initially constructed facilities was ¥389 million, and that for the additional facilities was ¥309 million. Froth treatment facilities, however, were not expanded because related construction cost would be enormous. The problem of froth portions that could not be treated through original facilities was dealt with by transporting the portions to other fish residue treatment facilities.

Improvement of Facilities (1974)

After the adoption of the countermeasures, wastewater treatment facilities operated smoothly, so the purpose of wastewater treatment was achieved. However, how to reduce wastewater treatment expenses remained as a major issue. Further, the management of froth treatment facilities which have to be operated around the clock and the disposal of excessive froth proved to be serious burdens.

As a result of improvement study, the entire process was changed as follows: For the treatment of protein in wastewater, the use of the enzymatic decomposition method was replaced with the formula of screwpress-based solid-liquid separation, which was enforced after the wastewater was heated and coagulating agents were added to it; dehydrated cakes were carried out of the plant as raw materials for feed, while residual liquid was reverted to raw water, and coagulating flotation treatment was repeated.

Thus, after various improvements were implemented, technology that enables stabilized treatment was established. The wastewater treatment cost at that time was about 130 yen per 1 m^3 of wastewater, and approximately 165 yen, if personal expenses and depreciation expenses were included.



Changes in the Production Form

After 1977, the processing form of enterprises in the Shiogama Fishery Processing Industrial Housing Complex greatly changed due to the setting of 200-nautical mile economic waters and stricter worldwide regulation of fishing in high seas. Pollution load (water volume, water quality) in effluent greatly diminished, because the primary processing was shifted to other areas as a result of fishing ground alteration, and also because a considerable volume of primary processing-finished raw fish was imported from abroad. Consequently, water quality sufficiently below the standard could be secured only through the treatment under the direct activated sludge method concerning effluent from plants. The effluent volume for 1 ton of ground fish became about 17 m^3, while the BOD concentration in the effluent became approximately 7,000 - 8,000 mg/l.

Results of Activities

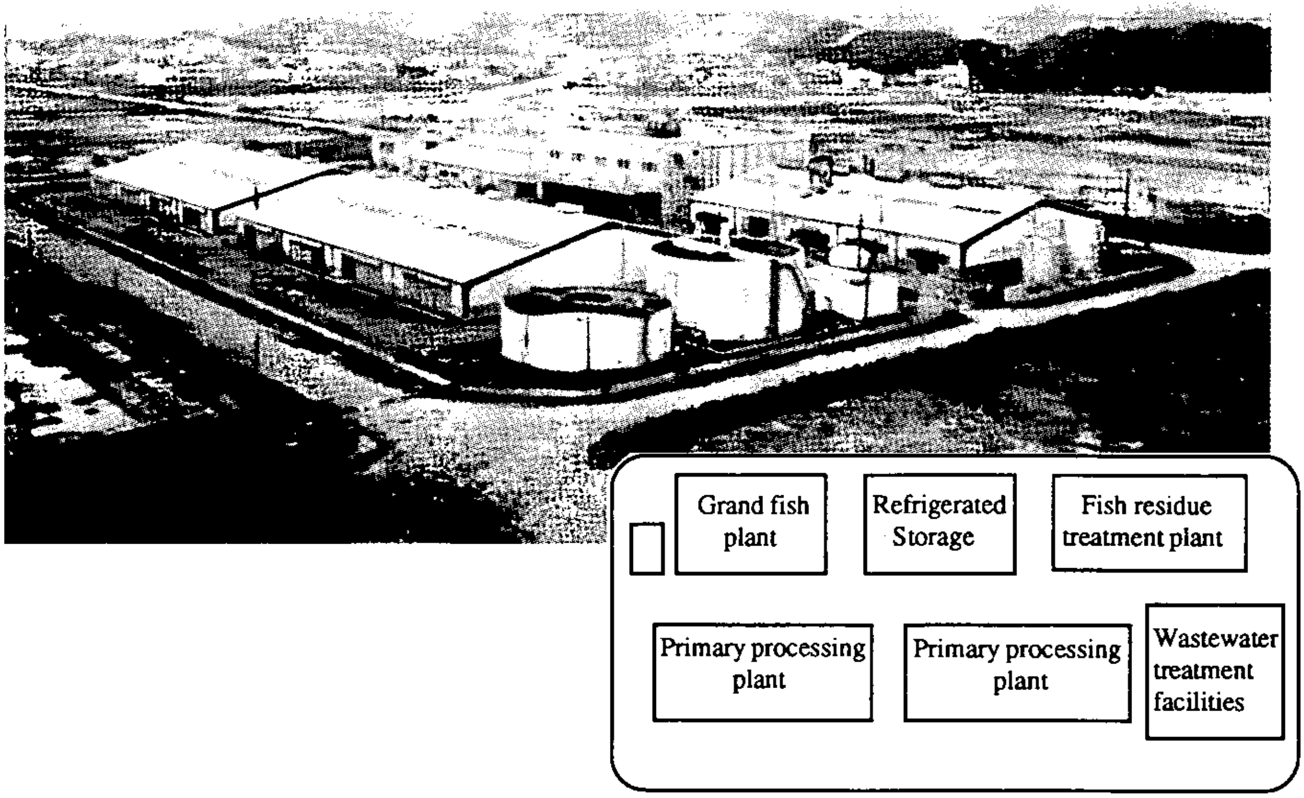
After such trials and errors, the Shiogama Marine Products-Processing Industrial Housing Complex was completed as an unparalleled complex in Japan, measuring 17 hectares in area and having an wastewater treatment center able to treat 6,000 m^3 per day, and most marine products-processing enterprises moved their plants into this complex.

As a consequence, the continued operation of marine products-processing and shallow-water culture fishing and the protection of the natural environment were achieved at the same time, and the urban environment was improved simultaneously.

After that, the form of production changed due to worldwide waves of fishing regulation. Even so, marine products-processing enterprises in the industrial housing complex are continuing their activities as a vigorous driving force of the economy of Shiogama.

In addition to attaining its purposes of pollution control and the development of the local marine products-processing industry, the projects made great contributions toward the development of wastewater treatment technology. This was because the experience of countermeasures, taken in dealing with problems that arose in the course of project implementation, provided a variety of know-how, usable for the subsequent construction of similar facilities in Japan.

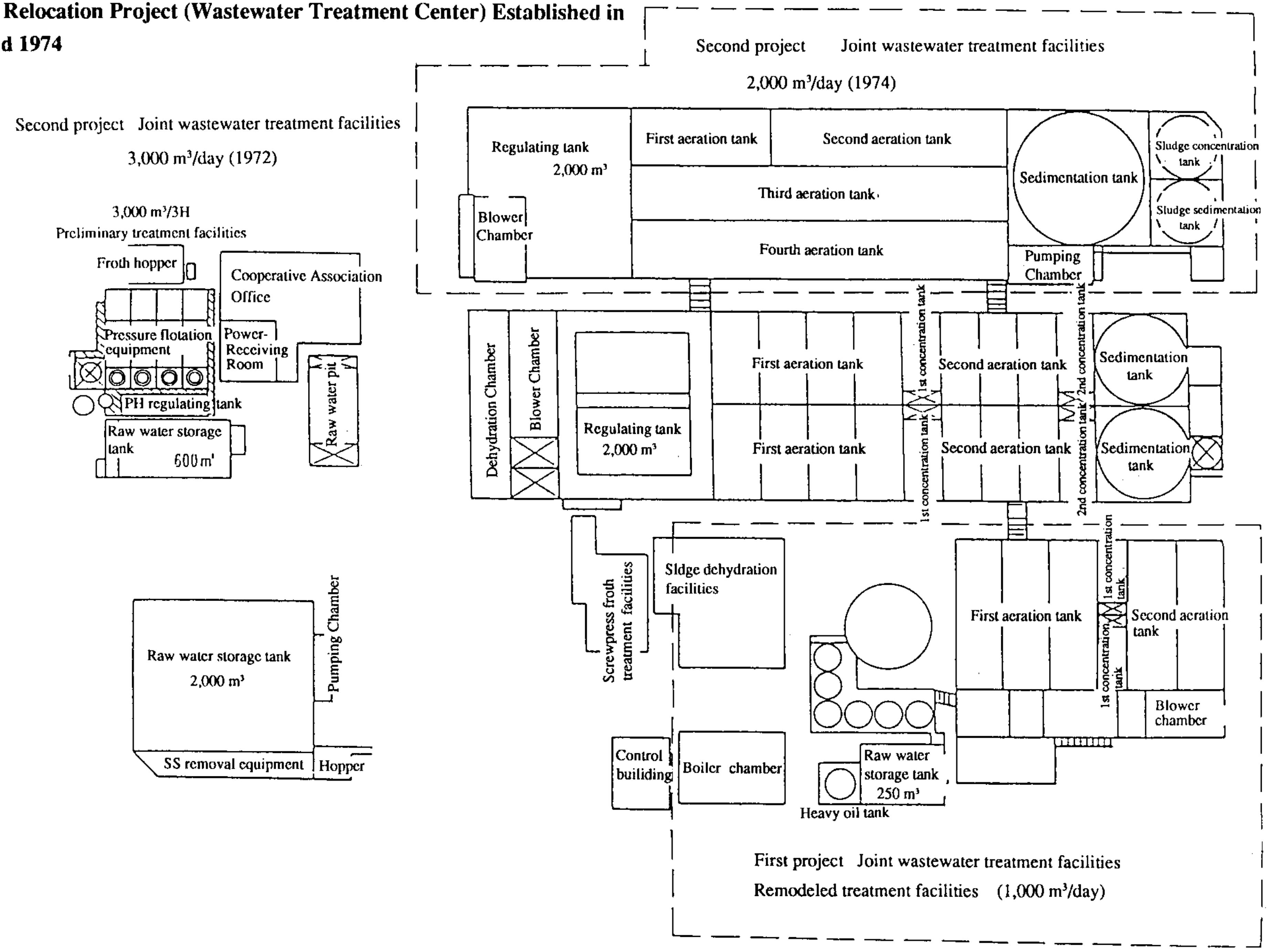
First Relocation Project (Marine Products-Processing Center) 1968

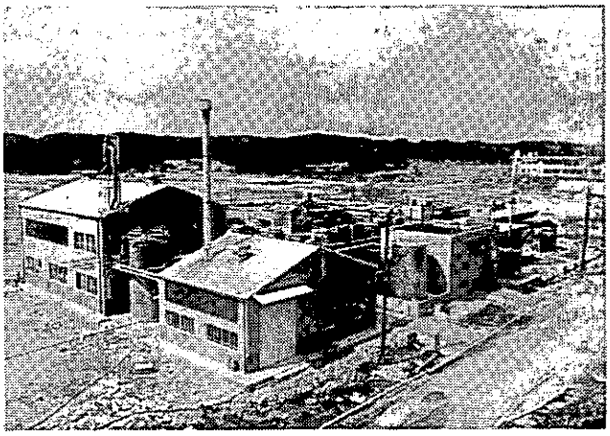



Primary processing of fish

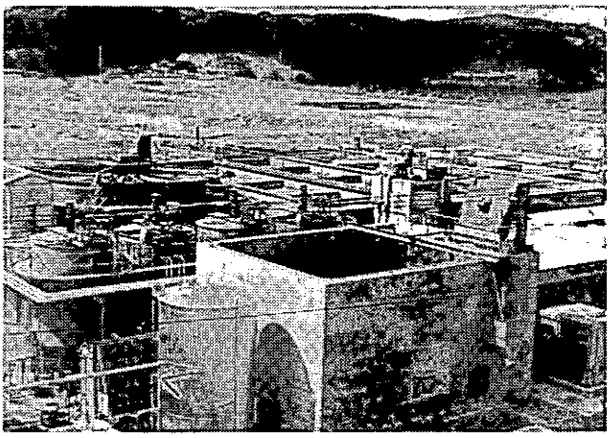

Static screen (after remodeling)

Second Relocation Project (Wastewater Treatment Center) Established in 1972 and 1974

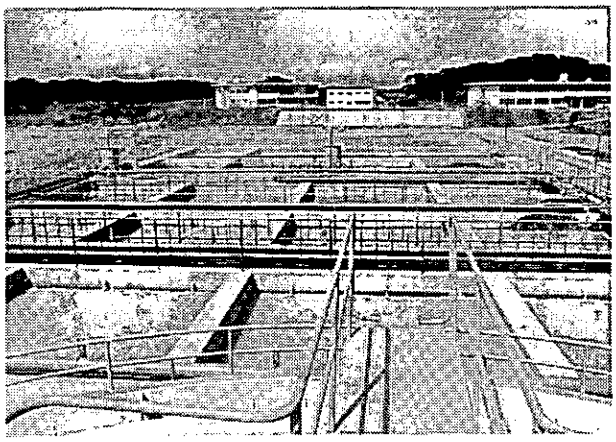




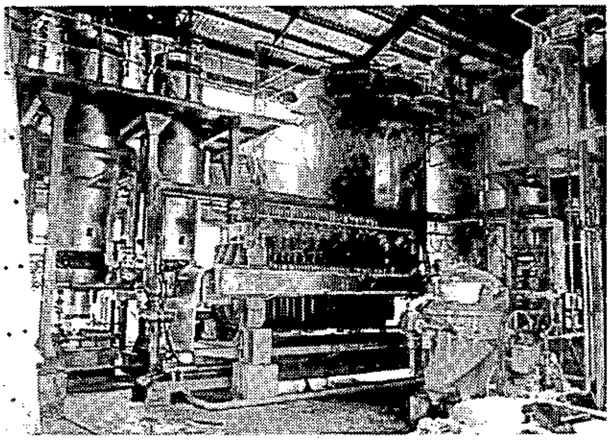
External appearance of total facilities



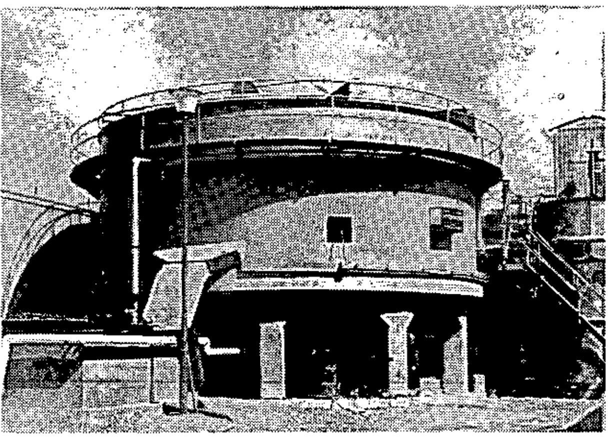
Outdoor treatment facilities



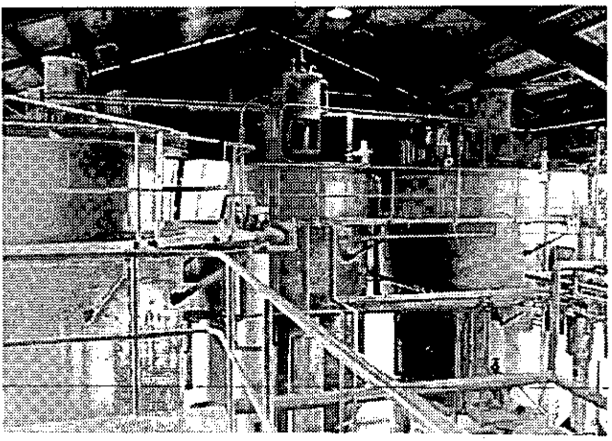
Activated sludge treatment tank



Froth treatment equipment



Coagulating flotation equipment



Enzymatic-decomposing system

Detailed Case Explanation (2) Joint Marine Products-Processing Wastewater Treatment Facilities and Joint Utilization Plant in Hakodate (1979)

"Establishment of Model Facilities for Pollution Control for Local Industries"

Background for Project Implementation

Located at the southernmost tip of Hokkaido at 42° N. Lat., the city of Hakodate has been thriving as an entrance for the traffic/cultural flow to and from Honshu (the main island of Japan). It has also developed as a base for inshore fishing. As such, there are many marine products-processing plants within the city, constituting a principal industry in the area.

In 1971, the effluent standard was set under the Water Pollution Control Law, and the marine products-processing industry was subject to control based on this law. In 1976, the effluent standard was reinforced. Many enterprises tried to deal with stricter restriction by establishing wastewater treatment facilities, but actually, there were problems with regard to wastewater treatment technology, and related enterprises were afflicted with the economic burden due to the management of facilities.

Enterprises subjected to legal control were those which discharged effluent totaling 50 m^3 or more per day. However, whether or not small marine products-processing enterprises, issuing less than 50 m^3 of effluent per day and therefore not subject to restriction, should pay wastewater treatment expenses has become a pending issue.

Model Facilities

The Hakodate Municipal Government hoped that model facilities that can satisfy the reinforced standard under the Water Pollution Control Law would be materialized on behalf of small and medium-sized marine products-processing plants, which constituted a local industry. At that time, however, it was considered technologically and economically difficult for a small or medium-sized marine products-processing enterprise to construct and manage wastewater treatment facilities by itself.

The facilities concerned were jointly envisioned by four small-sized devilfish-processing companies dispersed within the city; i.e. these companies planned to establish the facilities to meet the effluent regulation and to cope with offensive odor and noise in producing so-called "chinmi" items. Under the good offices of the Hakodate Municipal Government, the facilities were eventually blueprinted as model facilities for pollution control.

On the occasion of their relocation to a suitable plant site, the related small-sized companies enforced modernization of their plants and sought expense curtailment by jointing utilizing facilities. The installation of a refrigeration storage, in particular, was considered to substantially reduce the financial burden resulting from the establishment/operation of new wastewater treatment facilities. This was because the refrigeration storage was expected to help the companies flexibly deal with fluctuation of market prices of raw fish, to facilitate the leveling of daily processing work and to eventually help increase corporate profits.

In response to a request by the cooperative association organized by the four companies, the Japan Environment Corporation constructed the joint utilization plant building and common-use pollution control facilities (joint wastewater treatment facilities), and assigned them to the cooperative association.

Outline of the Project

Facility utilizer: Hakodate Chinmi Processing Cooperative
Association No. of association members: 4 marine products-processors
Capital: ¥ 19 million (average)
No. of employees: 65 (average)
Plant shipment value: ¥ 2,000 million (average)

Project implementation period: March 1977 - March 1979

Scale of facilities:
Joint wastewater treatment facilities
Wastewater treatment volume: 1,000 m^3 max. per day
Wastewater load volume: 2,900 kg BOD max. per day
Management Office: 85 m^2
Joint-use plant building
Total processing area: 3,320 m^2
Refrigeration storage: 2,485 m^2

Land area: 14,450 m^3
Joint wastewater treatment facilities site: 1,800 m^2
Joint-use plant building site: 12,650 m^2

Project cost: ¥1,073 million
Land acquisition expenses: ¥226 million
Construction cost of joint wastewater treatment facilities : ¥156 million
Construction cost of joint-use plant: ¥590 million

Design/supervisory expenses	(Wastewater treatment facilities)	¥2 million
	(Plant)	¥30 million
Managerial expenses		¥69 million

Examination of Wastewater Pollution Load

Important points in designing wastewater treatment facilities are to accurately grasp the kinds, volume and quality of wastewater discharged from production processes and to accurately determine the values that will serve as design standards. Especially in the following cases, it is necessary to implement examination carefully:

1) In the case of newly installing plant facilities
(including remodeling and recycling system introduction)

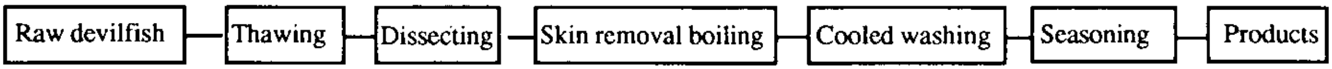
2) In the case that several companies having different production processes jointly enforce wastewater treatment

3) In the case of forming a system with other facilities, including a project for the re-utilization of treated water

Before the design of wastewater treatment facilities, the Japan Environment Corporation implemented investigation and treatment-effect testing to determine design conditions. Investigation items were as follows:

a) Production items
b) Production/processing processes
c) Processing machines and their functions
d) Kinds of wastewater
e) Volume of wastewater
f) Quality, concentration and alteration of wastewater
g) Kinds of raw fish and water quality
h) Time-series changes
i) Seasonal change
j) Future changes
k) Differences depending on enterprises

As a result of the investigation, it turned out that the representative production/processing courses are as shown below and that wastewater can be divided into (1) thawing water, (2) dissected fish-washing water, (3) wastewater from boiling, (4) washing water, (5) waste seasoned liquid and (6) floor-washing water.



Based on the above results, wastewater pollution load volume for the raw fish treatment unit was calculated for each kind of wastewater. At this stage, study was made of the existence/ nonexistence of the possibility of pollution load and treatment cost curtailment due to a review of the production process. No effective curtailment steps were found, however.

Basic Thinking about Wastewater Treatment

Based on the results of effluent pollution load investigation, the drain system was divided into the following two segments in consideration of bioremediation functions and effects:

1) A system for high-concentration wastewater consisting of boiling wastewater and waste seasoned liquid

2) A system for low-concentration wastewater consisting of other wastewater
In line with this division, processing lines and plant floor were so arranged that their wastewater can be divided into two separate discharge systems.

Concerning the treatment method, because high-concentration wastewater was at relatively high temperature, it was decided to first conduct fermentation treatment of such wastewater to reduce its concentration to the level, on which activated sludge method is applicable, and to subsequently mix the wastewater with low-concentration wastewater, implementing treatment based on the activated sludge method.

Effluent Treatment Tests

To carry out wastewater treatment testing, the treated water was regulated so that its concentration would meet the design effluent concentration standard. Subsequently, functional testing of anaerobic fermentation treatment and contact oxidation/activated sludge treatment was carried out, with treatment function data collected. The results of this testing confirmed that treating wastewater to the level of the standard was possible.

Various Items and Characteristics of Wastewater Treatment

1. Because the solid portion within wastewater greatly affects pollution load, it is necessary to achieve removal up to as small particles as possible. Solid particles are removed first with screens in both cases of high-concentration wastewater and low-concentrate wastewater. The screens should be static screens that have the function of discharging removed solid particles on the strength of the flow of wastewater.

2. High-concentration wastewater is stored in a tightly-sealed anaerobic fermentation 1.9 kg/m^3 day, inner-tank sludge concentration 3,500 mg/l), and 75% of BOD load is removed by decomposing organic substances into low-class fatty acid and alcohols by means of facultative anaerobic bacteria. (Oil content removal ratio about 60%, SS removal ratio approximately 85%)

3. Fermentation-treated wastewater is mixed with low-concentration wastewater and stored in a contact oxidation tank for 1.6 days, where anaerobic bioremediation is implemented through biological films. (BOD volume load 0.54 kg/m^3 day, BOD filter bed area load 20 g/m^2 day, MLSS 3,500 mg/l, oxygen supply volume 3.8 kg O_2/kg BOD)

4. Assuming that the sludge recirculation rate of the final sedimentation tank is 100% (water surface area load 29 m^3/m^2 day, and the period of retention 3 hours), the method is made the low load bioremediation one, so that surplus sludge will hardly generate as a result. (Sludge conversion ratio 0.1 kg SS/kg BOD) In consideration of water volume, water quality changes, and functional changes, however, sludge dehydration equipment has been installed. (Pressure vacuum-type dehydrator 100 kg/24 hours)

5. Offensive odor gas that arises in the anaerobic fermentation tank (gas generation volume 30 m^3/hour) is mixed with recycled sludge from the final sedimentation tank and then reverted to the contact oxidization tank, so offensive odor is removed through adsorption.

Effluent Volume, Water Quality and Unit Raw Fish-Based Load

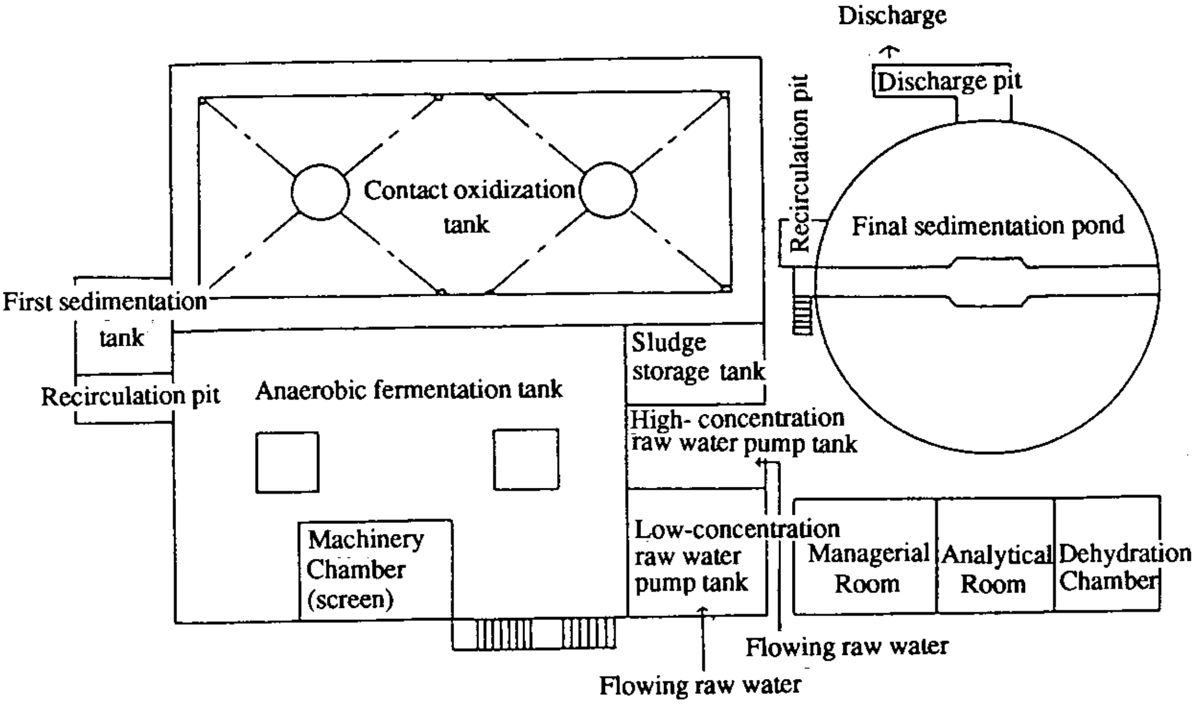
Raw fish treatment volume per day: 32.7 tons

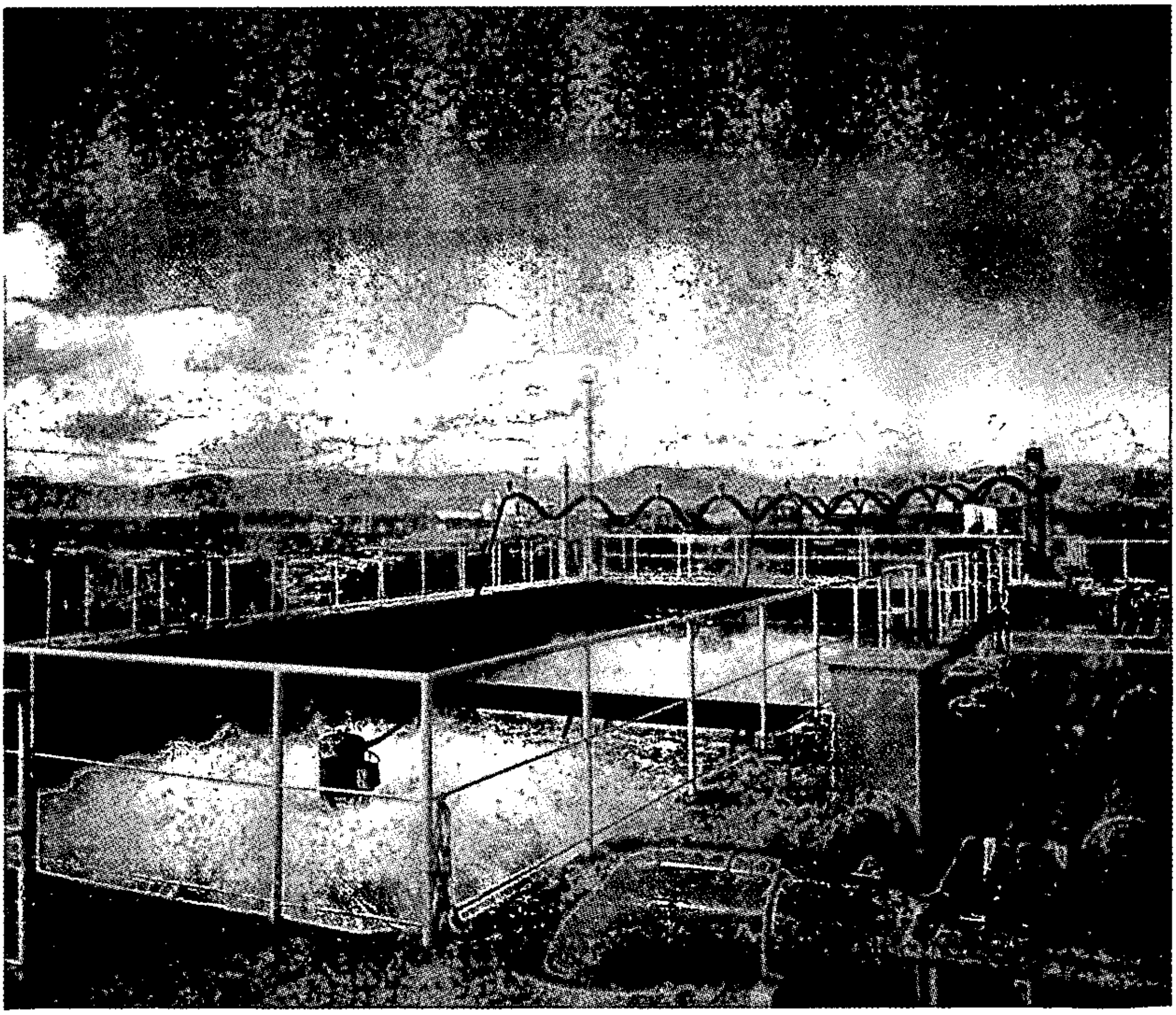
Kind of wastewater	Drainage volume	Pollution load volume kg/day (mg/ℓ)			
	m^3/day	BOD^5	COD^{Mn}	Oil content	SS
High-concentration wastewater	218	2,697 (12,372)	1,097 (5,032)	84 (385)	1,204 (5,523)
Low-concentration wastewater	782	203 (260)	73 (93)	0	72 (92)
Total	1,000	2,900	1,170	84	3,901
Original unit/ton	30.58m^3	88.7 kg	35.78 kg	2.57 kg	39.01 kg

Water Quality Standard of Treated Water

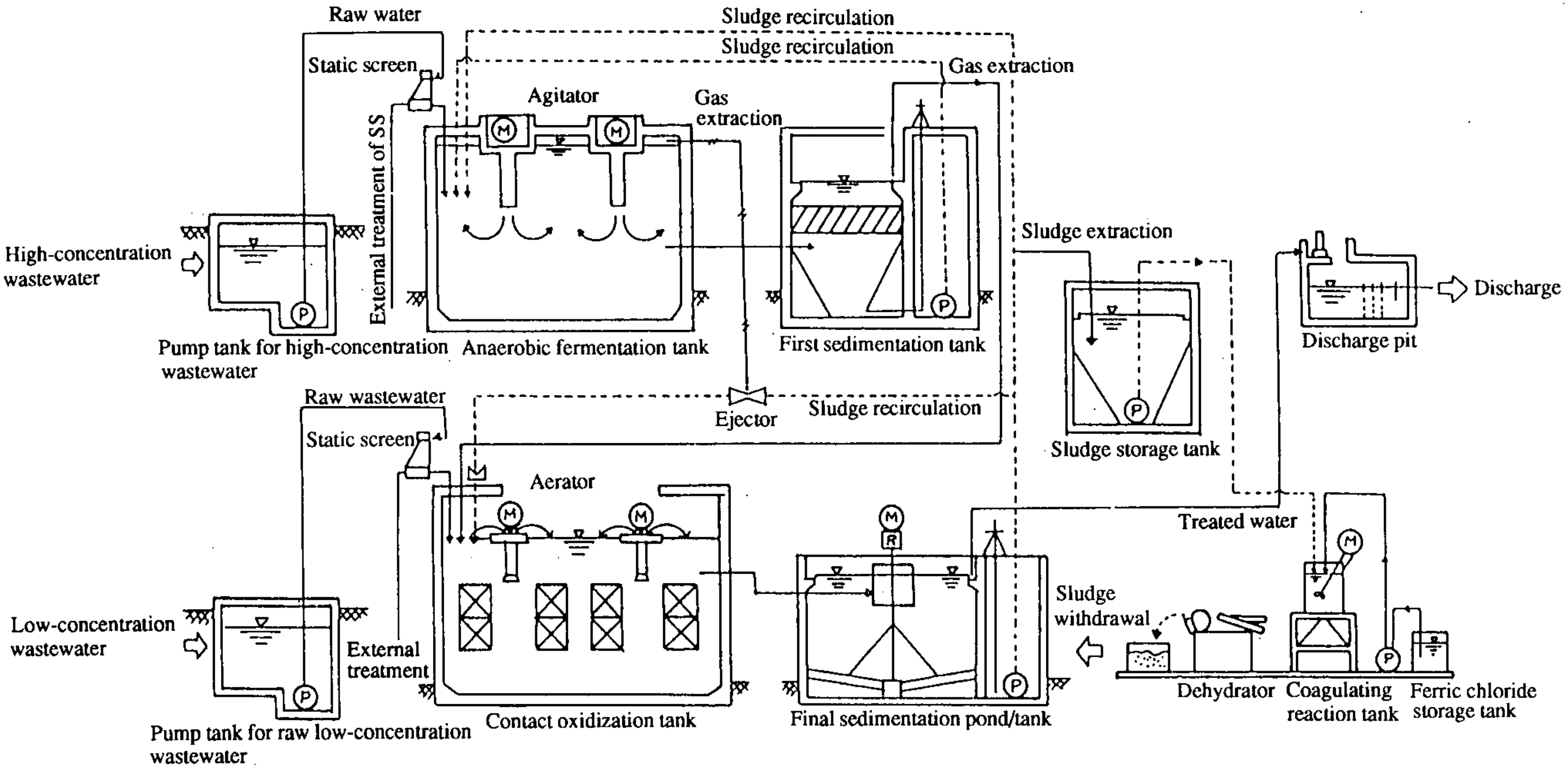
Item	Unit	Concentration
BOD$_5$	mg/l	100 or less
COD $_{Mn}$	mg/l	100 or less
Oil content	mg/l	30 or less
SS		150 or less
PH		5 - 9
No. of coliform bacillus	Bacterium /cc	3,000 or less

Joint Wastewater Treatment Facilities for the Marine Products-Processing Plant in Hakodate





Wastewater Treatment Flowchart



Operation and Remodeling after the Completion of the Facilities

Wastewater treatment facilities smoothly operated, and wastewater was suitably treated, so the effluent standard was attained. With regard to the quality of treated wastewater, water volume was less than the design volume in both high-concentration and low-concentration wastewater. Accordingly, concentration of both kinds of wastewater tended to rise.

Subsequently, the production status changed from the the design status (increases in the raw fish treatment volume, alteration of raw devilfish species and changes in raw devilfish-processing method, such as the handling of guts), and treatment effects of the anaerobic fermentation tank proved to be lower than their designed level, causing growth of load on the low-concentration wastewater system from the design value. For this reason, the generation volume of excess sludge in the contact oxidization tank increased. As countermeasures for this problem, the Corporation attached an aerator to the contact oxidization tank and remodeled the lateral centrifugal separator (addition of a sludge dehydrator). Furthermore, the treatment of offensive gases that generate in the aerobic fermentation tank, such as hydrogen sulfide, was not complete either, so the contact oxidization tank was covered with a lid, while a deodorizing tower filled with activated carbon was installed at the exhaust outlet.

The wastewater treatment cost was about ¥120 per 1 m^3 of wastewater and ¥6,000 per ton of raw fish (excluding personnel expenses and facilities depreciation expenses).

Several years later, fishing grounds for raw fish changed, and the ratio of primary processing within fishing grounds or bases near fishing grounds increased as a result. As such, a great portion of raw materials for the plant became post-primary processing materials. This led to the substantial decline of wastewater treatment load.

Because of lower wastewater treatment load, no excess sludge is now produced within the contact oxidization tank (contact oxidization tank BOD volume load 0.4 kg/m^3 day, MLSS 3,500 mg/l). As a consequence, sludge treatment became unnecessary, while no offensive odor is generated. Thus, smooth treatment is currently going on.

4.2.14 JEC Loan Program Cases

The Japan Environment Corporation extends loans to entities that are desirous of establishing pollution control facilities. Loan targets are funds required for the establishment of facilities. Purchase expenses of land for facilities installation are included in loan target, but loans will not be extended for funds to be used for the operation and control of pollution control facilities or for the redemption of already-executed investments.

The marine products-processing industry has been occupying a major position in the loan extension activities of the Japan Environment Corporation. The following shows typical cases of loan extension for pollution control facilities of the marine products-processing industry. It is true that ideal data are not necessarily completely caught. It is possible, however, to discern here the historic changes of pollution control measures and the flow to cleaner production (starting with the improvement of peripheral treatment facilities, to be followed by overall generation source countermeasures, based on the reuse of resources or process alteration).

With a view to helping the analysis of such loan-extension records, the Japan Environment Corporation is pushing for the sorting-out of data in the form of standardized data sheets and for data entry into a personal computer database.

Establishment of Secondary Treatment Facilities (1973)

Previously, thawing and raw material treatment wastewater from fish can-manufacturing facilities was partially (blood stains, broth and solid portions) recovered and processed into soluble, essences and fish meal, with other portions (thawing liquid, washing water, etc.) tentatively stored and subsequently discharged. During busy times, however, the pollution of effluent sometimes surpassed the existing standard, and reinforcement of the restriction was also anticipated. As such, we expanded treatment facilities, introducing a new system. The new system, called "MO Lagoon," was based on the sequential batch reactor method and designed to attain discharge quality of 50 mg/l or less in BOD and 70 mg/l or less in SS when treating wastewater in the case of the inflow volume of 1,000 m^3/day and wastewater quality of 290 mg/l in BOD and 100 mg/l for SS. At the inception of the operation of the new system, incomplete treatment occurred because of the entry of fish oil, but after fish oil was thoroughly removed, its operation became smooth. Because fish treatment is seasonal, lasting from April to October, the system is used for the treatment of tangerine orange can wastewater, which is also seasonal in nature, from November to March.

Production scale	Fish can-manufacturing plant Monthly production 75,000 cases (yearly sales ¥6,200 million)
Cost for required improvement	¥55 million (JEC 80.0%, own funds 20.0%)
Construction cost percentages	Civil engineering work (65%), machine installation/engineering (25%), electric engineering, etc. (10%)
Maintenance management cost	Unknown

Heating/Pressure Flotation Treatment

At first, SS of fish-washing and ground fish-manufacturing wastewater (250 m³/day, COD(Mn) 1,280 mg/l, SS 1,386 mg/l, oil content 139 mg/l) was removed through a revolving screen, and the wastewater was diluted by 20 times with compressor-cooled water (sea water) so as to meet the effluent standard (COD(Mn) 110 mg/l, SS 150 mg/l, oil content 20 mg), and was subsequently discharged. However, regulation under a Prefectural ordinance was strengthened, and the Prefectural Government's guidance for improvement — meeting the standard without any dilution — was simultaneously extended. Accordingly, the Corporation installed wastewater treatment facilities, based on the heating, coagulation pressure flotation formula.

The facilities are designed to remove SS from wastewater that stemmed from fish-washing and ground fish-manufacturing processes through a revolving screen, to coagulate protein by means of a heating tank, to add coagulating agents after the adjustment of pH, to add pressurizing water (250 m³/day) and to effect floating separation. Treated water (500 m³/day, 90 mg/l or more in COD, 50 mg/l or less in SS, 10 mg/l or less in oil content) is diluted with compressor-cooled water (sea water) as before, and then it is discharged. Separated solid contents (SS, froth) are used as raw materials for fish meal.

Production scale	Ground fish-processing plant, Monthly production 1,251 tons (Yearly sales ¥2,311 million)
Cost for required improvement	¥43 million (JEC 80.0%, own funds 20.0%)
Construction cost percentages	Land cost (20%), civil engineering (16%), machine installation/engineering (26%), electric engineering (16%), piping work (19%), others (3%)
Maintenance management cost	¥70 per 1m³ raw water

Froth Recovery/Offensive Odor Countermeasures (1974)

A fish can/meal-manufacturing plant was relocated to the industrial housing complex for marine products-processing to deal with pollution problems. After the relocation, wastewater was subject to preliminary treatment through batch-type coagulating filter equipment and then treated through joint treatment facilities. Because volume of froth generated in the internal preliminary equipment was too much, however, treatment capacity was hampered, and load on the joint treatment facilities became heavy. Since the adoption of countermeasures was requested, improvement of treatment facilities, with effective recovery of froth included, was determined. Meanwhile, strong malodor was generated in the fish meal-manufacturing process, and in response to recommendations by a local government, countermeasures were taken.

Based on the coagulating flotation formula, solid contents were separated from wastewater, and treated liquid was led to joint treatment facilities after pH adjustment. Froth caught here (10 tons/day) was subject to heating and enriching treatment, and 200 kg/day of fish dregs, 500 kg/day of soluble and 200 kg/day of fish oil were effectively recovered through heating/enriching treatment.

Offensive odor that arose in the fish-meal manufacturing process was collected through a cyclone, and after odor was removed through washing/combustion-type deodorization equipment (removal rate 70%), the remaining gas was released into air.

Production scale	Fish can/fish meal manufacturing plant, Can 60,000 cases/month, fertilizer/feed 425 tons/month, soluble 100 tons/day
Cost for required improvement	¥66 million (JEC 79.3%, own funds 20.7%)
Construction cost percentages	Froth treatment equipment (45%), washing/combustion deodorization equipment (32%), electric engineering, etc. (23%) wastewater treatment facilities were remodeled based on own funds.
Maintenance management cost	Froth treatment equipment ¥5,459,000/year, deodorization equipment ¥2,130,000/year

Recovery of Condensed Fish Protein (1978)

Administrative guidance for water quality and odor improvement was provided regarding effluent from processes for manufacturing fish meal, fish oil and condensed fish protein from fish residues. Enriching equipment for supernatant (stick) water, which accounted for the majority of pollution load, was improved, while the method of releasing evaporating moisture into the air after deodorization was adopted. The hot-air-flow-type enriching equipment was combined with a hot-air deodorization furnace and a heat exchanger. Evaporation residues are recovered as condensed fish protein (products) and sold as feed materials.

Production scale	Fish meal/fish oil/condensed fish protein manufacturing plant, capacity 300 ton/day
Cost for required improvement	¥96 million (JEC 80.0%, own funds 20.0%)
Construction cost percentages	Construction - a set of total work (100%)
Maintenance management cost	Kerosene 190 kg/day, steam 60 kg/day

Recovery of Condensed Fish Protein (1978)

Previously, scum and excess sludge (20 tons/day) that generated from wastewater treatment facilities (activated sludge method) of a fish can-processing were subject to landfill disposal, but because there was a limit to available land, enriching equipment was introduced, and they were recovered as condensed fish protein (2 tons/day). Accordingly, the generation of sludge was stopped. Condensed fish protein recovered is sold for ¥10/kg (¥20,000/day).

Production scale	Fish can-processing plant Capacity 150,000 cases/month
Cost for required improvement	¥23 million (JEC 65.4%, own funds 34.2%)
Construction cost percentages	Construction - a set of total work (100%)
Maintenance management cost	Power cost 69 kwH/day (¥3,118), fuel cost ¥800 ℓ /day (¥20,000), personnel expenses 0.5 person (¥4,000)

Closed Wastewater System Formation and Improvement of Product Quality (1987)

Because waste water out-flow accidents and generation of offensive odor due to the superannuation of a fish meal plant invited administrative guidance for improvement, the Corporation established treatment facilities designed to enrich and evaporate produced wastewater within the plant system. Accordingly, wastewater production stopped, and offensive odor generation ended. Consequently, treatment expenses for wastewater previously delivered to joint treatment facilities becamenil.

In the new treatment system, broth, blood water and other process wastewater are evaporated through thin-film, dropping-type enriching equipment, etc., while residual contents are reduced to products. Evaporation odor is collected by a blower and combusted. Due to this system, the production efficiency of fish meal, the primary product, increased by 18 to 21%, while product quality (protein containment ratio, etc.) also rose, causing increased sales as feed for high-class fish. Expenses required for the joint treatment of wastewater (¥4,375,000 per year) became unnecessary.

Production scale	Fish meal plant Capacity 350 tons/day
Cost for required improvement	¥304 million (JEC 65.4%, own funds 34.2%)
Construction cost percentages	Construction - a set of total work (100%)
Maintenance management cost	Unknown

4.2.15 JEC Survey and Research Reports

The Japan Environment Corporation has been engaged in research and study activities for the purposes of establishing pollution control technologies in technologically unprobed fields and utilizing them in constructing joint pollution facilities. Such activities were started, as BOD value of raw water for joint treatment facilities in the Shiogama Joint Marine Products-Processing Plant, established in 1967, was substantially higher than the original estimate, and planned treatment effects were not attained as a result. The Corporation conducted thorough technological study for improvement in that connection, and it launched research and examination activities in 1970 to utilize their results for not only facilities in Shiogama but also for subsequent projects. At that time, recognition of marine products-processing wastewater as pollution generation source was not necessarily sufficient, and technological measures for pollution treatment were not yet established. For this reason the role of research and examination by the Corporation was significant.

Subsequently, the Corporation implemented research to achieve technological development in continuous stages from basic research to conversion into actual plants, under the theme of joint treatment by small and medium-sized enterprises. Its achievements were evaluated highly, as research and study enforced, with the know-how of an executive agency put into actual use.

Representative research cases related to treatment of marine products- processing wastewater, among such research and study cases, are described below. It should be noted in this connection that research contents and their conclusion reflected the state of technological development at the time of research execution, and not necessarily the present status (in 1995).

(1) Research and study regarding treatment of marine products-processing wastewater (Putrefactive method) (Fiscal 1970)
Research and study regarding treatment of marine products-processing wastewater (Centrifugal dehydration method) (Fiscal 1971)

<u>Background for the Research</u>

Wastewater from marine products-processing has a high rate of contribution to the pollution of public waters. As such, it poses a major menace to the conservation of fishing waters, as well as the living environment. Joint wastewater treatment facilities, installed in the industrial housing complex for marine products-processing industry in Shiogama to reduce wastewater contamination load, were unable to have the planned treatment effects, because BOD, SS and oil/fat contents greatly surpassed the limits of those under the activated sludge treatment process. Accordingly, the preliminary treatment method was re-examined to reduce BOD, etc., in raw water. For enforcement of prompt countermeasures, processes characterized by sure treatment effects and lower operational cost were examined. Furthermore, methods of dehydrating floating particles, froth and sludge from marine products-processing and wastewater treatment processes were also investigated.

Outline of Research

In this study, the following technological steps were examined regarding primary processing wastewater (15,000 mg/l of BOD) and ground fish-related wastewater. The examination took the form of preliminary testing at laboratories and, partially, operating tests at package plants on actual scale.

1) Removal of floating particles and oil/fat contents through a rotary screen and an oil-water separator.

2) Removing floating particles and oil/fat contents through a rotary screen and an oil-water separator, and treating wastewater based on a putrefactive method, in a short period, or in a lagoon pond.

3) Coagulating pressure flotation treatment of floating particles through pressure flotation equipment, and dehydrating froth that has generated.

4) Floating scum in a lagoon pond, and recovering oil/fat and protein through a drumrevolving-type oil-water separator.
5) Dehydrating rotary screen dregs, froth, excess sludge, etc., based on a SD-type centrifugal dehydrator.

6) Using froth that was generated by pressure flotation equipment, as fish feed, and channeling wastewater treated through pressure flotation equipment into laver fishing grounds.

As a result, following findings were obtained:

1) Rotary screens have such problems as blinding, so the oil separator did not bring anticipated results.

2) The putrefactive method is easy to use, its operating cost is low, and conditions of treated water are excellent. On the other hand, much scum remains in a tank, and dehydration conditions of sludge that contains oil are extremely insufficient. The use of the method in a lagoon-pond, for preliminary treatment for the activated sludge process, is ineffective.

3) The coagulating pressure flotation treatment method can purify wastewater to the degree that it can be treated under the activated sludge process. However, froth dehydration based on that method proved unsuccessful.

4) Because oil/fat and protein are liable to separate from each other in scum, it is necessary to collect scum as promptly as possible.

5) Excess sludge can be sufficiently dewatered by adding coagulating agents. Because other sludge and froth abound in oil/fat contents, the coagulating agent-adding ratio is high, while both of its solid content recovery ratio and dehydration ratio are low. BOD of its supernatant does not decline below 2,000 mg/l, so its treatment functions are not adequate.

6) Compared with marketed pellets for carp, feed effects turned out to be almost half, but no liver damage due to the oxidation of fatty contents was found, nor did the death of tested fish occur. Based on 10- to 50-fold dilution, no adverse effects on the living conditions of laver were seen.

Results of the Research

Results of this research not necessarily point out the most suitable treatment method. Rather, its results were considered to have provided data concerning the limit of treatment technologies, which can serve as a basis for the selection of future treatment technologies for marine products-processing wastewater. From this, we could draw the following conclusion: In preparing a plan for future treatment facilities for marine products-processing, solution should be sought not solely through wastewater treatment facilities; it is necessary to recover fish guts or fish meat pieces in working sites as much as possible by improving manufacturing processes and working conditions, to thereby reduce pollution load on wastewater treatment facilities and to strive for the development of technologies to effectively use recovered substances or generated froth, scum, etc.

(2) Research on advanced technology for treatment of marine product-processing effluent in cold regions (Fiscal 1973)

Background for Research

In line with the scale expansion of fishing, fishing haul is being concentrated in specific ports. In consideration of such trends, the construction of market facilities, cold storage facilities, treatment and processing facilities and pollution control equipment is progressing to achieve concentrated improvement of distribution and processing facilities for marine products. Large-scale production sites are mainly located in Hokkaido and the Tohoku district, which are cold areas. Because wastewater temperature is close to 0°C, treatment under ordinary bioremediation methods are difficult. The Japan Environment Corporation established a committee and conducted study to establish wastewater treatment technology suitable for cold areas through the committee.

Outline of Research

The committee first implemented general study regarding the present and future status of the marine products-processing industry and wastewater treatment by the industry. Subsequently, it discussed problems inherent in cold areas and selected four promising treatment methods for such areas: the lagoon process, activated sludge process, electric coagulation process and pressure flotation method. These treatment methods were then examined through treatment tests, using pilot plants in which actual marine products-processing wastewater was utilized as raw water. The following findings were obtained as a result.

The single adoption of the electric coagulation process or pressure flotation method is not sufficient to produce the effluent that can meet the uniform effluent standard. Bioremediation methods (activated sludge method, lagoon process), on the other hand, are adequately able to effect biological treatment even at a low temperature, by curbing BOD volume load at a low level (0.2 kg/m^3 day). Regarding removal of phosphorus, the electric coagulation process proved effective, but the pressure flotation method also turned out to sufficiently carry it out. As for the removal of nitrogen and oil contents, much expectation cannot be put on any single process.

Conclusion from the Research

If the change of the water quality of wastewater and the removal of floating particles are taken into account, it is desirable to implement the electric coagulation process or pressure flotation method for the primary treatment and to execute bioremediation for the secondary treatment.

In the case of a low BOD volume load, much difference cannot be found between the activated sludge method and the lagoon process as a bioremediation method. For this reason, choice between the two methods should be determined based on overall judgment regarding the construction cost, site area, ease/difficulty of maintenance and control and running cost.

(3) Technological study and research regarding the fluidized bed activated sludge method (fluid medium bioremediation method) (fiscal 1979)

Background for the Research

A great improvement in the treatment of plant wastewater has been attained in recent years, but achievements of small and medium-sized enterprises in this regard cannot be considered sufficient as yet. It is now an important task to study methods of reasonably treating organic wastewater that includes nitrogen and phosphorus in BOD and COD contents through better methods than previous ones.

Although the adoption of bioremediation is reasonable for organic wastewater, including marine products-processing wastewater, conventional bioremediation methods are characterized by a low BOD volume load that can be set, so that a considerable load is imposed on the establishment area of treatment facilities and construction cost. Furthermore, there are many problems with regard to maintenance and control, as well as operational cost. Meanwhile, plants treating organic wastewater through physiochemical treatment methods, such as the sedimentation process, are afflicted with the inability to sufficiently remove BOD, but further introduction of bioremediation facilities to cover that shortcoming would bring much burden. As such, bioremediation methods that can effectively utilize existing facilities are considered necessary.

In this research, the applicability of the fluidized bed activated sludge process (fluid medium bioremediation method), which was judged to be effective based on preliminary research results, was studied in a positive, demonstrative manner, while the revelation of various design conditions and a variety of values was attempted.

Outline of the Research

Under the activated sludge method, the bulking phenomenon occurs during high-load times, and there is no technology to surely prevent it. Biofilm processes (such as sprinkling filtration method, rotary disc method, contact oxidization method, etc.), which are free from bulking, cause such problems as clogging and the shortage of oxygen supply. Because the fluidized bed activated sludge method that uses a granule-type medium is considered to have the highest possibility as the bioremediation process free from bulking or clogging and having a large oxygen supply potential, that method was selected as the treatment formula to be subjected to close examination in the research. The demonstration of treatment performance was carried out in bench-scale testing equipment that employed actual marine products-processing (kamaboko-manufacturing) wastewater. Sand was used as the granule-type medium.

Conclusion from the Research

Under the fluidized bed activated sludge method, such a high treatment efficiency as the BOD removal rate of 97% was obtained, even in the case of a high BOD load like 15 kg BOD/m^3 day. Compared with the treatment capacity of the activated sludge method, the capacity of the aforementioned method represented 15- to 30-times higher for the unit wastewater volume. Thus, it was proved that the minimization of aeration tanks, which used to require wide installation areas, is possible.

Furthermore, the fluidized bed activated sludge method hardly requires the measurement of MLSS and SVI, recirculation of sludge and other work that is troublesome in operation and control; what is needed to do in its operation is only to control the supply air volume so that the DO level within the aeration tank will remain at the level of 1 mg/l or higher. Further, excess sludge generation volume during high BOD load time has been hardly different from the generation volume under the ordinary activated sludge method, and its dewatering property has been confirmed to be excellent. SS can also be effectively removed by converting the final sedimentation tank into a coagulating sedimentation tank, and adding high-molecular coagulating agents.

If actual equipment adopting the fluidized bed activated sludge method is designed based on aforementioned test results, the new equipment is expected to allow saving of about 30 to 40% in required areas, 30% in construction cost and 7 to 10% in operation expenses, compared with conventional equipment using the ordinary activated sludge method. The practical use of such a treatment method is expected to pave the way to wastewater treatment even in plants where the installation of treatment facilities used to be difficult, because of equipment cost restrictions.

Conclusion

The Japan Environment Corporation established the "Committee for Investigation and Research Related to Building of Database for Transferring Environmental Information to Overseas" in fiscal 1992. Since then, it has extensively discussed effective methods for sorting out information about technologies applied, expenses and effects, etc. of cases of construction/transfer and loan programs of the Corporation, and for trasferring to developing countries so as to assist their efforts of environmental protection.

Based on the strategy concluded by the Committee, the Corporation worked out a report entitled "Overview of Japan Environment Corporation (JEC) and Case Study" (in both Japanese and English) in fiscal 1993. This report, which presented the functions and experience of the Corporation and described cases of its construction/transfer programs (case files), were delivered to international organizations, governments of developing countries, etc. Regarding loan program cases, summaries were compiled in the form of data sheets, and they were successively input to computers, so that preparations for their utilization as a database progressed. In fiscal 1994, meanwhile, they were distributed in printed form (514 data sheets).

This publication was planned to supplement "Overview of Japan Environment Corporation and Case Study." In short, it is planned to describe pollution control technologies for small and medium-sized enterprise, which are considered to urgently require the improvement in pollution control in developing countries, based on project cases of the Corporation. In this fiscal year (fiscal 1995), two industrial sectors — metal plating industry and marine products-processing industry — were chosen, and it is programmed to extend the sectoral coverage successively in next and subsequent fiscal years.

This publication was drafted, originally in Japanese, by Minoru Tanaka (Japan Environment Corporation), Masakazu Ichimura (Overseas Environmental Cooperation Center) and Osamu Suda (Nihon Suido Consultants Co. Ltd.). Specific portions written by each of them are:1.-3., 4.1.6, 4.1.17-18, 4.2.5 and 4.2.14-15 were under the charge of Ichimura; 4.1.1-5, 4.1.7-15, 4.2.1-4 and 4.2.6-12 were written by Suda; and 4.1.16 and 4.2.13 were authored by Tanaka. These sectors were finalized after a series of discussion by the three members.

We joint authors hope that experience of pollution control in Japan will be utilized as reference information by countries tackling pollution control and that it will make some contribution toward the environmental protection throughout the world.

Finally, we hereby express our sincere appreciation to those in related organizations who kindly provided us with valuable advice and information in connection with the production of this publication.

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7-1, Kanda Sudacho 2-chome, Chiyoda-ku, Tokyo 101

(3) Japan Plating Suppliers Association
1-2, Torigoe 1-chome, Taito-ku, Tokyo 111

(4) UNEP Industry and Environment
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75739 Paris CEDEX 15, France

(5) International Programme on Chemical Safety
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20 avenue Appia, 1211 Geneva 27, Switzerland

(6) Food and Agricultural Organization of the United Nations
via delle Terme di Caracalla, 00100 Rome, Italy

Separate Table
Annual Conversion Indices of Improvement Expenses, etc.

Year	Total average	Construction materials	Durable consumer goods	Exchange rate (¥/US$)
1965	43.7	40.4	81.6	360.00
1966	44.7	43.3	81.4	360.00
1967	45.6	45.6	81.3	360.00
1968	45.9	45.6	81.0	360.00
1969	46.9	46.7	81.1	360.00
1970	48.6	49.0	82.6	360.00
1971	48.2	47.0	81.2	308.00
1972	48.6	49.7	81.3	308.00
1973	56.3	64.1	84.9	308.00
1974	74.0	79.6	102.9	308.00
1975	76.2	73.9	103.7	308.00
1976	80.0	78.3	102.6	308.00
1977	81.5	82.5	102.5	308.00
1978	79.5	84.0	101.5	234.00
1979	85.3	94.0	101.2	206.00
1980	100.5	105.0	102.9	242.00
1981	101.9	101.3	102.6	210.00
1982	103.7	100.9	102.1	233.00
1983	101.4	100.2	100.6	237.00
1984	101.1	101.3	100.3	231.00
1985	100.0	100.0	100.0	254.00
1986	90.9	97.5	97.4	185.00
1987	87.5	98.7	94.5	151.00
1988	86.6	100.4	90.9	127.00
1989	88.8	104.9	86.2	130.00
1990	90.6	108.6	84.6	150.00
1991	90.8	111.2	83.5	135.00
1992	88.6	123.4	82.9	130.00

Source: Japan Statistical Yearbooks (1992, 1990, 1984, 1979, 1974 and 1969 editions, with the 1985 figures used as 100)

Reference matters in using conversion indexes:

1) The basic classification indexes in overall wholesale price indexes are used for the total average column, while specially-classified demand stage-based, application-based indexes are used for columns of construction materials and durable consumer goods.

2) Reference information in the case of judgment based on object contents, in implementing conversion
   - a. In the case of reviewing several objects in an overall manner: The column of total average
   - b. In the case of reviewing intermediate materials related to construction work: The column of construction materials
   - c. In the case of reviewing final goods, including equipment, etc.: The column of durable consumer goods