rely on labor force, thus preventing the development of a suitable mechanized system. In the case of electronic and electrical industry for which a mechanized packaging system has been developed and is ready for introduction, non availability of maintenance company to service the system in Singapore has prevented them from introducing the mechanization.

5.1.2.5 Necessity to address environmental issues

Reduction of disposable waste is now global concern. Singapore embarked on "Clean and Green Project" in 1990 in an attempt to reduce the amount of waste which is expected to increase by 2.5 times from 1980 to 2000, through the recycling of various materials including packaging materials.

At the same time, industrial users of packaging materials in Singapore are heavily dependent upon export and are thus expected to address environmental issues facing importing countries.

Unfortunately, however, the packaging sector has not been very active in dealing with the issue. To be sure, packaging materials makers and package users are increasingly demanded in future to work together in devising adequate measures, including the development and supply of recyclable materials for corrugated cartons and cushioning materials, the use of packaging materials that do not produce environmentally harmful gas upon incineration, and the use and recycling of off-grade products. In response, more and more countries, particularly industrial countries, are reappraising the value of glass containers and are refrained from using vinyl chloride and composite plastic materials. In Singapore, the first step in that direction is to dissipate latest information on recycling of packaging materials to related companies and organizations.

5.2 Packaging Sector and Development of Packaging Technology Center

5.2.1 Development Strategy for Packaging Sector

5.2.1.1 Basic strategy

(1) Importance of developing the packaging sector in industrial development

Developing the packaging sector in Singapore contributes greatly to industrial development of Singapore in the following respects:

1) The packaging sector assumes a major role of supporting other industries, and its up-grading contributes to the advancement of related industries.
2) The packaging industry contains a large number of local industries which represent one area of weakness and vulnerability in the Singapore economy, and its modernization helps strengthening the foundation of the country's economy.

3) The fostering of the advanced packaging sector enables the country to export packaging-related service in the future, thereby contributing to the expansion of "service exports linked to manufacturing industry" envisaged by Singapore as a national objective.

Overall, these constitute the rationale for the government to officially assist the development of the packaging sector as part of their industrial development efforts.

(2) Actions required for development of the packaging sector

Actions required for fostering the packaging sector can be structured into the following three levels: 1) Actions for improvement of packaging quality as a final goal, 2) the development of packaging technology base to empower and sustain quality improvement of the packaging sector, and 3) Fostering and strengthening of the packaging (materials) industry to support these actions.

1) Actions for improvement of packaging quality

As discussed in 5.1.2, improvement of packaging quality in Singapore covers a wide range of areas, which are roughly divided into 1) packaging design, 2) packaging materials manufacturing, 3) packaging work, and 4) environmental consideration. Clearly, these issues can not be effectively dealt with by a short-term approach to cope with an individual problem as it arises. Such an approach does not lead to the build-up of technology resources for the future. On the other hand, many R&D activities have been conducted on these areas, and the packaging industry should capitalize on the results of the R&D efforts to devise a realistic and effective approach for each area. In the process, they will be able to collect necessary data which are very important in ensuring future development of the industry's foundation.

2) Improvement of packaging technology resources

Packaging technology resources serve as the basis of the packaging sector's activity as well as accumulating activity results. At present, there is little effort being made in the country to develop technological infrastructure related to packaging. Some of foreign-affiliated companies have internal standards and manuals which are supplied by their parent companies or customers, which are not shared by the entire sector as technological resources, thus not available to future development. To develop technology basis for the future growth, the packaging sector needs to make efforts to strengthen the following areas:

a) Standardization

b) Technical support system (for technical guidance, dissemination of information, and testing)

c) Human resource development system

3) Enhancement of the packaging industry

a) Expectations for the industry by packaging users

At present, packaging users in Singapore do not have high expectation for the packaging sector, partly because of their peculiar business pattern and partly because of the limited ability of the packaging industry.

The peculiar business pattern of user industries may be described as that of MNCs and local small enterprises. Major industrial users of packaging materials in Singapore are mostly MNCs or joint ventures with MNCs. These companies use packages designed by their parent companies. They also procure packaging materials only from large makers who can satisfy strict quality requirements. Another major user group, local enterprises are divided into those which supply products to MNCs, their joint ventures, or export markets, and those which are not related to MNCs or export markets. The former type purchases packaging materials and packages under instruction from its customers and seldom carry out packaging design nor supply source development. The latter type tends to give priority to price over quality, and it is basically a small-lot customer and has to procure commodity materials available in the market. As a result, local enterprises do not have strong voice to demand quality improvements. In both cases, therefore, packaging users in Singapore do not face the urgent need to develop own packaging or to seek for new supply sources.

On the other hand, the packaging industry in Singapore has the limited ability to meet customer needs, with varying degree according to the size of enterprise. As discussed above, the lack of expectation of industrial users for the packaging industry has been working as a major factor restraining the development of the industry, regardless of size. As the users did not feel the need for joint packaging design and development with the packaging industry, most of packaging companies including large ones have not had an opportunity to have technical service capability, with the exception of some foreign-affiliated companies. In addition, SMEs in packaging industry are limited in terms of product quality, partly because of price-oriented customers in contrast to major customers of large packaging suppliers who give priority to product quality.

b) Need for enhancement of the packaging industry and its direction

The enhancement of local packaging enterprises is essential for desirable development of the packaging sector. They are expected to be in a position to provide basic design data including characteristics of available packaging materials and machinery, when the industrial users are to do packaging design in Singapore in the future. Also, they can assist their customers in conducting R&D activities to find data required for compliance with local conditions and requirements.

Nevertheless, the packaging industry with the limited technological capability is not viewed as a reliable partner in improvement of packaging quality by user industries. In fact, the users (actually their parent companies overseas) take leadership in packaging development and modification, and they place order to the packaging industry by specifying their own design. If local packaging manufacturers can not meet customer's request, these materials are imported. As a result, local packaging enterprises have failed to built up technological resources of their own.

To reverse the trend in the future, it is important to empower the local packaging industry to have the ability to participate in improvement of packaging quality by its customers. This way, the industry will be able to rank with the user industry in developing packaging according to diverse needs and to build up its own technological expertise.

In particular, the packaging industry can assist the user industry in the following areas: 1) provision of technical information, 2) provision of after-market service related to packaging materials and machinery, and 3) support related to packaging technology including joint development. Technical information and after-market service that can be made available by the packaging industry are summarized as follows:

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(1) Technical information on packaging technology, Materials, and machinery

1) Information on highly productive packaging technology

2) Technical information on nature and quality of packaging materials: Basic information and data on raw material and quality used for packaging materials, which is important in identifying possible safety and hygienic effects of packaging materials on contents. In particular, if a food product comes into contact with it packaging material, a constituent of the material may migrate into the food product. Also important is information on features and characteristics of the packaging material related to environmental protection. In addition, if the packaged product is exported, the similar information related to environmental protection laws and regulations in the importing country.

3) Information on functional performance and characteristics of packaging materials: Recent development of packaging materials is directed toward the addition of new functionalities to existing materials through new processing technology, and the development of secondary packaging materials with the ability to preserve contents (including those which do not constitute packaging containers but are used in primary packaging, such as the oxygen scavenger for perform environmental control in the container), rather than the development of new materials. The functional performance and the preservation effect are tested in the process of developing packaging materials by using actual foods, and basic data are collected. The user receives these data from the packaging materials supplier and conducted its own test to evaluate the claimed effects for quality verification. Data on environmental preservability are collected in the similar process.

4) Information on technical evaluation of different packaging materials, methods, and technologies: In designing a package, a variety of packaging materials, methods, and technologies should be compared and analyzed for sound technical evaluation. If these data (evaluation results) covering different types of contents (such as foods) are furnished by the packaging materials manufacturer in advance, the user will be able to conduct efficient evaluation of its own. These data are particularly important in the case of a newly developed packaging material, method or technology.

5) Information on highly productive packaging machinery and system: To provide information and data on newly developed packaging machinery and system through information service or at a trade show. Also, to promote alliance with packaging materials makers and users for efficient development, commercialization, and market introduction.

(2) Troubleshooting information related to packaging

1) Troubleshooting information on packaging materials required for quality preservation: The scope of variation in characteristic values of packaging materials related to preservability, safety and hygiene of contents (such as foods), changes in characteristics, and methods to identify poor quality, and other related information.

2) Troubleshooting information related to packaging work (manual and mechanized operations): Information on methods to identify causes for trouble occurring in the packaging process using packaging materials, as well as corrective measures; and troubleshooting information related to packaging materials as part of the entire packaging system including machinery and equipment, particularly when a special type of packaging form or system is used, information on specific troubles related to such packaging form or system should be furnished from the packaging materials maker. These information allows the user to establish standards for process control and quality control.

3) Troubleshooting information on defective packaging: Causes for trouble related to package quality, such as defective packaging, are not limited to packaging machinery. Thus it is important to establish troubleshooting methods covering packaging materials and operation procedures. Information under this category, therefore, includes emergency measures to deal with trouble and packaging defect caused by particular packaging machinery, and methods to handle trouble and defect related to the packaging machinery that is likely to occur in connection with packaging materials and machine operation.

(3) Technical information required to maintain functional performance of packaging machinery:

Information on (1) daily inspection and maintenance, and (2) minor servicing including replacement and repair, to be conducted by the user, including the method, frequency, and troubleshooting. Also, information on highly specialized technical service conducted by the machinery supplier or maintenance service company needs to be furnished, including troubleshooting and emergency procedures, and maintenance cycle, to allow the user to be ready for such service if needed.

(4) Maintenance and repair service

1) Technical service: Packaging machinery maintenance services, which require expertise. While some users are expected to have their own maintenance personnel, many of them are likely to rely on outside service, due to (1) a small size of user industries in Singapore, and (2) an increasing use of advanced technology for latest packaging machinery, including computers, electronic equipment, and electromechanics.

2) Adequate parts supply: Except for commodity parts and components, special parts should be supplied by the packaging machinery maker at reasonable prices.

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(3) How to tackle the sector development

Packaging standards and practices in Singapore vary significantly with the industry as well as the enterprise. In particular, there is a considerable gap between MNCs and their joint ventures and large local enterprises under their influence, and local SMEs. Also, there is a large gap in the attitude to the improvement of packaging quality between companies which mainly serve the export market and those which principally supply to the domestic market. In any case, these companies are not involved in packaging design, either 1) procuring packaging materials in Singapore while packaging design is conducted outside the country, or 2) following the packaging of those used by other companies, without original design. Thus, the difference in packaging quality occurs due to various reasons, e.g., whether or not package design made by the parent company matches with physical distribution conditions in Singapore, and whether or not package design used as an example is suitable for actual situation in Singapore.

Physical distribution or production divisions of user industries in Singapore are responsible for packaging service, but they do not have much knowledge on packaging technology. On the other hand, few packaging companies are capable of providing technical service for users. Thus, even if any problem arises in connection with packaging, it has been dealt with on a case-by-case basis and few analysis has been made to go into the basis of packaging technology. As a result, Singapore has failed to build its own packaging technology resources common to related industries.

Obviously, issues related to packaging can not be treated as individual cases. Rather, each company should deal with its own problem in a systematic manner and has to solve it from its root cause. In particular, MNCs have to become free from dependence on parent companies and are expected to have human resources for proper management and development of packaging technology, enabling each company to solve its problem locally. This way, individual companies can learn and build packaging expertise through experience in problem solving, which should form a basis of developing the packaging sector in the country.

With efforts of individual companies to build their own resources, the packaging sector as a whole should support their activities, as discussed later (see 5.2.1.2), in order to compensate for limitations felt by individual companies. In Singapore, relatively a small size of packaging company impedes a fundamental solution for packaging-related problems, likely to result in an individual approach. In particular, the packaging sector should assist its members in working with issues related to packaging technology. Here, the packaging sector includes those involved in packaging of package user industries, the packaging industry, the physical distribution industry, related research organizations, extension centers, training institutes, and government organizations responsible for industrial policy. The close communication with among these organizations is a prerequisite to the effective result. Nevertheless, activity of the packaging sector should be led basically by private sector who benefit from improvement in packaging technology. And the public sector should form a institutional supporting system for their activity.

5.2.1.2 Organizations related to development of the packaging sector and their roles

This section examines how organizations and institutions in the packaging sector should work toward the development of the sector, in particular what role each should play, for each area of improvement identified in the previous section. Also discussed is how they should promote the development of packaging technology resources and the fostering and enhancing the packaging industry.

(1) How to tackle the issues related to packaging design

1) Improvement of cushioning packaging design

To improve the quality of cushioning packaging design, much study and research is needed to collect basic data and information concerning 1) shipping environment, 2) physical properties of packaged goods, and 3) characteristics of packaging materials. In particular, such study and research should aim to combine theoretical knowledge on packaging design technologies with actual experience in physical distribution work.

For this purpose, related industries consisting of the packaging industry, user industries, and the distribution industry should establish a certain form of research and development organization for joint research activities with publicly owned research institutes.

To ensure that the result of the joint R&D project can be effectively incorporated into day-to-day operations, each user company needs to establish their own organizational setup to manage and develop packaging technology. In the course of their establishing packaging resources, public research institutes can provide technical assistance and advice on packaging design technologies, particularly regarding transportation packaging. At the same time, they should help educate packaging design experts through joint research projects. Packaging companies are expected to collect technical information on packaging materials and supply it to the joint R&D project. In return, they will obtain the result of the project and improve packaging materials to reflect distribution environment in the country.

Meanwhile, the public research institutes will build a database containing basic data useful in developing related testing standards, which will be used by related industries to develop industrial standards and to revise and update existing ones.

The research activity centering around the joint R&D project will provide useful information for designing packages to transport precision and valuable products, which will be increasingly demanded in the near future.

2) Research on optimum transportation packaging design

Research on optimum transportation packaging design is an important activity to maintain international competitiveness of manufacturing industries in Singapore. It should be noted, however, that such a research should cover many aspects related to packaging including the designing of products to be packaged, and the scope and nature of research varies from one company to another. Thus, separate R&D activities at each company will be the core of research in this area. The basic data related to package design will be available from the joint R&D project aiming at the improvement of cushioning packaging design, as described in the previous section. Since, various tests to be conducted in connection with the research projects on optimum transportation packaging require special facilities and equipment, they are likely to be assigned to public research institutes. This means, public research institutes will be able to provide technical assistance in the research products conducted by individual companies through testing.

Another way to assist the corporate-based research projects is the exchange of technical information between companies. In particular, information exchange based

on actual experience would provide useful hints, and related industries including package suppliers, industrial users, and distribution companies are recommended to from a study society, and the society should organize a seminar or workshop for this purpose.

3) Improvement of food packaging design

Again, the improvement of food packaging design is undertaken basically by individual food companies because it deals with issues related to a particular food processing line. Thus, individual food companies have to develop their own packaging management and development systems, which should be supported by packaging companies, the packaging industry as a whole, and public organizations.

The most important elements of outside support are: 1) provision of related technical information, 2) development of human resources required for processing and quality control, and 3) testing service and technical assistance. Ideally, related technical information should be supplied by the packaging industry (packaging materials and machinery suppliers), but actually, packaging companies in Singapore are relatively small in size and are limited in ability to collect latest information. Thus, public organizations are recommended to provide backup for collection and dissemination of technical information.

Development of human resources for processing and quality control is also recommended to be led by the food industry which is familiar with changing needs from time to time. However, the industry does not have a sufficient ability to promote such an activity on a systematic and continuous basis. On the other hand, the packaging industry, which should be partly responsible for technical assistance, serves a very small market and can not provide the sophisticated technical service. Thus, public organizations should take initiative in promoting education activities, and related industries should take over as they obtain resources and know-how to conduct them by themselves.

(2) How to tackle the issues related to supply of packaging materials

1) Production and use of proper packaging materials

The major issue here is the ways to determine and proliferate specifications for packaging materials suitable for natural, social and economical environments in Singapore. In particular, specifications for moisture contents of wood pallets and moisture absorption of corrugated cardboards are requiring immediate attention. The basic data on the country's packaging environment can be obtained in the process of improving cushioning design, as described in the previous section.

Defining proper specifications for packaging materials is an important challenge for the packaging sector as a whole, rather than a issue of individual companies. It is considered to be part of the industry-wide efforts to promote the standardization of packaging materials subject to frequent claim, which would be developed into the industry's technological resources. The standardization process should start from necessary tests and experiments which are to be conducted by public organizations. Then, related industries should take leadership in developing draft standards on the basis of data obtained from the tests. In principle, most of the standards may be voluntary standards. However, if voluntary standards fail to exclude poor quality products from the market to cause damage to users, mandatory standards should be introduced.

2) Quality improvement in locally produced packaging materials

To improve the quality of packaging materials such as corrugated cardboards and plastic films, the upgrading of production and quality control technologies is called for. For this purpose, technical assistance to individual companies is considered to be most effective and such assistance is mostly provided by packaging machinery makers or overseas partners in technical ties-up. Packaging companies in Singapore, however, are not in a position to receive sufficient technical assistance, because they are relatively small in size and often such assistance is not available to them. Thus, public organizations should be called in for help.

3) Diversification of packaging materials

Demand for new packaging materials includes: 1) consumer packaging to satisfy diverse consumer taste and shopping behavior, and 2) transportation packaging for transportation of sensitive and valuable products. In developing and commercializing these new materials, technical information is essential. Basically, collection and dissemination of these information, together with development of new packaging materials are responsibility of private sector. However, judging from relatively small packaging demand in Singapore, it is difficult to rely on packaging companies to play such a role at present, and public assistance is essential to fill the gap.

Public organizations are also expected to assist in product evaluation test and related technical service, as well as necessary standardization of product specifications.

4) Improvement of package graphic design and printing technology

The most important factor in improving package graphic design capability is the development of human resources. For designer who are currently engaged in package

graphic design, design competitions and dissemination of overseas design works are effective tools to develop creativity and knowledge. These activities should be led mainly by private sector. Design schools should be utilized for designer education. All of these activities, however, can be handled together with promotion of industrial design in general. TDB's design promotion activity is also available for this purpose.

Regarding printing technology, improvements are required in the areas of printing machines, including computer-based systems, printing ink, and education of engineers and technicians. Note that these can also be treated as part of activities to upgrade printing technology in general.

(3) Activity to deal with the issues related to packaging operation

1) Improvement of food packaging process technology

Improvement of packaging work in the food processing industry involves: 1) the improvement of quality control in the food processing line, and 2) the improvement of packaging operation. The primary target is SMEs, and technical assistance to individual companies is considered to have the highest effect. Generally, technical assistance of this type is carried out in the form of alliance with foreign companies in industrial countries or technical service of packaging machinery makers. However, food processing companies are not large enough to have foreign partners, and packaging machinery suppliers are not capable of providing such a service. Public organizations are expected to supplement these roles.

2) Automation of packaging process

Successful process automation requires sufficient knowledge on available machinery and equipment. The slow progress of automation in the packaging industry in Singapore, however, is attributable to other reasons pointed out earlier, such as the lack of an automation system suitable for relatively small companies, and the lack of maintenance service companies and technologies that are indispensable to support the system. These obstacles need to be cleared if automation is to be effectively promoted. Otherwise it is doubtful if the automation system can be retrofitted to existing packaging lines in the country.

Therefore, it is of primary importance for the packaging sector to study and develop conceptual design for the automation system which is most suitable for the packaging industry as well as users. For this purpose, a research society should be organized by related industries and organizations for information exchange and data analysis in the

form of case study. The scope of the research activity of the society will be required to be extended to the optimum packaging design based on the automated process.

The packaging machinery industry is expected to collect necessary information for this purpose, and public organizations should assist from time to time when the need arises.

(4) Packaging to support streamlining of the physical distribution system

The most significant subject for streamlining of physical distribution service on the packaging industry is the standardization of pallets and other containers. It requires industry-wide commitment involving the packaging industry, user industries, and the physical distribution industry. It should be noted that the contemplated standards need not to gain the national status from the beginning. Rather, they can be established and operated as association standards developed by a organization, say the packaging technology society, and once their validity and applicability are verified, they may be upgraded to national standards. The related industries should be responsible for drafting the standards, while collection and analysis of basic data will require assistance of public organizations.

(5) Activity to environmental preservation measures

Environmental preservation measures are roughly divided into those requiring concerted efforts of related industries and government organizations, and those directly related to individual companies and their efforts. The former includes collection and analysis of information on export markets, and development of domestic systems for collection and recycling of waste materials. Again, organizing a research society focusing on case study can be effective in converging efforts of participating organizations. The latter requires support by public organizations in the areas of testing and technical assistance.

5.2.2 Role of Packing Technology Center

5.2.2.1 Current state of Packaging Technology Center

(1) Background

Packaging Technology Center was established within SISIR in 1991 to work with various issues related to packaging and to support promotion of the packaging industry.

SISIR is a government organization under the Ministry of Commerce and Industry, established in 1989 for the purpose of promoting standardization in the country. It is a leading organization specialized in industrial technology, currently responsible for

guiding manufacturing industries in the areas of quality and technology, for the interest of enhancing their international competitiveness.

SISIR is providing the following services for manufacturing industries to assist their product and process development efforts: 1) contract research and development, 2) product design and development, 3) technical consulting service and training, 4) testing, 5) troubleshooting, 6) calibration, and 7) other technical service.

Packaging Technology Center is one of 8 technology centers under SISIR's Product and Process Technology Division (one of 7 divisions), as shown in SISIR's organizational chart Figure 5-1.

The center plans to provide the following services which are described in detail in Table 5-2:

1. Standardization and certification system
2. Inspection and analysis of packaging materials
3. R&D
4. Consulting service
5. Marketing and technical information service
6. Training courses and seminars

(2) Current state of Packaging Technology Center

The center is currently building its function, organization, and equipment, thus it can not render all the services listed above. The center's resources and activities are summarized as follows[4].

1) Equipment

As shown in Table 5-12 (attached in the later part of this chapter), the installation of equipment is confined to testing equipment in the areas of transportation packaging. Most of the basic testing items relating to transport packaging can be undertaken with equipment used for and made available to by this JICA study. Nevertheless, the further efforts are needed for additional installation of equipment required for some other basic testing items and for meeting sophistication of packaging research testing in the future.

The center plans to render the services, which are not covered by the existing equipment but possible to be provided by using equipment and staff of other technology centers within SISIR, acting as a coordinator between clients and the centers. The names and equipment relating to packaging, of other technology centers are shown in Table 5-3.

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[4] As of March 1993

2) Staffing

The current staffing of Packaging Technology Center and its employment plan in 1993 are as follows:

Number of staff

	(present)	(after new employment)
1. Manager	1	(1)
2. Scientist	2	(2)
3. Engineer	0	(3)
4. Technician	0	(3)
5. Secretary	1	(1)

This manpower plan has been established under the assumption that the center will only provide services related to transportation packaging and will assign other services to other technology centers.

3) Performance

In 1992, the center implemented the following projects:

1. Testing on transportation of dangerous goods
2. Testing on packages for electronic products
3. Pallet test and design
4. Permeability test on plastic films
5. Corrugated container test

Note that the center did not have its own testing equipment with only one staff in 1992, and the above services were provided by other technology centers on a contract basis.

At present, the center plans to implement the following projects by using existing equipment and equipment scheduled to be procured.

1. Cost optimization for package design
2. Study and simulation of transportation and distribution conditions for products exported to the U.S., Japan and Europe
3. Study on shock absorption of cushioning materials
4. Study on the effects of vibration and impact at different humidities on the strength of palletized corrugated shipping containers

These projects are highly demanded in related industries, and in particular, there are many requests for participation from foreign-affiliated electronic/electrical product manufacturers.

(3) SISIR's position within public organizations

The Government of Singapore is organizing the multi agency network which enables responsible government organizations to support the development of local industries through the following 3 schemes:

1) Financial support
2) Tax incentives
3) Development programs

The multi agency network consists of the following 6 organizations and 3 polytechnics, as listed in Table 5-4.

Thus, SISIR is expected to serve as the core organization to support manufacturing industries in Singapore in various aspects of industrial technology. Other technical support organizations are AAC and polytechnics. The former is an organization centering on automation, and the latter focuses on technical training for corporate employees and other people.

5.2.2.2 Expected function of Packaging Technology Center

(1) Role of public technical organizations in the packaging sector

As discussed in 5.2.1.1, individual companies are expected to assume the most important role in implementing strategies required for development of the packaging sector. These strategies can not be effectuated unless individual companies develop their own resources for management and development of packaging technology. Also required are 1) an organization to take lead in empowering related industries to assist individual companies in such efforts, and 2) an organization to support the development of technological infrastructure. Public organizations, in line with this, will provide 1) support for the packaging sector to develop its own technological infrastructure, and 2) supplemental assistance for related industries and individual companies who are limited in ability or resource to conduct required activities.

(2) Expected activities of public technical organizations

Within the above framework to define the role of public technical organizations in promotion of the packaging sector, the organizations are expected to participate in the following technical activities:

1) Development test and research on packaging technology
   a) To conduct joint development test and research projects with related industries.
   b) To conduct own research projects and dissipate the results to related industries.
2) Promotion of standardization
   a) To conduct research projects required for development packaging standards.
   b) To provide technical support for development of draft standards and amendment proposals by related industries.
   c) To disseminate standards.
3) Technical support
   a) To encourage the packaging sector to upgrade its level of technology by introducing advanced technologies that are at the maturing stage in industrial countries.
   b) To conduct packaging-related tests under contract with private enterprises.
   c) To provide technical guidance on the basis of test results above.
   d) To provide support and assistance in other activities conducive to technological improvement of the packaging industry.
4) Human resource development

   To assist related industries in human resource development efforts and to take initiative if necessary.

(3) Demarcation of functions between Packaging Technology Center and other public technical organizations

In addition to SISIR, AAC and polytechnics are public organizations to provide technical support for manufacturing industries.

AAC is involved in development of packaging technology through its expertise in automation, which is one of the most important areas of improvement for the industry. Packaging Technology Center is expected to provide technical support on the software side of automation. Development of hardware required for automation of the packaging process is in rapid progress in various countries. Yet, the packaging industry in Singapore seems to be reluctant to introduce the automation system, despite the fact that they are facing the rise in labor cost and the shortage of labor supply. This is because they do not have know-how in integration of the automated packaging process with packaging design and management practices. Packaging Technology Center should

focus its efforts on guidance and support in this area, while AAC provides technical support in hardware aspects.

Polytechnics are specialized in vocational training. In addition, they provide guidance for private enterprises in the areas of management and technology.

Any of polytechnics does not provide vocational training in packaging. Packaging Technology Center is in a position to provide training for development designing engineers, who are actually engaged in packaging design and manufacturing within companies, and management. This is along SISIR's mission to take leadership in advanced technology and quality. At the same time, the development of training programs and curricula and the provision of necessary human resources should be emphasized from the interest of proliferating the results of research and development efforts to related industries and future generations.

Polytechnics are not providing technical support directly related to packaging, thus Packaging Technology Center is only one organization capable of providing such a service. Once the center establishes methodology of technical guidance through the involvement in development tests, it can transfer it to polytechnics and other organizations for guidance activity. At that stage, the center's technical guidance can be shifted to projects which involve packaging development.

(4) Demarcation of functions among Packaging Technology Center and SISIR's other technology centers

As discussed in 5.2.2.1, SISIR operates technology centers which are responsible for technological development, technology transfer, and technical guidance. This section examines how relations between these centers and Packaging Technology Center should be coordinated.

1) Transportation packaging

There are two technology centers which are capable of conducting tests and R&D activities related to transportation packaging: Electronic Testing Center and Paper and Board Testing Laboratory.

Electronic Testing Center is equipped with machines and equipment to perform environment, vibration and impact tests. The environmental testing machine can only perform tests for consumer packages and small transportation packages, and can not handle unit load and large packaged goods. Other testing equipment is in operating condition, although some of them do not have sufficient capacity or are outmoded. Nevertheless, the center is designed to test strength and other characteristics of

electronic equipment and components. Although some of test results can be used for development and design of packaging, they are collected as testing data for the specific purpose, without systematic approach. At the same time, the center does not have equipment to collect sufficient data in the field of packaging.

On the other hand, Paper and Board Testing Laboratory is capable of performing tests for paper and corrugated cardboard as packaging materials. However, the laboratory does not have equipment nor staff to evaluate specifications and design features for corrugated cardboard boxes and carton board containers.

To conduct testing and research activities for development and design of transportation packaging, relevant data should be collected in a systematic manner to optimize package design throughout the packaging and physical distribution process. For this purpose, Packaging Technology Center needs to have a complete set of testing equipment, regardless of equipment owned by these centers.

2) Consumer packaging

Consumer packaging, especially food packaging, are characterized by difficulty in performing evaluation and technical guidance separately for food containers and food without test. Thus, evaluation and guidance are performed for both containers and contents, and it tends to result in duplication of equipment and function with other centers of SISIR.

The most important element of food packaging evaluation is to determine the degree and level of preservation of food quality. Here, it is very difficult to determine whether a particular evaluation result originates from food itself (or its processing method), packaging materials, packaging methods or technologies, prior to testing. That prevents a responsible authority from determining whether the test should be conducted by Packaging Technology Center or Food Technology Center. Furthermore, most of evaluation methods are unique to certain types of food products. If all of them are to be covered by the two centers, they have to maintain equipment and staff which are largely duplicated between them.

The second important function of Packaging Technology Center, development and improvement of food packaging technology, is also closely associated with food processing and preservation technologies.

In delineating responsibilities of Packaging Technology Center, Food Technology Center, and other technology centers, package inspection items can be used as a criteria for this purpose as classified as follows:

1. Condition of container itself
2. Direct impacts of container on contents (food)

a. Changes in container due to contact with food
b. Constituents of container in food

3. Indirect impacts of container on contents (food)
- Quality of food

Based on the above criteria, Packaging Technology Center should be responsible for evaluation on the conditions of containers, related research and development, and technical guidance, while Food Technology Center will examine the indirect effects of containers on contents. In addition, the direct effects of containers on contents are jointly evaluated by the two centers; the former is primarily responsible for evaluation of containers, and the latter for constituents of containers in food. This principle should be applied to evaluation of food packages. The two centers, however, should be jointly responsible for selection of alternative characteristics for quality verification, though Food Technology Center should perform analysis and evaluation so as to avoid duplication of equipment and staff.

Regarding the second function of development and modification of packaging technology, and related guidance and transfer, Food Technology Center should assume responsibility for primary packaging which is closely associated with quality preservation and marketing functions, while Packaging Technology Center will take leadership in the issues related to the quality of packaging materials, the form of packaging, and the packaging system.

The third function – services related to analysis and standard testing for packaging materials – should be performed by Packaging Technology Center. However, tests requiring equipment which is not owned by Packaging Technology Center but is available at other center (such as testing of gas-barrier and similar characteristics) can be performed as the joint project. For instance, analysis of materials and their quality performance can be performed jointly with Polymer Technology Center. In this case, however, Packaging Technology Center should appoint an engineers for coordination of the testing operation for prompt and reliable service.

The fourth function, evaluation of package's effects on marketing and consumers, is a critical function in ensuring quality improvement of food packaging and development of new products. However, evaluation is based on personal sensitivity and taste, not suitable for equipment analysis evaluating alternative characteristics. For this reason, it should be performed by Design and Development Center and other qualified organization. If not available, Packaging Technology Center may have to consider possible expansion of its activity into the field.

On the other hand, issues related to environmental compliance, waste disposal, and the quality, composition and additive of packaging materials should be led by Polymer Technology Center. Packaging Technology Center should be responsible for characterization of environmental compliance systems and packaging materials.

Overall, Table 5-5 lists evaluation items related to food packaging, which should be responsibility of Packaging Technology Center.

Packaging Technology Center should maintain the function to evaluate safety of packaging materials in relation to safety and to issue certificates as required. Table 5-6 summarizes tests and standards applicable to plastic materials undertaken in Japan.

(5) Cooperation between Packaging Technology Center and related industries

As discussed earlier, the strengthening of the packaging center should be led by the packaging industry and user industries, and the function of Packaging Technology Center should be concentrated to form the core of building technological infrastructure. Nevertheless, the center should keep close relationship with related industries to identify and meet changing needs of the sector.

For this purpose, an industry forum, say "packaging technology society", should be organized by those from the packaging industry, user industries, and other related organizations. Note that the packaging technology society is not necessarily a single organization. Rather, two or more societies may be established for a particular industry group or other purposes. SISIR serves as the core organization to bond activities of various societies together, although SISIR should assume a subordinate and supportive role to maintain the initiative of industries concerned. Major activities of the packaging technology societies, among other things, are:

1) Information exchange based on study and research of member companies
2) Mutual training through field tours on companies with advanced technology and practice, and participation in trade exhibitions
3) Publication of a bulletin reporting the activity and research results of the societies.

5.2.2.3 Major activities of Packaging Technology Center

Industrial users of packaging materials in Singapore can be classified according to quality requirements of their packaging, into the following 4 types, and the difference in quality requirement level determines priority to deal with issues related to packaging.

1) Manufacturers of products that are exported to international markets: Electronics/electrical products are a primary example of this, with some of food products. These industries have strict quality requirements for packaging materials and limit supply sources to large makers. However, packaging design is based on

requirements and conditions applicable to industrial countries, and proper adaptation is needed in consideration to meteorological conditions, shipping practices, and other local conditions peculiar to Singapore and importing countries.

2) Manufacturers of food products which are exported to specific markets: Food products in this category are characterized by relatively a small volume of production compared to internationally traded products, and customers give priority to price over quality. As a result, the packaging cost allocated by the maker is limited, and packaging materials are procured from a general market. Overall, packaging in this category serves to satisfy part of functions expected for food packages or fails to satisfy an overall requirement level.
3) Manufacturers of products which are imported and repackaged in Singapore for re-export: Including chemicals and food products which are contract packaged or refined (edible oil). In the case of contract packaging, the shipper specifies packaging materials. Generally, imported packaging materials are specified while Singapore provides low-cost labor force. Other industries which do re-packaging, also do not have the ability to add a significant value to individual products or to add advantages in physical distribution.
4) Manufacturers of products which are imported, stored and transshipped in Singapore without re-packaging: Including electronic and electrical products, and automotive parts. In this case, companies in Singapore do not make any packaging, but some of packaging and physical distribution companies are involved in collective packaging and palletizing for shipping. Nevertheless, pallets are not designed in accordance with local conditions related to physical distribution, and those available in the market are used without modification. Finally, the packaging industry fails to keep pace with ongoing streamlining of physical distribution work to capitalize on the advantage as a regional distribution center.

Major industrial users of packaging materials in Singapore are food and beverage, electronic and electrical, and chemical and pharmaceutical industries, which account for 40.0%, 22.1%, and 20.2% of total consumption of packaging materials by all the manufacturing industries, with a combined share of 82.3%.

At present, the electronic and electrical industry shows the most urgent demand for improvement of packaging. There are three reasons for this: 1) electronic/electrical products and parts are exported to international markets and the quality of packaging is closely associated with their competitiveness, 2) electronic/electrical products and parts packaged in Singapore are increasingly sophisticated and high priced, so that packaging

defect often leads to a considerable commercial damage, 3) although most of packages are designed at headquarters of MNCs, packaging defect often occurs because field data related to transportation and handling conditions in Singapore and importing countries, including climatic conditions, are not fully analyzed and supplied to designers, and 4) MNCs are rapidly shifting production bases for electronic/electrical equipment and parts to overseas, and in the case of transfer to Singapore, package development and design capabilities are often included. The industry largely wants the improvement of shipping packaging, which Packaging Technology Center can deal with.

The next largest demand for improved packaging comes from the food industry. However, unlike the electronic and electrical industry, it is not likely to surface as the need handled by Packaging Technology Center. Generally, development of food packaging materials in recent years emphasizes the development of new applications by increasing types of existing materials with diverse characteristics, rather than the development of new materials. As discussed earlier, the food industry in Singapore is divided into the subsector which serves the international market and those who serve local markets and specialty markets consisting of a particular ethnic group. In the former type, development of packaging materials is carried out by users, food consultants or jointly with the packaging industry. Further, packaging materials available can be used in most of places because required specifications of these materials are not significantly different among the international marketplace. In contrast, products in the latter category have unique characteristics adopted to local conditions, and further, because of small size of these food manufacturers, packaging makers are not likely to cooperate in developing packaging according to their needs. Also, consumers of these foods give priority to price over quality, thus generally tolerate packaging defect, so that food makers select packaging materials which are essentially copied from their competitors'. Although these makers sometimes have to develop or design own packaging materials and need to have support for improvement of packaging technology, most of problems arise in the area closely associated with food processing technology, thus packaging is rarely taken up as an issue to be dealt with.

The chemical industry shows low interest in improvement of packaging because packages for chemical products have reached a matured level and there is small demand for development of new packaging materials. On the other hand, the pharmaceutical industry is active in developing new packaging materials and design, as seen in the food industry. However, most of development work is done at headquarters of MNCs, and there is little demand for Package Technology Center in Singapore.

Among other industries, the toy industry seems to need technical support for package design, which is very similar to that wanted by the electronic/electrical industry.

Further, common issues facing all the industries are 1) packaging which addresses the need for streamlined physical distribution, and 2) adaptation to environmental issues. Packaging Technology Center receives high expectation as an organization capable of providing the proper guideline.

In overall consideration to the above factors, Packaging Technology Center, while its activity should be based on transportation packaging, should pursue the following policies: 1) in the area of transportation packaging, the center should be ready for taking leadership in joint activities with other centers, and 2) in the area of food packaging, it should promote joint activities with Food Technology Center for the time being, but it should assume responsibility for services related to packaging.

5.3 Recommended Development Plan for Packaging Technology Center

5.3.1 Framework of the Plan

Based on the foregoing analysis, development thrusts for the proposed Packaging Technology Center are recommended in this section, together with programs to implement each development thrust.

Thrust 1: Giving support to upgrading industries in Singapore through promotion of the advanced packaging sector

Program 1: Accumulation of packaging technology at the center

Program 2: Transfer of packaging technologies to the packaging sector through joint research with industries

Program 3: Collection and accumulation of data and development of data base related to transportation packaging through joint and own research projects

Program 4: Development of packaging technologies reflecting packaging environment in Singapore through own research efforts

Program 5: Collection and dissemination of packaging technology information from overseas

Program 6: Organizing associations for the study of packaging technology

Program 7: Stepping up of efforts to deal with environmental issues

Thrust 2: Provision of technical infrastructure for packaging development

Program 8: Support for technological development of the packaging sector

Program 9: Promotion of standardization in packaging

Program 10: Development of standards testing system for packaging

Program 11: Human resource development

Thrust 3: Evolution to Southeast/Southwest Asian Packaging Centers

Program 12: Evolution to a packaging engineer training center for Southeast and Southwest Asian Regions

Program 13: Evolution to a integrated packaging testing center for Southeast and Southwest Asian Regions

Each of the above development thrusts and programs is described in the following sections.

5.3.2 Development Plan

5.3.2.1 Development thrusts and programs

Thrust 1: Giving support to upgrading industries in Singapore through promotion of the advanced packaging sector

Traditionally, the packaging sector in Singapore has been coping with packaging-related issues on a case-by-case basis, with individual companies having almost no section nor staff specialized in packaging. It is not capable, therefore, for the existing packaging sector to meet the increasingly sophisticated and diverse packaging requirements, particularly those of the electronics/electrical products industry.

The advanced packaging sector is expected to have the ability to analyze and solve problems in a systematic manner by staff specialized in packaging having appropriate packaging technology, and to develop new packaging in a time- and cost-effective manner. Such an ability cannot be learned only through seminars and training courses, but it should be acquired through participation in actual research and development projects or various case studies.

These R&D projects and case studies will also provide good opportunity for the packaging sector to develop new expertise.

The Packaging Technology Center can play a core role in introducing packaging technology into Singapore, transferring it to the sector and accumulating experience and expertise in this country.

Program 1: Accumulation of packaging technology at the center

1) Program outline

a) Introduction and acquisition of advanced packaging technologies and skills by the center's staff, and the formulation of curriculum for technology transfer programs

b) Inviting packaging experts from other countries which have advanced packaging technology, and/or ties-up with packaging technology centers in these countries for technology transfer

2) Activities

a) To continue ongoing training programs related to packaging technology, so that staff of the Packaging Technology Center can learn packaging technology in a systematic manner. Then, contents of these training programs will be developed into textbooks which will serve as a basis of future technology transfer to related industries, while this process will work as follow-up process of staff training. As an example of systematic packaging technology training, the outline of a training program for packaging managers conducted by the Japan Packaging Institute is presented in Table 5-7.

b) As supporting staff until the center's staff attain sufficient expertise and practical experience and become capable of promoting technology transfer by themselves, experts may be invited from countries having advanced packaging technology on an individual contract basis or through a technical assistance agreement with an appropriate foreign packaging technology center. The supporting staff are essential in the initial stage of technical support service to be provided by the center to the packaging sector, in addition to staff training. Also, implementation of various programs described later is an important method of accumulating technological resources at the center, and the supporting staff are expected to provide useful advice. Also, they can be of great help to develop the center's own training curriculum.

3) Program requirements

a) Recruiting and securing of Packaging Technology Center's staff

b) It is important that all the expert staff (engineers or higher) will learn all aspects of packaging technology regardless of their specialty. (Note that, while the packaging training center focuses on the area of transport packaging, all the expert staff are expected to learn consumer packaging as well.) In addition, staff who also work at other centers will learn all aspects of packaging technology.

c) The program will start from training courses based on lectures by foreign experts, which will then gradually be replaced with the center's expert staff. The foreign experts will serve as advisors for a certain period of time.

4) Implementation

a) Implementation of training courses for expert staff: 1 year and 6 months including the ongoing courses. Use of training courses conducted by foreign organizations may be another alternative.

b) Technical support by foreign experts: For periods until the following programs are completed (excepting technical support for the establishment of regional centers for Southeast Asia/Southwest Asia):

1. Training of expert staff:	1 year and 6 months
2. Joint research and development:	Period required to implement 4 – 5 projects
3. Proprietary research:	2 years

Program 2: Transfer of packaging technologies to the packaging sector through joint research with industries

1) Program outline

To conduct joint research and development projects with related industries. At each stage of project, relevant packaging technology and research methodology will be transferred to the participants.

2) Activities

Major study and research projects related to transport packaging will be the following:

a) Study on transportation environment

Field study on domestic and foreign distribution channels, modes of transport, and port and harbor facilities, and measurement and analysis of impacts due to rough handling in the physical distribution process, vibration on transport, compressive load during the storage, condensation and soaking due to temperature and humidity changes.

b) Measurement of physical properties of packaged goods

To develop and design packages which can withstand vibration and shock in the distribution process by using a minimum required amount of material, it is important to establish "shock fragility" of a particular product by measuring how far it can

withstand vibration and shock. By detecting and reinforcing a damage-susceptible part of the project, the packaging can be reduced significantly.

c) Measuring of physical properties of packaging materials

To evaluate various types of packaging materials, including corrugated boards, cushioning materials, and dump proof or rustproof materials, through standard testing methods, thereby to establish a basis of quality control for packaging materials. Also, physical properties of newly developed packaging materials are measured and evaluated in consideration to transport and handling conditions measured earlier. In the future, the methods of these quality tests will be made into industrial standards, based on which a quality certification system will be operated.

d) Simulation test

To check if a package is suitable for transport and handling conditions expected, the product is tested by applying external forces, such as vibration, shock (falling and collision), and compression, unfavorable climatic conditions including temperature, humidity, and raining, as well as their combination. In the future, the methods of these simulation tests will be developed into industrial standards, which will form a basis of a quality certification system.

Some of the above study and research projects are already proposed by the Packaging Technology Center as testing and research projects to be jointly conducted with related industries. (See 5.2.2.1) Also, the program should be operated in a flexible manner to address the issues which arise from time to time and require technical assistance of the center.

3) Program requirements

Each of the tests described above needs to be designed consistent with basic packaging technologies, and technical advice of experienced experts will be required in the process.

4) Implementation

Many companies wish to participate in the study and research projects proposed by the Packaging Technology Center, and they should be started as soon as required equipment is installed and is ready to operate. At the same time, their schedule should preferably be timed with invitation of foreign advisors.

Usually, one project can be completed in one year, and one staff can handle two projects concurrently.

Program 3: Collection and accumulation of data and development of data base related to transportation packaging through joint and own research projects

1) Program outline

To collect and accumulate data required for transport packaging design, which are obtained through joint and own research projects, in a systematic manner.

2) Activities

Required data will be collected from the results of the study and research projects. The data will be indexed and sorted out to develop a database accessible by those who need the data. Then, it will be incorporated into an outside database if suitable for the purpose.

In Japan, data and information related to packaging technology are stored in JICST Science and Technology Literature File[5] and are provided through on-line retrieval and publication.

3) Program requirements

It is important to let the database widely known to both people engaged in data collection as well as users, and to make data stored from time to time available in a timely manner. For this purpose, information on data collection activity and database service should be periodically provided through house bulletins of the Packaging Technology Center, SISIR, and PCS, and other media.

4) Implementation

Preparation for data base design should be initiated immediately.

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[5] The database provided by Japan Information Center for Science and Technology (JICST), storing periodicals, technical reports, conference proceedings, and other excellent scientific and engineering literatures published in around 50 countries. Key words used to retrieve packaging-related information from the database are shown in Table 5-8.

Program 4: Development of packaging technologies reflecting packaging environment in Singapore through own research efforts

1) Program outline

The Packaging Technology Center will undertake its own research focusing on matters related to the improvement of packaging, which are not likely to be taken up in contract research or joint research, and make it the results public.

2) Activities

a) Research topics

Research topics which are not usually taken up in contract or joint research projects include 1) the test to measure compression strength and vibration resistance of corrugated cardboards under temperature and humidity conditions of Singapore, 2) the experiment using dummy cargoes of varying sizes and weights to identify cargo handling conditions in Singapore and its trade partners, and 3) the measurement of vibration in different modes of transport. Also, there are various research items that can not be handled by individual companies, such as the fixing of cushioning materials, rust-proofing, dump-proofing, collective packaging, and other packaging-related technologies, and automation; development of packaging materials which are demanded by smaller packaging users who are not capable of developing on their own, and which can be made available to general users in Singapore; and data collection and analysis for development of standards discussed later.

b) Implementation of study and research projects

The study and research projects should be conducted by expert staff of the Packaging Technology Center. However, an urgent project or a project which cannot be conducted by the center for time constraint may be contracted out to universities or other SISIR technology centers.

3) Program requirements

There are numerous topics for proprietary study and research, and appropriate ones need to be selected according to the priority and urgency for the industry. Also, foreign advisors should be engaged from time to time for effective research design and productive use of foreign research results.

4) Implementation

Preparation for implementation of the program should be started as soon as the initial training for key staff is completed. It includes the selection of research topics

and appropriate research design. The assistance of foreign advisors is recommended to be obtained this stage of implementation.

Program 5: Collection and dissemination of packaging technology information from overseas

1) Program outline

To collect and disseminate overseas packaging technology information to the related industries, thereby providing a"technological stimulus" to the packaging sector. At the same time, information so collected will be made to a database available to the packaging sector.

2) Activities

a) Collection of literatures and documents related to packaging, physical distribution environment, methods of testing and measuring;
b) Collection of packaging-related standards in major countries (focusing on major export markets for Singapore);
c) Incorporation of the above information into a database;
d) Dissemination of information through seminars and workshops;
e) Dissemination of latest information through periodicals of Packaging Technology Associations, which are discussed later; and
f) Making the database available to the packaging sector.

3) Program requirements

The program requires full-time or near-full-time staff and budget for information collection. Also, to ensure smooth and timely flow of collected information to related industries, they should be organized in the form of membership for the Packaging Technology Society (described in detail later) or support membership for the Packaging Technology Center.

Also, short-term seminars are helpful for people who are engaged in packaging-related work or who require general knowledge on packaging, in contrast to a formal training program to educate experts. In particular, they are effective means to acquire information on specific technology trends, new techniques and products, while serving as a primer to packaging technology. It should be noted, however, that program development requires careful considerations to possible participants, program organization, and selection of lecturers.

The program may cover special events jointly held with related industries, such as 1) exhibitions on packaging materials and machinery, and related equipment and

materials, and 2) study and research on overseas packaging technology. In fact, certain types of exhibitions could provide opportunities for productive information exchange and commercial meetings. In particular, for small- and medium-size enterprises which are limited in ability to collect useful information by themselves, exhibitions offer advantages in allowing them to compare and evaluate similar types machinery and materials, to check their performance and operating conditions, to obtain samples for packaging materials, and to have technical consultation. Nevertheless, exhibitions do not always produce favorable results, especially if poorly organized, and the use of expert organizers may be a good choice for certain types of exhibitions.

Further, the sending of overseas missions to study latest production technology is an effective means to upgrade an overall level of packaging technology. At exhibitions and seminars held in foreign countries, large amounts of valuable technology information not available in Singapore can be obtained. Field tours on food processing and packaging operations, and market study allow visual comparison of a current level of domestic technology versus an international level of technology, another useful method to motivate the upgrading of packaging technology.

4) Implementation

Preparation for implementation of the program should be started immediately, covering 1) selection of permanent information sources, 2) appointment of staff responsible for program implementation, and 3) organization of the Packaging Technology Society and support members for the Packaging Technology Center.

In addition, ongoing short-term seminars will be continued.

Program 6: Organizing associations for the study of packaging technology

1) Program outline

To organize associations for the study of packaging technology under participation of packaging experts from packaging makers and users, distributors and related industries, and other academic and government organizations, for the purpose of technology exchange and mutual learning to upgrade technical expertise of packaging personnel and to encourage and revitalize corporate R&D activities.

2) Activities

The associations will serve as the core of the packaging sector in technology exchange and mutual learning. It will be operated as a regular informal discussion session where members exchange information and ideas on the basis of the results of

the center's own research, joint research projects, and individual research projects. Major findings and discussions will be compiled and published as a house bulletin.

Two or more associations may be organized for specific topics when considered necessary, e.g., an association for the study on corrugated cardboard and collective packaging.

3) Program requirements

A prerequisite to the program is that the industry welcomes and is ready to encourage technology exchange. If the societies are used as a place for "information snatching" or "job hopping," some adjustment should be made to devise a more feasible means, e.g., to limit types of disclosed information to technology information that is at the maturing stage or the outcome of the center's research projects.

4) Implementation

The societies establishment of workshop is proposed to companies who have announced the intent to participate in joint research projects, and those who participate in seminars. Members will be individuals and companies.

Program 7: Stepping up of efforts to deal with environmental issues

1) Program outline

To initiate a systematic approach to comply with environmental regulations in export markets, thereby not only assisting Singapore's manufacturing industry in effectively dealing with the issues, but also making the advancement in the attitude for environmental protection as one of competitive edges of Singapore's products.

2) Activities

To organize the association for the study on environmental protection under participation of those from the packaging industry, user industries, and SISIR's related centers. The association is one of associations for the study of packaging technology proposed in the previous section and will conduct activities described therein, which will initially include the following:

a) To understand environmental measures and regulations enforced in major export markets; and
b) To learn actual cases of environmental measures related to packaging in countries having advanced environmental protection measures.

In the future, the workshop will propose a draft guideline for environmental protection measures in Singapore.

3) Program requirements

Environmental measures can serve their purpose only after they are implemented. The implementation is the only one effective way to improve reputation of Singaporean products in export markets. For this reason, active involvement of related industries in the program is essential to its success.

4) Implementation

To analyze information on environmental measures obtained through the collection of technology information, as described in Program 5, and to disseminate it to the industry in order to demonstrate the need for effective environmental measures. Also, the need for the Environmental Study Association will be appealed through other study associations (Program 6). As soon as the need is recognized in the industrial community through these activities, the study association will be started.

Thrust 2: Provision of technical infrastructure for packaging development

Actual development of packaging technology is conducted by individual companies. To help produce effective results from efforts of individual companies, a variety of technical infrastructures are called for, including industrial standards as norms for product development and quality control, means and tools to evaluate development results, technical assistance in product development, and means to foster human resources for packaging development. The center will develop and provide these technical infrastructure to support individual companies and promote the upgrading of the packaging sector.

Program 8: Support for technological development of the packaging sector

1) Program outline

a) To conduct tests on packaging materials and quality on contract basis;

b) To provide consulting service for improvement of packaging, based on the test results; and

c) To supply experts for technical assistance upon request from clients.

2) Activities

Technical assistance is designed as a follow-up service for transfer of advanced packaging technologies to individual companies, as implemented in Programs 1 through 7, by dealing with problems that occur in the process of putting such technologies in practice. Basically, technical assistance will be provided in the form of contract testing.

The center will inform a requesting company of test results and give advice on required and feasible areas of improvement. While technical assistance is subordinated to testing service, it will promote closer relations between the center and industries by inducing testing service. Furthermore, technical assistance will help streamline technological development by individual companies. In the case of contract tests which need to be re-assigned to SISIR's other organizations, the center should provide technical assistance from the interest of packaging.

In addition, individual companies may want technical advice for development of new packaging technology or materials, which requires experienced experts who can provide consulting service for a variety of problems. Obviously, the center's staff do not have the ability to provide sufficient service for every problem, or they may face time constraint. Thus, this type of technical assistance should preferably be provided by 1) experts to be sent under the contract with similar foreign organizations, or 2) experts, domestic or foreign, who are registered with the center and are assigned upon request.

3) Program requirements

To give proper technical advice after testing, technical background and practical experience are required. Thus, it is imperative to engage experts at the initial stage of the program, from countries having a high level of packaging technology.

Meanwhile, proper industrial standards should be developed as the basis of evaluating test results.

4) Implementation

As testing service is one of basic duties of the center, it should be started upon opening of the center.

Program 9: Promotion of standardization in packaging

1) Program outline

a) To conduct research projects required for development of packaging-related standards;

b) To provide Technical Committee on Standards or the industry with technical advice on preparation and revision of draft standards; and

c) To promote use of standards among the relevant industries.

2) Activities

To establish and update national standards in Singapore, the Technical Committee on Packaging Standards is organized by representatives from related industries (packaging industry, user industries, and distributors and related service companies) and government organizations. The committee sets priority on standards to be developed and commissions preparation of draft standards to an appropriate organization, usually the industry affected by such standards. Here, the center can provide basic data which are essential in preparing the draft standard. These data are mainly obtained from compilation and analysis of results of joint research projects described earlier. If no data are available, the center will collect such data through its own research, from time to time as required.

Also, it is desirable for the center to give advice on priority of development of packaging standards and contents of draft standards.

Further, proliferation and acceptance of standards should be promoted by demonstrating their merit in practical use, and a certification system is one of the most effective way in this connection. It is recommended to consider the possibility of establishing a certification system, including mandatory one, for the area where the use of technical standards can be most effectively promoted through such a system.

It should be noted, however, that the center focus on promotion of voluntary use rather than promotion through regulation. The dissemination is recommended to undertake through the Center's programs to advertise and demonstrate advantages of use of standards.

3) Program requirements

In Singapore, there are 7 standards related to packaging. All of them are based on international or foreign standards. Since the country's manufacturing and physical distribution industries have to establish their international competitiveness through harmonization with other countries in terms of product and service qualities, international standards should form the basis of national standards as far as possible, rather than insisting on Singapore's own standards. Nevertheless, care should be taken to make sure that each standard to be introduced will conform to practical needs and requirements peculiar to the country. In this sense, therefore, extensive study and research on foreign and international standards are called for to develop the basis of preparing acceptable and enforceable standards.

4) Implementation

Selection of required packaging standards should be started as soon as possible through the societies for the study on packaging technology and other media. The immediate step is to appoint personnel in charge of standardization within the Packaging Technology Center.

Program 10: Development of standards testing system for packaging

1) Program outline

While packaging companies as well as user industries have some equipment to conduct packaging-related tests, there are various tests that have to be conducted by the third party organization. Such tests are one of SISIR's important functions, and the organization is expected to have facilities and equipment capable of handling most of tests based not only on Singapore standards but also on foreign and international standards.

2) Activities

a) In principle, the center will have facilities and equipment to conduct tests related to transportation packaging. On the other hand, tests related to consumer packaging and physical properties of packaging materials will be conducted at other center, as far as adequate equipment is available. If not, such equipment should be procured by the Packaging Technology Center or other center.

b) For division of responsibility for testing service, see 5.2.2.2 (4). If a test is to be conducted by other center, the Packaging Technology Center will be responsible for coordination of packaging-related tests.

3) Program requirements

Testing equipment required to conduct transport packaging tests should be procured as soon as possible to offer complete testing service.

4) Implementation

As this is one of fundamental functions of the Packaging Technology Center, necessary procurement should be made to be ready for a complete line of service expected by the industry.

Program 11: Human resource development

1) Program outline

a) To conduct training courses to develop expertise in packaging technology; and

b) To provide manpower to assist the industry in developing human resources.

2) Activities

a) As an example of training for packaging engineers, the outline of an educational program for packaging managers conducted by the Japan Packaging Institute is shown in Table 5-7 (described in the former part). In the future, the center is recommended to take initiative in developing its own training program to teach comprehensive knowledge on packaging technology by industrial specialists.

b) The Packaging Technology Center will appoint planners for training courses. Instructors will be selected from experts who are sent by outside organizations or are registered with the center, as described earlier. While it is desirable for the center to have its own expert staff who can work as instructors, as the center's staff are expected to cover a wide range of duties, thus, the use of foreign experts (local experts to be considered in the future) seems to be the most economical and feasible solution.

c) Persons who have completed the training program should receive a certificate to enhance the value of the program to educate professional engineers. However, an actual system should be carefully designed so as to take into account conditions peculiar to Singapore, e.g., engineers tend to avoid field work, and professional qualification or certification accelerates job hopping.

d) To send experts of foreign organizations or registered experts to technical workshops, seminars, and field tours sponsored by related industries.

3) Program requirements

a) To nurture in-house planners.

b) To establish appropriate training programs.

c) To ensure and maintain necessary instructors.

4) Implementation

The training program will be developed in line with ongoing staff training. As professional training will form the basis of joint research, it should be implemented prior to or concurrently with joint research projects.

Thrust 3: Evolution to Southeast/Southwest Asian Packaging Centers

At present, packaging technology in Southeast and Southwest Asian countries is still at relatively a low level, and many countries have strong interest in improving packaging quality[6]. On the other hand, many of MNCs operating in these countries have testing equipment for a limited number of test items only, and do not have the ability to conduct a complete range of packaging tests. Under these circumstances, there is a clear need and opportunity for the Packaging Technology Center in Singapore to serve as a regional center offering testing and other services.

If the center can fulfill such a function, it leads to improved reputation for the packaging sector in Singapore, then its industrial products. And the increased reliability on the packaging sector in Singapore will create opportunity for the sector to make service exports to countries in the region.

Program 12: Evolution to a packaging engineer training center for Southeast and Southwest Asian Regions

1) Program outline

To conduct training courses for packaging engineers in Southeast and Southwest Asia regions

2) Activities

a) Formulation of training program for packaging engineers

b) The Packaging Technology Center will appoint planners to design training courses and will organize instructors who are mainly experts sent by foreign organizations and registered experts. Although the center's staff are expected to have expertise and experience sufficient for instruction, they are likely to cover a wide range of duties, so that instructors need to be recruited from outside (those in Singapore and other Southeast/Southwest Asian countries will be considered in future).

c) Persons who have completed the program will receive a certificate or other form of qualification.

3) Program requirements

a) To appoint in-house planners.

b) To develop an adequate training program. The internationally acceptable program should be prepared under collaboration with related organizations in countries

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[6] Participation in JICA's International Packaging Technology Training Course (conducted by Japan Packaging Institute) by trainees from Southeast and Southwest Asian countries is shown in Table 5-9.

having advanced packaging technology. It will cover general items for the time being, and will be revised to reflect packaging needs in the region.

c) To recruit and maintain required instructors.

d) To ensure smooth program development and recruiting of instructors, collaboration with foreign technical assistance organizations and those specializing in packaging technology is desirable.

4) Implementation

The program should be developed concurrently with development of the local training program. The first step is to make arrangement with foreign organizations for technical assistance in various aspects of program development, which would be essential in successful implementation of the program.

Program 13: Evolution to a Integrated packaging testing center for Southeast and Southwest Asia Regions

1) Program outline

To conduct standard tests on packaging on contract basis with users in Southeast and Southwest Asian countries, and to receive trainees on package testing techniques.

2) Activities

a) To operate a package testing system under International Laboratory Standards[7];

b) To make advertisement on contract testing service;

c) To establish a training program to receive trainees on package testing techniques; and

d) To expand international mutual accreditation of testing laboratory with foreign laboratories[8].

3) Program requirements

As a testing laboratory, the center will have to be capable of conducting reliable tests in the first place, and for this purpose, guidance of foreign experts is desirable at

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[7] International laboratory certification standards are provided by ILAC (International Laboratory Accreditation Conference) and ISO. In particular, ISO offers "ISO/IEC Guide 25-1990. General requirements for the competence of calibration and testing laboratories."

[8] Many countries maintain their own laboratory certification systems (in Singapore, SINGLAS (Singapore Laboratory Accreditation Scheme)), and if mutual accreditation is agreed between Singapore and other country, a testing laboratory accredited under SINGLAS is automatically accredited in the counterpart country.

the initial stage of testing service. Also, the center should satisfy basic resources requirements as an internationally acceptable laboratory.

At the same time, the center should serve as a research organization capable of receiving trainees on the basis of an established training program.

5.3.2.2 Staffing Plan

(1) Staffing

The staffing plans for individual program are shown Figure 5-2 and Table 5-10. The staffing plan for the Center on the basis of the above is as follows:

Manager	1
Senior staff	2
Staff (Engineer)	3
Assistant staff	3
Secretary	1

(2) Staff training program

The staff training program has already started since the equipment was installed. The program implemented and the program required are shown in Table 5-11.

5.3.2.3 Equipment Plan

(1) Transport package-related testing equipment

Major testing equipment for transport packages is as follows:

1) Testing equipment related to transport packaging
   a) Testing equipment and materials to simulate transport conditions;
   b) Testing equipment to check damage susceptibility of products; and
   c) Measuring instruments to check transport environment.
2) Equipment to test performance of packaging materials

These equipment is described as follows.

1) Major testing equipment related to transport packaging
   (See Table 5-12)
   a) Compression tester

The compression tester is used to check strength of general transport packages, empty containers, and pallet loads against pressure at the time of loading.

ISO 3676–1983 (Packaging–Unit Loads Sizes–Dimensions) specifies the limits for loading in maritime containers (ISO Series Freight Containers) and jumbo freighters for export; the maximum length of a unit load measured as flat dimensions is 1,240mm and the maximum stack height 1,500mm. As a result, the compression tester requires a compression board and stroke larger than these dimensions, and the maximum compression load of 5 tons.

Also, since the test includes edges and corners, in addition to flat crush, the testing equipment includes metal fasteners to prevent movement and deformation of a test specimen, while it should be able to record test results (compressive load – displacement line diagram) automatically.

Applicable standards are as follows:

ISO 2872–1985:	Packaging – complete, filled transport packages – compression test
ISO 2874–1985:	Packaging – complete, filled transport packages – stacking test using compression tester
ISO Z 0212–1987:	Transport packages and containers – compression testing method
ISO Z 0200–1987:	Transport packages – general rules for appropriate evaluation and testing methods

b) Vibration test system

The vibration test system is used to check the degree of damage to contents and/or packages of general transport packages and pallet loads due to vibration during transportation, and vibration isolation and buffering effects of packages, and the resonance effect.

A vibration table to place a test specimen should be flat and 1 square meter or less, with the maximum loading weight of 200kg or larger. The test system should be capable of vibrating in vertical and horizontal directions, with variable frequencies in constant, sweep, and random modes.

Applicable standards are as follows:

ISO 2247:	Packaging – complete, filled transport packages – vibration test at fixed low frequency
ISO 8318:	Packaging – complete, filled transport packages – vibration test using as inusoidal variable frequency
ISO Z 0232–1987:	Transport packages and containers – vibration testing method
ISO Z 0200–1987:	Transport packages – general rules for appropriate evaluation and testing methods

c) Shock test system

The system is designed to evaluate and test damage boundaries measured by allowable vector of energy under shock-generating environment in the process of distribution and use of products. The damage boundaries are required for appropriate cushioning design. The system is capable of conducting free fall equivalent tests as well as cushioning suitability of transport packages. Applicable standards are as follows:

ISO 8568-88:	Mechanical shock-testing machines, characteristics and performance
IEC 68-2-27:	Basic environmental testing procedures Ea: shock
ASTM D3332-88	Mechanical-shock fragility of products, using shock machines
JIS C 0041-87:	Environmental testing methods (electronic/electrical), shock testing methods

d) Drop tester

This is the testing equipment to evaluate the quality of transport packages by applying shock equivalent to a typical drop in the handling process. It is capable of testing a package weighing less than 100kg, which can be dropped in three orientation, flat face, edge, or corner. Applicable standards are as follows:

ISO 2248:	Packaging - complete, filled transport packages - vertical impact by dropping
ISO Z 0202-1987:	Transport packages - drop testing method
ISO Z 0200-1987:	Transport packages - general rules for appropriate evaluation and testing methods

e) Electric hook

It is designed to evaluate the quality of transport packages by applying shock equivalent to a typical drop in the handling process. By using a hoist and an electric hook equipped in a test chamber, a transport package with mass of up to 2 tons is lifted to a specific height for dropping.

Applicable standards are as follows:

ISO 2248:	Packaging - complete, filled transport packages - vertical impact by dropping
ISO Z 0202-1987:	Transport packages - drop testing method

ISO Z 0200–1987: Transport packages – general rules for appropriate evaluation and testing methods

f) Inclined plane tester

This is used to apply shock equivalent to horizontal impacts subject in the distribution process of general transport packages and pallet loads. The tester consists of two rails that are installed with an angle of 10 degrees to the horizon, and a slider which collides with a vertically held shock plate to measure the speed on collision.

Applicable standards are as follows:

ISO 2244: Packaging – complete, filled transport packages – horizontal impact tests

JIS Z 0205–61: Incline plane testing methods for transport packages and containers

g) Bump tester

The bump tester is used to check the cushioning effect of packages against repeated impacts during transportation, and the adverse effect on contents.

A table to place a test specimen should be of flat type with 1 square meter or less. The tester should be capable of generating vertical shock with variable degree of impact and test frequency.

Applicable standards are as follows:

IEC 68–2–29: Basic environmental testing procedures Part 2: Test Eb: Bump

JIS C 0042–87 Environmental testing method (electronic/electrical): bump testing method

h) Acceleration measuring system for laboratory

The system is used for measuring and recording of acceleration at the drop test and inclined plane test for transport packages, the anti–shock test for products, the dynamic compression test of cushioning materials, and similar tests. Each system consists of a X–Y plotter, a personal computer, and acceleration sensors of varying sensitivities according to the purpose.

Measuring instruments are all accommodated in a cabinet rack and are arranged in such a manner to ensure the ease of operation, and a power unit is attached.

i) Climatic simulation chamber

The climatic simulation chamber is used for pre-treatment or conditioning of packaging materials and transport packages before testing (tests to evaluate resistances against compression, vibration, drop, and other adverse conditions), and for testing adaptability of transport packages and contents to different temperature and humidity conditions. The chamber should have a sufficient volume to accommodate and test a pallet load (1,240mm x 1,240mm x 1,500mm in height). ISO and JIS specify relatively wide ranges of temperature and humidity for testing, namely +55 degree C to -55 degree C and 30% - 85%R.H., which are divided into two ranges, one for the climatic simulation chamber, and other for the low-temperature climatic simulation chamber, described in the following section. The climatic simulation chamber is capable of conducting test and pre-treatment under specified temperature and humidity conditions in the ranges between 0 degree C and 50 degree C, and between 30 to 90%R.H.

Applicable standards are as follows:

ISO 2233:	Packaging - complete, filled transport packages - conditioning for testing
JIS Z 0203-1987:	Pre-treatment for testing of transport packages

j) Low-temperature climatic simulation chamber

Like the climatic simulation chamber, the low-temperature climatic simulation chamber is used for evaluation of transport packages and contents in adaptability to specific temperature and humidity conditions, and pre-treatment of packaging materials and transport packages before testing (tests to evaluate resistances against compression, vibration, drop, and other adverse conditions).

The low-temperature climatic simulation chamber is used for testing and pre-treatment in the temperature range between 0 degree C to -50 degree C.

Applicable standards are as follows:

ISO 2233:	Packaging - complete, filled transport packages - conditioning for testing
JIS Z 0203-1987:	Pre-treatment for testing of transport packages

k) Sprinkle chamber

The sprinkle chamber is used to measure damage to transport packages and containers during transportation, caused by splashes of rain water or seawater.

The chamber is required to have a sufficient volume to accommodate and test a pallet load (1,240mm x 1,240mm x 1,500mm in height), with functional specifications, according to ISO and JIS.

Applicable standards are as follows:

ISO 2875:	Packaging – complete, filled transport packages – water spray test
JIS Z 0216–78:	Water spray test method for transport packages and containers

l) Drop dynamic testing machine for package cushioning materials

The machine is used to conduct a dynamic compression test for package cushioning materials in sheet, block, strip, granular, and mold forms. Data showing cushioning characteristics of various materials can be used as the basis of cushioning package design. The test is conducted by dropping a weight equivalent to package contents onto a test specimen placed on steel bed, and measuring the acceleration of the weight and dynamic displacement of the test specimen. Measured data are fed to an analytical system using a X–Y plotter, a personal computer, and other equipment.

Applicable standards are as follows:

ASTM D 1596–78a:	Shock absorbing characteristics of package cushioning materials
JIS Z 0235–76:	Drop dynamic testing method for package cushioning materials

m) Distribution environmental record system

It is important to identify adverse environmental conditions working on transport packages during transportation to domestic and export markets, including vibration, shock, temperature, and humidity, which serve as basic data to establish testing standards of transport packages. An accelerator, a thermometer, and a humidifier using microelectronic devices, and a distribution environmental recorder equipped with IC memory chips and a power source are carried in the form of transport package, and recorded data are analyzed by a special software program. Data processing and presentation are done by a personal computer, a printer, a X–Y plotter, and other equipment. As a result, environmental data such as distribution of accelerations, drop height and direction, and temperature and humidity conditions are obtained.

n) Scale

The scale is used to weigh transport packages and pallet loads before testing. At least two types of scales are needed; a load cell type 2-ton scale and a 300kg platform scale.

2) Major testing equipment to measure performance of packaging materials
(See Table 5-13)

a) Ring crush tester

Compressive strengths of liners, corrugating media, and package carton boards are measured by the ring crush test. The machine can also be used for compression testing of other materials. Dimensions of test specimen and supports are specified. Based on the measured data, compressive strength of corrugated cardboard boxes is calculated by using Kellicutt formula and similar.

Applicable standards are as follows:

JIS P 8126-1987: Testing method for compressive strength of carton boards

b) Mullen type bursting tester (high pressure type)

Mullen bursting strength is one of representative characteristics showing strength of paper, card board, and corrugated board known to have a close association with tensile strength (elongation).

The test is conducted by tightening two parallel sections and a test specimen, applying pressure through a rubber membrane, and reading pressure at the time of bursting. The tester used for 14kg/cm^2 or over is called the high pressure type.

Applicable standards are as follows:

JIS P 8131-1977: Testing method for bursting strength of paper and carton boards by using the Mullen type high-pressure bursting tester

c) Elemendorf type tearing tester

The tester is used to check tearing fragibility of corrugated cardboard boxes by measuring potential energy loss of a fan-type pendulum between the moment at which the tearing of a sheet starts and the moment at which the tearing has reached a specified length.

Applicable standards are as follows:

JIS P 8116-1976: Testing method for tearing strength of paper and carton boards

d) Strograph

The strograph is designed to measure tensile strength and extendibility of paper, plastic films, and sheets. It can also be used for assessment of laminating adaptability (take up adaptability) of corrugators.

Applicable standards are as follows:

JIS P 8113–1976: Testing method for tensile strength of paper and carton boards

JIS Z 1702–1986: Package polyethylene films

e) Bekk smoothness tester

Surface roughness of paper is measured by duration of time during which the air in contact with the surface flows in a specific amount. Smoothness is used to evaluate printability of paper.

Applicable standards are as follows:

JIS P 8119–1976: Testing method for smoothness of paper and carton boards by using Bekk smoothness tester

f) Air permeability tester (Gurley type densometer)

The tester is used to measure the ease of air permeating from the front side to the back side of paper.

In addition to assessment of paper density, absorbability, and printability, the test can be used to determine adaptability of a corrugated container to vacuum operation. The tester is also called Gurley densometer.

Applicable standards are as follows:

JIS P 8117–1980: Testing method for air permeability of paper and carton boards

g) MIT folding endurance tester

The machine is used to measure folding endurance of paper, carton boards, and plastic sheets.

Applicable standards are as follows:

JIS P 8115–1976: Testing method for folding endurance of paper and carton boards by using MIT folding endurance tester

h) Puncture tester

The tester is used to measure resistance of corrugated cardboard sheets against puncturing by a corner of a wooden box and other sharp edge. The test is used as an alternative to the bursting test which is not suitable for triple wall corrugated board.

Applicable standards are as follows:

JIS P 8134–1976: Testing method for puncturing strength of carton board

i) Adhesion tester

The tester is used to measure resistance of adhesion between a liner and a corrugated medium against tensile force. It is indispensable in checking corrugated board used for the compression tester and the ring crash tester.

Applicable standards are as follows:

JIS Z 0402–1988: Testing method for adhesion of corrugated cardboard

j) Precision sample cutter

It is used to collect a test specimen accurately and produces a test specimen of specific dimensions by shearing.

Applicable standards are as follows:

JIS P 8113, P 8114, and P 8126

k) Abrasion resistance tester

The machine measures abrasion resistance of carton and corrugated cardboard by applying force in the form of drawing an arc on the surface of a specimen. Abrasion resistance is judged from print and other surface conditions.

Applicable standards are as follows:

JIS P 8136–1876: Testing method for abrasion resistance of carton board

l) Friction tester

Coefficient of friction for paper, plastic films, and corrugated cardboard is measured. This is one way to determine the ease of slip which affects workability of packaging containers and prevention of collapse of stacked packages.

Applicable standards are as follows:

JIS P 8147–1987: Dimensional requirements for testing to determine coefficient of friction for paper and carton boards

(2) Testing equipment related to consumer packaging

Testing related to food packaging will be carried out jointly with the Food Technology Center. The basic policy, however, is that the Packaging Technology Center will lead packaging-related service. The following examines the equipment and facilities required for the Packaging Technology Center, in this connection.

Most of testing equipment required for evaluation, and research and development of food packages is owned by the Food Technology Center, including the following:

a) Gas permeability tester

To measure permeability of gas through different packaging materials. Data obtained are used to evaluate performance of packaging materials related to decaying, deterioration, and preservation of food.

b) Gas chromatography

To analyze trace constituents produced, dissipated, dispersed in food. Data collected are used to determine the effect of packaging environment on deterioration and preservation of food.

c) Chamber type vacuum/gas flash packaging machine

To produce samples of package food in small quantities to be used for packaging and preservation tests to determine suitability of packaging materials and techniques.

d) Retorted pouch packaging machine

To produce samples of package food in small quantities to be used for packaging and preservation tests to determine suitability of packaging materials for retorted food products.

e) Steam retorting food sterilizer

To sterilize samples of package food to be used for packaging and preservation tests to determine suitability of packaging materials for retorted food products.

f) Aseptic packaging machine (for bulk)

The machine is designed to fill and pack sterilized liquid-type food in microbial-free condition, particularly to produce samples for preservation test.

Major equipment required for evaluation of food packages is listed according to its function, in Table 5-14. As discussed earlier, functions of the Packaging Technology Center related to food packaging are defined as follows (See 5.2.2.2 (4)):

To clearly differentiate the Packaging Technology Center, the Food Technology Center, and other centers, according to their functions, inspection and testing items are classified as follows:

1. Condition of container itself
2. Direct impacts of container on contents (food)

a. Changes in container due to contact with food
b. Constituents of container in food
3. Indirect impacts of container on contents (food)
– Quality of food

Based on the above classification, the Packaging Technology Center will be responsible for evaluation on the conditions of containers, related research and development, and technical guidance, while Food Technology Center will examine the indirect effects of containers on contents. The direct effects of containers on contents will be jointly evaluated by the two centers; the former is primarily responsible for evaluation of containers, and the latter for direct effects of containers on food. The two centers should be jointly responsible for selection of alternative characteristics for quality verification, but Food Technology Center should perform the analysis and evaluation so as to avoid duplication of equipment and staff.

Regarding development and modification of packaging technology, and related guidance and transfer, Food Technology Center should assume responsibility for primary packaging which is closely associated with quality preservation and marketing functions, while Packaging Technology Center will lead the issues related to the quality of packaging materials, the form of packaging, and the packaging system.

Services related to analysis and standard testing for packaging materials should be performed by Packaging Technology Center. However, tests requiring equipment which is not owned by the Center but is available at other center (such as testing of gas-barrier and similar characteristics) can be performed as the joint project. In this case, however, Packaging Technology Center should appoint an engineer for coordination of the testing operation for prompt and reliable service.

Evaluation of package's effects on marketing and consumers will be performed by other center which has the ability to do such service. If not available, Packaging Technology Center may have to consider possible expansion of its activity into the field.

Finally, regarding environmental issues, Packaging Technology Center should be responsible for evaluation of systems and packaging materials in view of environmental compliance.

Aside from the above guideline, immediate priority should be given to improvement of testing equipment related to transport packaging, while testing service related to food packaging will be rendered by using existing facilities where possible. After a complete line of testing equipment related to transport packaging is procured, testing service and equipment for food packaging will be considered.

5.3.3 Operation Plan

5.3.3.1 Financial evaluation of the operation

(1) Projection of revenue

Major revenue sources for Packaging Technology Center are as follows:

1) Standards testing service

2) Other contract testing and contract research service
3) Joint research
4) Short-term seminars
5) Training courses for packaging engineers

Table 5-15 presents the projected revenue from the above services. The revenue in this table includes those from establishing the Center alone, and excludes the revenue transferred from other existing centers of SISIR, such as fees from standard testing. Actually, even in the case of revenue from standard testing, the amount of revenue is expected to increase with the establishment of the Center, due to increasing dissemination of standards, increase in the number of applicable standards, and increase in contract testing ordered to SISIR with improvement of equipment available and reliability on testing technology. The increased revenue thus obtained may be defined as revenue for the project, though it is not included in the projection.

Of the above services to be provided by the Center, the joint researches and the training programs are assumed to be implemented from the second and third year of its operation respectively, since these services require a certain extent of expertise to conduct such services.

According to the above revenue estimate, the major revenue comes from contract researches accounting for 40to 55% of the total revenue followed by the fee from contract testing, accounting for 27 to 32%, with both amounting to 70 to 90%, indicating these services be the most important services of the Center.

Besides the above, the additional revenue may be expected from 1) dispatching staff for instructors of outside seminars and training courses, 2) selling technical information, and 3) contract research for standard development, etc. Since such revenue is not large, these are excluded from the above projection. The entry fee of the study societies and the fee from secretariat services for the societies, as well as supporting members' fees are the possible additional sources of the Center, and these revenue is expected to contribute stabilize the financial position of the Center, as discussed in the later part of this report. Further, the services related to the packaging center in the Southeast and Southwest Asian regions will increase the revenue of the Center, but these are also excluded from the above revenue projection.

(2) Estimated costs and expenses

Only the operation costs and depreciation expenses were included in the above projection, but no cost was included with respect to building, since the existing building is available for the Center. The manpower cost was estimated on the basis of staffing plan in 5.3.2.2 assuming 1 manager, 2 senior staffs, 3 staffs, 3 assistant staffs and 1 secretary. These staffs are assumed to be employed from the first year of operation in view of needs to undertake staff training. The overhead cost was assumed to be proportional to direct manpower cost.

All the incomes of the Center were assumed to be exempted from taxes, and insurance costs were excluded from the projection since it is negligibly small.

The depreciation expenses and maintenance costs were calculated on the procurement costs of equipment and facilities shown in Tables 5-12 and 5-13, which were assumed to be procured on commercial basis from the beginning of operation of the Center.

All the costs for senior staff are to be compensated by the government with subsidy for the first three years of operation, and these were excluded from the projection in the first three years.

The projected costs and expenses are given in Table 5-17.

(3) Financial viability

The balance between the revenue and expenses projected in the above is shown in Table 5-18. According to the projection, the center is expected to generate an operating deficit of S$70,000 (equivalent to 105% of total revenue) in the fourth year when the government subsidy to supplement operating cost will be terminated, let alone depreciation expenses for machinery and equipment. Then, the deficit will decrease slightly as demand for the center's service increases, but the cash flow will remain negative even in the 8th year.

The following sections analyze the change in the balance according to the change in such major affecting factors of revenue as rates of fees, number of contract testing, number of participants to short-term seminars and training programs, and discuss the recommendation on what the operation plan should be like.

1) Rates of fees

The rates of fees in the projection were calculated assuming the rate being around 0.75 times of prevailing rates in Japan, taking into account the paying capacity of the potential users in Singapore (Table 5-16).

The assumed rates seem to be justifiable for MNCs, which are the major users of the Center for the time being.

The higher rates, however, could impede the local SMEs, which really need the technical assistance of the Center, from use of the Center. There is a subsidy system, in this regard, to supplement a half amount of SISIR's fee by the government for the use by local SMEs. However, the application for the subsidy is not necessarily encouraging, due to its sophisticated application procedure as well as time-consuming subsidy payment. Nevertheless, if this system can be utilized, the fee at the level of 75% of that of Japan means 37.5% of that for the subsidized users. Thus, the Center can set its rates at 75% level, with existence of the subsidy system.

If such subsidy system is not available, then the Center is necessary either 1) to set all the rates at the lower level, or 2) to set rates at different level for general users and for local SMEs. However, such rates will make the operation not viable.

Despite the above, the actual rates should be set taking into account the prevailing rate level and costs to be incurred on the basis of detailed cost analysis. In the case of participation fee for joint research, particularly, the rate should be determined on the basis of costs needed.

2) Estimated number of tests and participants

Since the number of tests and participants was estimated on the limited data/information available, the actual number could diverse from the estimates. The following analyzes the possible cause of the difference and the resulting change in the revenue.

The number of contract testing is estimated by the following formula on the basis of the number of firms in the electronic/electrical industry:

$$F=((C0x(1+Cr)t)+(D0x(1+Dr)t))x(E1xE2xE3)$$

where, F=Number of contract testing per year,
C0, D0=Number of firms in the industries in question in 1990(C for electronics industry, D for electrical industry),
Cr, Dr=Annual growth rate of the number of firms,
t=Number of years with t=0 in 1990,
E1=Average number of product development per firm,
E2=Required number of contract testing for one product development, and
E3=Ratio of contract testing to be contracted to SISIR among the total number of contract testing.

In addition to the above industries, some testing demand can be expected from the toy manufacturers using electronics parts, though it will not be large. The demand for tests on food packaging is not included in the above, since these are carried out using the testing equipment of the Food Technology Center.

The contract testing demand comes mainly from product development. Firms undertaking product development is very limited in Singapore (the ratio of them among the firms in the industry was assumed only one to 15 in the above estimate). If the ratio is one to 20, the total revenue will decrease by 18% (in the 4th year of operation). The rate of test contracted to SISIR is assumed 50% in the above estimate (other testing will be done by their parent companies, etc.). If the rate decreases by 10% (to 40%), the total revenue decreases by 13%. If the ratio of firms to undertake product development is one to 20, and the contract rate with SISIR is 40%, then the total revenue will decrease by 26%.

The number of participants for short-term seminars and training programs were estimated using the following formula:

$$M=((C0x(1+Cr)txCi)+(D0x(1+Dr)txDi)+(J0x(1+Jr)txJi)+(K0x(1+Kr)txKi)) \\ x(S1xS2)x(1+Sr)t$$

where, M=number of participants for short-term seminars or training programs
C0,D0,J0,K0=Number of firms in the industries in question in 1990 (C for electronics industry, D for electrical industry, J for food & beverage industry, and K for chemical & pharmaceutical industry)
Cr, Dr, Jr, Kr=Annual growth rate of the number of firms in the respective industries,
t=Number of years with t=0 in 1990,
Ci, Di, Ji, Ki=Rate of firms interested in seminars and training courses in the respective industries,
S1=Rate of firms to participate the seminars and training courses among the firms interested,
S2=Number of participants per firm, and
Sr=Annual growth rate of (S1xS2)

The rate of firms to participate in seminars/training courses of SISIR may be the major factor to cause the difference from the projection, if any. The rate of interested firms was estimated using the results of questionnaire survey on packaging industry and

packaging user industries conducted by the Packaging Center[9] . The actual number of participants will be slightly lower than its estimate since it includes their expectation. The actual number of participants per firm will not be different significantly from the projection. The participation rates of firms to SISIR's seminars and courses are assumed at 45% and 30% respectively, but the actual rate for seminars could be lower than expected, while that of training courses will not differ much from the projection. If the rate for seminars decreases to 30%, it results in decrease in total revenue by 3.5%.

3) Operation costs

The largest share occupied in the operation costs are direct manpower costs and overhead costs. If the current plan of 10 staffs is modified to that of 7 staffs, reducing a senior staff, a staff and an assistant staff, the number of testing crew is decreased to 2 from the planned 4. With such reduction, the annual costs can be reduced by S$209,200, but the annual revenue will be also decreased by S$217,000 in 4th year and S$350,000 in 8th year due to decrease in the test handling capacity to 92, and thus, financial condition will be deteriorated. The decrease in the number of staff, however, is not recommended not because of financial position, but because of technology acquisition and accumulation and ensuring capacity to provide diverse services.

(4) Recommendation on operation in view of financial viability

It should be noted that actual revenues are likely to exceed the estimates, because specification testing services related to packaging, now conducted by other SISIR's centers, will be transferred to the center. Also expected are fees for experts to be sent to outside seminars and workshops, revenues from sales of technical information, and fees for contract research on development of industrial standards.

The current actual operation condition is different from the presumed condition shown in Table 5–19, in that (1) the number of the staff of the Center is five including a secretary, (2) all the equipment and facilities have been provided by a grant, and (3) these equipment and facilities do not cover all of those presumed as required ones. If the Center is operated with the current costs and expenses conditions, and the assumed revenues, then, the financial balance will turn to be positive in the fifth year of operation. However, it assumes the continued operation with five staff, and will result not only in difficulty in implementing all the assumed services but also in accumulating appropriate technology and expertise.

9) The result is compiled in LNE Report.

In order to improve the financial revenue, the Center should pursue the additional revenue sources. The potential additional revenue sources include, for example, (1) member fee with organizing study societies relating to packaging technology, and (2) receiving contract from overseas clients.

Table 5-20 shows the financial projection with the more realistic assumptions that only the urgently needed equipment and staff are facilitated. In the costs and expenses, (1) only the urgently required equipment are assumed to be added to the existing ones, and (2) costs of staff for the existing SISIR's function, namely, a half of that of the manager, a staff, an assistant staff, and a half of that of the secretary, are assumed to be covered by the budget compensated by the government. The projected revenue assumes the additional revenue given in Table 5-21.

According to the financial projection, the balance will turn to be positive in the seventh year at single fiscal year basis, with accumulated balance becoming positive at the ninth year. Nevertheless, the depreciation will be difficult to be materialized. Under such situation, to upgrade the function of the Center further, and to keep maintain the existing equipment with appropriate renewal, the support of the government should also be considered particularly in financing. Such financing support of the government may be justified in view of the social and economic effects anticipated from establishment and activity of the Center.

Packaging technology centers, in the case of Japan, are generally established as a part of industrial technology guidance organization of public sector at regional (prefectural) level. Most of them are not operated as a self-sustenance body. This is because the operation scale of manufacturers in Japan is mostly large enough to equip with the testing facilities by themselves, resulting in the limited demand for contract testing. The packaging centers in the public sector, therefore, have mostly focused on technical services for SMEs and the third party testing services. Their operation costs are burden by the local government as a part of their expenses for industrial promotion, and the centers are allowed to use their revenue for renewal of their facilities. In the case of Singapore, however, since the industries still have significant expectation to the services provided by the public established organizations, the Center will, to some extent, be possible to operate it at self-sustenance basis. However, since the fully self sustained operation seems to be difficult to attain, the financial support from the government is recommended to prevent such conditions as high fee rates, which is feared to result in discouraging the use of the Center by the potential clients, and insufficient functions caused by deficiency in equipment and staffing.

5.3.3.2 Other issues related to management

(1) Strengthening relations with related industries

1) Effective communication

The Packaging Technology Center is expected to contribute primarily to the promotion of the packaging sector in Singapore. The board members of the SISIR include representatives from industries to reflect the needs of industries on its activities. However, in order to ensure that the intent of the packaging sector is reflected in the center's activity to properly address needs of the sector that change from time to time, it is important for the center to have a place of regular and formal communication with representatives of the packaging sector in order to discuss on management policy and strategy of the center. Note that the packaging sector should include the packaging industry, industrial users of packaging service and materials, and the physical distribution industry.

2) Societies for the study of packaging technology bridging the center and related industries

Needless to say, the center's activity has to address needs of related industries, and its research products are conducted under close collaboration of related industries to reflect the current state and problems facing them. Also, the outcome of research projects should be provided to the industry side so as to establish mutually beneficial and interactive relations between the center and the industry. The study societies on packaging technology can play a central role in meeting the above demand. It serves as an opportunity for the packing sector to participate in industry-wide joint efforts. At the same time, the center can use the study society as a principal partner in activity to promote modernization of the packaging sector.

(2) Level of service fees and improvement of government subsidy system

As shown in the projected financial balance of the Center, it takes 8 years from commencement of operation until the revenue exceeds the costs and expenses.

While service fees of SISIR set at market price are affordable for MNCs and their joint venture companies, they are likely to be very costly for local SMEs. Particularly, in the case of the technical services related to food packaging, the customers will mostly SMEs and their request is not defined well in advance. Therefore, the number of service items, and therefore, the fees are tend to increase accordingly. If the fees are collected from these SMEs at the projected rates, the utilization by the SMEs will decline. Therefore, some measures are needed to reduce the burden of customers, since most of these services have the nature of public service. However, at the same time, the

reduction of the service fee rate will result in deterioration of the financial viability of the Center.

At present, local small enterprises which use SISIR's service are eligible for government subsidy which covers 50% of actual fee. However, there are many complaints about complicated application procedures and relatively a long period of time required for processing. To be able to set the service fees at a market price level, and make it affordable to all the potential users, therefore, the government subsidy program should be reviewed and modified to maximize its use by eligible enterprises.

At the same time consideration is necessary in setting the fee rates, not to deteriorate the operation of the private testing laboratories with unfair low rates.

(3) Need for completing testing equipment

Testing equipment currently owned by Packaging Technology Center covers only a part of tests related to transport packaging. The center does not have testing equipment for primary packaging of food products.

The plan assumes that testing for food packaging will be undertaken as a joint service with and using the equipment of the Food Technology Center, if available. As for the testing equipment and facilities relating to transport packaging, however, further efforts for installation of additional equipment and facilities are recommended to provide the packaging users with the more sophisticated technical services required for their advancement, in addition to the services in the basic testing fields currently available. The most important equipment and facilities among others include, (1) Shock testing system, (2) Drop dynamic testing machine for package cushioning materials, and (3) Light vibration table used for up to 500 Hz.

There is a shock tester at the Electronic Test Center in SISIR. The Packaging Center, however, should facilitate another shock tester for its own, since the former is used for quality certificate of electronic products.

Other equipment and facilities required for the testing are also recommended to install in turn.

(4) Maintenance and upgrading of equipment

Equipment maintenance needs to be carefully planned to ensure smooth operation of the center, including adequate maintenance contract and proper budgeting. Also, equipment should be upgraded in a timely manner to provide the highest practicable level of service all the time, by addressing changing industry's needs and technological requirements.