3.1.3 Present Conditions and Status of Packaging

3.1.3.1 Packaging in the electric and electronics products industry

(1) The role of packaging in the industry

Major points related to packaging of electric and electronic products, in general are the following, in descending order of importance:

a) Protection of the products
b) Economics (minimization of packaging materials cost)
c) Suitability for the distribution process (transport, storage, handling)
d) Suitable regarding the environment
e) Efficiency of the packaging and processing work (usable on production lines, re-sealable containers, etc.)
f) Effective for sales promotion

1) Protection of products

The most important matter in the distribution process from the time industrial products are shipped from the factory, to the time they are in the hands of the final consumer, is that they are subjected to a variety of environmental conditions (vibration when in transit or being handled, physical shocks, being below the weight of other products stacked in storage, temperature and humidity changes, etc.). Because electric and electronic products themselves do not possess great strength, they may be subjected to damage by physical or chemical causes during that process, and hence are considered fragile goods. It is by means of shipping containers that the manufacturers seek to protect the products from deterioration of quality or performance as a result of damage by an environmental factor during the distribution process.

The two major causes of damage to electric and electronic products during the distribution process are 1) chemical damage by rusting or corrosion of metal parts of the product, and 2) physical damage in the form of breakage of circuit boards or deformation of the cabinet housing the product. As indicated in Table 3-8, "container design" techniques have been developed to prevent each of these types of damage.

2) Suitability for the distribution Process, and Economy

The requirements consumers have of electric and electronic products are diversifying, and the number of products offered in the market is increasing as a result. For this reason, there is a tendency for production lots to be smaller, for there to be a greater variety (number) of products, and for production times to be shortened, while in the field of logistics, need to meet market requirements has led to service improvements such as increased frequency of small lot deliveries, and shortening of transport times. In order to improve the efficiency of these aspects of the distribution process, many companies are replacing their old systems of mass production, distribution and sales of goods, with newer systems they have developed so as to have more advanced functions. The latter are looked upon as being integrated systems extending from the assembling of input materials at the production plant to the production process, distribution, and sales. In addition to this, there is the comprehensive coordination of these activities in order to assure smooth flow of the products, and give the maximum customer service at the minimum cost, or what is called "logistics strategy" (or total distribution strategy). This is likely to include such matters as having production facilities in more than just one country, the borderless state of markets, regional differences in labor supply, and so on.

This sort of total distribution strategy is expected to be central to the distribution process in the future, and it is becoming essential to consider product containers too as one aspect of this total system.

Containers bear an intimate relationship to many activities (product design, transport, handling, storage, etc.) as a consequence of their role in protecting the product and insuring suitability to the distribution process. In the past these activities had been controlled separately within the company, by the different departments concerned with technology, production, marketing, and so on. There also have been many instances when these functions were performed by separate companies in the same corporate group. Containers therefore at times involve tradeoffs, as improvement of efficiency in one part or phase of the distribution process may be at the expense of efficiency or cost control elsewhere. For example, for the sake of efficiency in warehouse storage, it should be possible to stack goods to a considerable height, but this increases the compressive force on lower containers, and the cost of making the containers able to withstand the force. Or, to reduce total container or packaging costs, less materials may be used, and the form and dimensions of containers may be changed, but this may increase costs of transport, handling and storage, by lowering efficiency in those processes. The same sort of tradeoff can be seen not only in containers but also in the design of products, but involving packaging and containers. For example, in the case of a electric or electronic product to be packaged that is not physically strong, and has a protruding part, the suitable container that would provide protection for the protruding part would be much more bulky than if there had been no protrusion. Consequently, the efficiency of the transport and storage processes in distribution would decline, and overall costs would rise.

As this suggests, efforts made up to this time for the rationalization of containers have not had high effectiveness in overall terms because they have been confined to narrow areas. In contrast to this, at present, packaging in containers is considered as one subsystem within a total distribution system (logistics system), and rationalization is done for optimization of the total system, or minimization of total cost. That is, in the design of protective container or planning of the container for greatest suitability to the physical distribution process, high importance is given to not merely assuring that the container protects the functioning of the product, but by the interrelation with activities related directly to the product and activities of participants in the distribution process, that it optimizes the overall situation -- in other words, a total approach to system design is needed.

(2) Trends of container packaging technology for electric and electronic products, and their trend

1) Development of container technology

It has not been a long time ago that technology for packaging goods for transportation was established as a discrete area of engineering, and came to be used for electric and electronic products and the like.

Basic research that has led to packaging technology as we know it today is said to have begun at the Forest Products Lab of the U.S. Department of Agriculture, during the 1940s. At that time, tests were undertaken in great detail with regard to static compressibility, and ability to withstand vibration and shock, for corrugated cardboard cartons, as well as shock-absorbing materials (styrofoam, expanded polyethylene, urethane foam, etc.), and information thereby obtained was utilized in the drafting of Military Standards (MIL), standards of the American Society for Testing and Materials (ASTM), the Technical Association of the Pulp and Paper Industry (TAPPI), and the Packaging Institute (PI), all of the United States, for evaluation of the properties of packaging materials, and the methods of measurement of them. Reference was made to the these testing methods when, in 1960, the Self-Defense Agency and Japan Industrial Standards (JIS) standard for "Static Testing of Shock-Absorbent Materials" were drawn up.

Thereafter, experiments and investigations were conducted, especially in the United States, on methods of testing strength of packaging materials for use when transporting goods, and during the 1960s evaluation tests were developed for containers' withstanding shock upon being dropped, or subjected to vibration, and so on.

Meanwhile with regard to planning technology for container materials for use for protection of goods in transit, in 1953 Michigan State University, in the United States, created the first department of packaging to be set up in any university of the world, and it was there that packaging technology for absorbing or shock or vibration was developed, on the basis of the laws of dynamics. This technology for planning of packaging materials for use when goods are transported was subsequently introduced to other countries and came to be widely used, in place of the craftsmen's approach hitherto employed. In particular, an early start was made by the electric and electronic products industry, and precision equipment and parts industries that required rigid maintenance of quality, as a means of preventing accidental damage during transport, and thereby assure the reliability and competitiveness of the products.

2) Container planning technology

The primary role of shipping containers is to ensure that during the transport process, external forces by way of shocks or vibration do not lower the quality of the product, enabling it to be safely delivered to the customer. A design approach using the laws of dynamics is necessary in order to properly, economically accomplish this. The procedure of design shock-absorbing packaging, that absorbs the shocks and vibrations during transport, thereby protecting the electric and electronic products inside, has 5 phases as shown in Table 3-9.

a) Phase 1: Transport environment survey

In the first phase, a survey is made of the external forces that are likely to be applied to the product during transport. Containers are subjected to a wide variety of environments, but the most severe physical forces are either when the product is dropped during handling, or when it is subjected to vibration during transport. Therefore, what is done is to ascertain the height from which it may be dropped, and to calculate the shock ensuing from such a fall. Further, vibration during transport often causes products to be knocked or rub against each other, so the acceleration force and frequency of its occurrence is surveyed.

b) Phase 2: Product fragility study

It is next proper to study the fragility that the unpackaged product has to withstand vibration and shocks during transport, without the benefit of protective packaging. Product fragility is often determined by its designer on the basis of general experience and "sense" but to properly, economically protect the product, it is essential that the fragility be measured. To measure resistance to shock, equipment designed for that purpose is used to ascertain the maximum acceleration the product can undergo, and the maximum velocity, without being damaged. The result is expressed in the form of the product's "damage boundary curve." This curve clearly shows whether it is necessary to protect the electric and electronic products from the shock of being dropped during transport. And this makes it possible to accurately know the magnitude of the force (acceleration) to be anticipated when shock-absorbing packaging is to be used. To study the resistance of the product to vibration, specialized equipment is used to determine the frequency that products are caused to rub against each other.

c) Phase 3: Selection of shock-absorbing material

As a result of the preceding steps in cushioning design, the magnitude of the shocks that must be absorbed has been determined, and the next phase calls for selection of the materials that will most economically absorb those shocks. The diagrams of cushion factors and stress curves for the materials available are used in order to do this, and the material that can accomplish the objective at minimal cost is selected. It is important at this time to consider not only the relative superiority of alternative materials but also the effect they have on the environment, ease of disposal, recycling potential, and possibility of re-use.

d) Phase 4: Cushioning design

The protective container is designed to lower a dropping shock during distribution up to the marginal acceleration level that the product can withstand. That is, the thickness of the material needed to protect the product to the required extent, and the area covered, are calculated. There are two methods for doing this now in use.

1. Use of the cushion factor (C)
2. Use of the maximum acceleration velocity-static stress diagram for the material in question

Use of the first method means deriving the thickness required by use of the relationship between the cushion factor coefficient and thickness of the material. This makes it possible to determine the minimum thickness of material required. Further, the second method, by use of the maximum acceleration velocity-static stress diagram, makes it possible to determine the minimum quantity of material that must be used.

e) Phase 5: Packaged freight test

The prior phases have enabled the specifications of shock-absorbing cushions to be determined, and a prototype container to be made. It is next necessary to determine if the design works as intended. Also, it is necessary to conduct a packaged freight test using an actual product, in the actual, designed container, to determine whether there is consistency in the qualities of the material, and whether it is suitable in practice for protection of the product. Packaged freight tests can be carried out by replicating the shock of being dropped during the distribution process (see Phase 1) and vibration during transport.

3) Container testing technology

It is necessary to check whether the container thus designed can actually provide the protective function for which it is intended. For this purpose, an evaluation test is made. This test reproduces in the laboratory the external forces that would be brought to bear on when the product is actually in the process of distribution, to determine suitability of the packaging, evaluate its strength qualities, and prevent problems before they can occur once the product is on the market. The test thus can be called an experimental replication of the environment of distribution.

For example, in Japan the ordinary situation regarding electric and electronic products is that after they leave the factory they pass through two stock points or depots before they arrive at the retail establishment. During that period the packaged products are subjected to various kinds and levels of force. These forces are reproduced in the laboratory in order to determine if the intended container performs its intended protective function. It is of great importance that the lab tests be capable of reproducing the actual forces that would be applied to the product with great accuracy. Those forces are extremely diverse in nature. It is nearly impossible to faithfully reproduce all of them. Nevertheless, the test evaluation items now in use by most makers of electric and electronic products are shown in Table 3–10.

These tests, however, merely reproduce, individually, the forms and strength of forces that will occur during the distribution process. Packaged products are almost certain to not be subjected to such forces continuously once shipped from the factory. It is necessary, however, to combine those forces which have a high probability of occurring, at foreseeable levels, for testing. Called the Performance Testing of Shipping Containers and Systems, this method of testing was adopted by the ASTM (as ASTMD 4169) in 1982, and has garnered wide attention[2].

Recently, as a simpler form of testing that is being developed, one that is to ascertain the quality of shipping containers, there is another evaluation testing method, that gives high importance to damage equivalence.

[2] ASTM D 4169 Performance Testing of Shipping Containers and Systems

Testing methods in use up to the present time have been based on high importance being given to faithfully reproducing forces that may cause damage to products during the distribution process (such as by vibration during transport, strength of shock imparted if the package is dropped during handling. In actuality, however, the manner whereby such forces are imparted to packages is extremely diverse, and complicated apparatus and considerable time would be required if they were to be reproduced in a lab. From the viewpoint of the quality assurance function, however, what is important that it is adequate for the testing of shipping containers to reproduce the damage conditions that might actually take place once the container is in use, whether or not such damage occurs in actuality. The damage equivalence test is based on such thinking. In this connection, use of shock reaction specters is under study. This method classifies the diverse forces occurring during distribution into a number of specters, and would make it possible to easily include damage equivalence in tests.

(3) Forms of shipping containers, and their materials, for electric and electronic products

Shipping containers for electric and electronic products are composed, in broad classification, of outer and inner containers. Each of them includes the following materials.

a) Outer containers:
b) Inner containers: Shock-absorbing materials, fixed supports, surface-protection materials, parts bags, waterproofing and moisture-proof materials, other ancillary materials.

The specific materials used are determined on the basis of the product in question and the distribution environment. Of the above, it is the outer container and shock-absorbent materials that are of greatest importance with respect to electric and electronic products.

1) Outer containers

In the past, wooden crates were frequently used as the outer container when electric and electronic products of 200 kg or heavier were to be shipped. But manual methods that had been in use were increasingly replaced by mechanical systems, starting in the 1950s, and containers came into use for marine transport, to the extent that container transport has become the dominant form of shipping. The distribution environment thus has been greatly improved, and the forces that shipping containers are subjected to have been reduced greatly. As a result, instead of wooden crates, corrugated cartons are in common use as outer containers, to the extent that they are almost universally used except for certain very large and heavy products (electrical products of 100 kg or heavier).

2) Shock–absorbent materials

Items that must be considered when selecting shock–absorbent materials for use in shipping containers for electric and electronic products are its shock absorptiveness, easy of forming and processing, workability, ease of acquisition, economics, durability, disposability, re–usable and recycle potential, and so on. Shock–absorbent materials currently in use for electric and electronic products containers are broadly classified into plastic and non–plastic types.

a) Plastic types

* Expansion–forming: styrofoam, expanded polyethylene, expanded polypropylene, expanded urethane.
* Insite expanded materials: expanded urethane
* Air–imprisoned film: air cushion material
* Bulk materials: fiber or chip form styrofoam, urethane foam

b) Non–plastic types

Corrugated cardboard cartons, pulp molds, cardboard, paper tubes, wood shavings

3) Other materials

By type of application, the following techniques and materials also are used for packaging electric and electronic products:

* Outer containers: pallet–mount shrink–film, stretch film
* Surface protection: kraft, polyethylene film, expanded polyethylene sheet, anti–static film
* Water and moisture protection: silica gel, aluminum metallized film, heat–seal film
* Sealing: adhesive tape, rubber tape, polypro/polyester bands, staples

(4) Environmental considerations

Packaging has played an important role in the development of industry and improvement of daily life. On the other hand, the disposal of packaging materials after they have been used is now a social problem of global dimensions. Limitations to the availability and usable scale of land fill and dump site locations, and existing processing equipment, especially in and near urban areas, while the volume of trash, including used packaging materials, that must be disposed of increases every year, have meant that capacity to process such material is approaching its ultimate limit. Further, the cost of such processing is expected to continue to increase, to the extent that it presents a serious problem in regard to daily life and business activities.

1) American and European approaches to the environmental problem

The United States and European countries have been ahead of the other countries in coming to grips with the problems of the world environment. They have taken an extremely forward-looking approach to measures for discarded packaging, through bottle and can deposits systems, tax policy, decisions on which packaging materials to use, use of returnable containers, collection and processing systems, and other arrangements.

There are two approaches seen in Europe regarding environmental measures. One, such as in Italy and Great Britain, does not rely greatly on restrictions and bans, but emphasizes individual efforts by industry and the household sector to set their own goals for recycling. The other approach is to regulate discarded packaging materials, as a major environmental policy of the nation. This approach may be seen in Scandinavian countries, Switzerland, and Germany. Germany, in particular, is extremely advanced in measures for collection of used packaging materials, and is exerting influence on other European nations.

In Germany, there is a law for prevention of the creation of waste materials and their management, intended to reduce the quantity of waste produced. This was the first such law in the world, and was enacted in 1986. After the law went into effect, however, the production of waste continued to rise, and the limit was reached in terms of capacity to process it. Another law was therefore passed, Verpack VO, that made it mandatory for manufacturers and sales agents to collect used packaging materials, such materials comprising about 20% of household trash. The law requires that materials thus collected be processed by facilities other than those owned by the government, and to either be reused or made into raw materials for other uses. By this step it is intended to achieve a rate of collection of used packaging materials of 80% by 1995, and promote effective use of available re-sources. Shipping containers for electric and electronic products are covered by these measures, and a collection system has been formed with participation by manufacturers, sales agents, collection firms and firms engaged in reuse of materials.

The Environmental Protection Agency in the United States has been largely concerned with land fill and dump site, in addition to issues related to incineration, heat energy collection and reuse, as well as reduction of the use of packaging materials, and recycling. Regulations differ from state to state. Widely used measures include separate collection of trash, compulsory indication of the nature of packaging materials used (in order to promote less use of materials), obligatory use of biodegradable materials, and the use of deposit systems. Some governmental authorities have prohibited use of styrofoam as a packaging material for electric and electronic products.

2) Japan's approach to the environmental problems

Japan adopted a law for promotion of use of reusable resources, in order to promote policies for effective use of limited resources, less consumption of resources, and reuse, in October, 1991. Popularly called the "Recycle Law," this was adopted because Japan is dependent on imports for most of the resources consumed, and much resources were being discarded with being reused. The law is based on the approach that at all stages, from manufacture to sale and actual use, the parties involved should autonomously strive to make effective use of resources.

Companies making or selling electric and electronic products are subject to the following under this law:

a) They are to make efforts for use of reusable materials
b) After use, products must have the potential for recycling as a resource
c) Byproducts are to be used as re-usable materials

Against this background, the electric and electronic products industry has endeavored to optimize packaging with respect to environmental measures. Originally, packaging of electric and electronic products had the primary objective of ensuring the safety of the products from vibration and shocks during the shipping process, and to thereby maintain the quality of the product, but because these materials are discarded once the product has reached its ultimate destination, it has become necessary to reduce the quantity or volume of such materials, to the minimum.

Japanese electric and electronic products manufacturers, having expanded their production facilities and sales activities in all parts of the world, are in the position where they mist make a strong effort on a global scale to act responsibly with regard to the environment.

At present, in the electric and electronic products industry, efforts are underway at the following four measures as one aspect of corporations' social responsibility with regard to the issue of packing materials in the environment.

a) Additional reduction of the quantity of packaging materials used

Re-examinations have been made of packages in order to reduce the quantity of materials required. In particular, use of styrofoam, frequently used as a shock-absorbent, has been gradually phased out where possible, and use of paper has been increased in its place.

b) Use of environment-friendly packaging

Efforts are being made to use packaging materials that can be easily disposed of or processed, or can be re-used, or can be recycled, or create low burdens on the environment. This has taken such forms as use of materials formed of waste paper, and gluing expanded materials to corrugated carton material.

c) Collection and reuse

In addition to study of rational measures for the collection, reuse, and recycling of packaging materials, various feasible measures have been gradually adopted. They include, in particular, the collection and recycling of styrofoam, through joint efforts of packaging materials makers and companies in the product distribution area.

d) Improvement of systems for carrying out environmental measures

Individual companies have made packaging optimization plans, and checklists for packaging assessment, and put them to use. In that connection, responsible persons have been appointed, and efforts have been made to improve the systems for implementation. Further, at the industry level, committees have been established and cooperative efforts are being made to promote optimization of packaging.

3) Problems for the future

Environmental issues related to packaging include the issue of consumption of limited resources, pollution on a global scale (degradation and destruction of the global environment), and the social problem of the rapid increase in production of waste materials. Among these, what is of most direct importance for the electric and electronic products industry is the social problem of the increase in resin materials such as styrofoam used for packaging. This is a problem common to many countries. Existing facilities and final disposal sites are approaching their limit in processing and accommodating demand. As a result, there has been pollution through the illegal discarding of materials, and an increase in the cost of processing (including increase in labor costs). On the basis of this, the electric and electronic products industry must continue to strive for effective use of resources, restrictions on throwaway containers in order to prevent pollution by means of used containers, reduction of packaging material consumption, and recycling of resources.

3.1.3.2 Present conditions concerning packaging in Singapore

(1) Products to be packaged

Electric and electronic products made and sold in Singapore encompass a wide variety, including home audio equipment, microwave ovens, air conditioners and other home appliances, telephones, facsimile machines and other telecommunications equipment, computers and many others. In addition, there is local production and importation of parts used to make those products (such as electronic parts including micro-motors, magnetic heads, optical pickups, semiconductor devices such as integrated circuits and LSIs, microcomputers and transistors), as well as materials (boards for printed circuits, ferroalloy, motor cores, etc.).

Therefore the products that have to be packaged in Singapore are of a wide range of sizes and weights, as they include large color TVs, refrigerators, and semiconductor devices. In addition, there are goods that are packaged and shipped or imported as final products, and goods that are both imported and exported as intermediate products, such as board assemblies, chassis, deck mechanism and the like. The forms of these products are diverse, their strengths vary, and the environmental conditions they are exposed to also vary.

(2) Types of packaging and packaging materials used

Similar to the situation in the electric and electronic products industry in the United States and Japan, the types and materials of packaging in use in Singapore are diverse.

1) Outer containers

Crates are used for some large, heavy electronic products (computers and related equipment). In addition, regular slotted containers are used for most medium and small electric and electronic products. It is standard for these containers to be sealed with gummed tape. For some appliances that are long, sleeve-type containers wrapped with bands are used. For unit load shipments using pallets, stretch film is used to hold the items on the pallet, but this is rare.

These forms of packaging are not unique to Singapore, and are the same as may be seen in Europe, the United States and Japan.

a) Wooden Materials

Lumber used to make shipping crates and pallets is imported primarily from Malaysia. The material used is mostly Malaysian lauan, a deciduous tree, that breaks easily and is hard to work. High moisture content in the wood means that it must be cured before it is suitable for use as crating material[3]. Nevertheless, lumber is often used without curing to avoid expense. But as a consequence, rusting often takes place when products are shipped in such wooden crates or on such pallets. Further, because of the high temperature and relative humidity, the wood is prone to attack by termites and mold. For this reason, there are some companies that fumigate the wood if it is destined for certain export markets[4].

Because of these conditions, there are some companies that are studying substitution of triple-ply cardboard cartons and cardboard tubes or other paper pallets for wood pallets.

The design of wood crates may be by the user or done for a fee by the box fabricator.

b) Corrugated Cardboard Cartons

There are about 40 companies in Singapore that do production or processing of cardboard cartons. The paper for these cartons is imported from Canada, the U.S., New Zealand, Australia, or Malaysia. Almost all of the imported paper comes in as kraft liner made of kraft pulp. Little used paper is employed. Cartons made of used paper are employed for export of certain electric products to Europe, and include about 20% used paper; use of such packages is increasing.

Cartons used as outer containers are primarily double wall corrugated fiberboard or double faced corrugated fiberboard. Triple-walled cartons are used for some especially heavy electric and electronic products. Double wall corrugated fiberboard is mostly made of BC flute; AB flute is not being manufactured. Double faced corrugated fiberboard is made of B or C flute, A flute being used only when requested by the user. For some outer containers for computers, white cartons have been used, but they are being phased out due to environmental considerations.

Adhesive for the cartons is made from substances including tapioca starch from Thailand.

The cost of cartons is more than twice that in Japan.

Design specifications for cartons are provided by the users (electric and electronic products makers). Some of the major makers of cartons possess strength and properties

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3) In Japan, the standard for moisture content in lumber is given in JIS Z1403, and crating material must be cured at 100-105 degrees, to bring moisture content to 20-24% or less.

4) These treatments are required of imports by China, Australia and some other countries.

testing equipment for liner and board (e.g, breakage, ring crush and end crush test apparatus). There are few makers or users, however, who undertake carton design and certify compressive force resistance with consideration given to the loss of moisture resistance under conditions of high temperature and relative humidity. In warehouses for electric and electronic products one can often see buckling of cartons stacked in storage. There is little done by way of acceptance examinations when a vendor delivers cartons.

2) Inner packaging materials

Cardboard cartons and dividers are the primary types of shipping containers for electric and electronic parts, deck mechanisms, chassis and other intermediate parts. Materials for dividers are mostly cardboard sheets, expanded polyethylene sheet, and styrofoam, to perform the function of preventing the items from striking against each other, support them rigidly, and cushion shock. Also, to prevent static electricity build-up during shipping, the items are sometimes covered with protective film, or nonconductive boxes are used.

For packaging of electric and electronic products that are finished goods, expanded, formed or processed plastic cushioning material is used as inner packing. The raw material for styrofoam is mostly imported from Germany, France and Malaysia; there is some domestic production of beads. Total production of formed styrofoam in all of Singapore is about 1,000 tons/month, of which about 90% is used for packing electric and electronic products.

The specifications for styrofoam to be used as cushioning material for electric and electronic products (product fragility, standards for drop test, foaming magnification, etc.) are often provided by the user, but there is little data based on actual measurements. The rate of expansion for styrofoam is often 50 times, and the quality of the product tends to be poor even at the large forming companies. Styrofoam made using imported beads tends to break easily, and domestic beads tend to result in low shock absorbency.

Expanded polyethylene is used for high-price electronics (computers, disk drives, etc.) at a cost several times greater than that of styrofoam.

(3) Distribution environment, and damage to products

The harbor of Singapore is not only well located in respect to international maritime shipping lanes, but also has excellent features as a natural harbor, and has been improved since many years ago as a matter of government policy. It leads the world in container traffic. Cargo handling facilities are equal to the best in the world. Import-export agents do their job swiftly and cargo handling is efficiently performed. A container is normally loaded or unloaded within 8 hours.

The road network within Singapore is excellent. The total length of the road system is 2,760km, of which 2,655km (about 95%) is asphalt–topped. Six highways criss–cross the country, and as surface conditions are excellent, there are relatively few accidents.

Warehouses (own–company or contractual) in which electric and electronic products are stored have ceiling heights of 5–6m (larger freight forwarders have warehouses with 7–10m heights) and medium and small electric products are stacked to heights of 4–5m. The top row is one unit less in number on a side and offset for stable stacking.

Nevertheless, the relative humidity in the warehouses ranges from 65 to 95% throughout the year, so conditions inside them are not favorable. When products that may rust easily must be stored, in some instances cooled warehouses of larger warehousing/forwarding companies are used, but most of the time no special measures are taken against humidity.

Overhanging from pallets, well crib–pilling, and uneven edges and corners can be frequently observed, but there is a low level of awareness that such storage methods lowers the compression strength of cardboard cartons.

The frequency of damage during shipping, according to the LNE Report, is higher when by air than when by ship, and higher by ship than when by truck.

The reason damage during air shipment is high is not the vibration of the plane in flight, but dropping of cartons when loading air cargo or unloading. The quality of air cargo handling work is low all over the world and the work at Changi International Airport is badly performed and in some instances cargo is dropped from a height of 1.2m.

Damage incurred during maritime shipment is less frequent than by truck, but the reverse is observed in Singapore. This is thought to be because overland shipping distances are short and road conditions are good, while the quantities carried by maritime transport are great, and harbor cargo facilities are operated at high speeds. The major cause of damage is dropping, and vibration during shipment and excessive weight loaded are second in importance and about equal as such.

In general, the most serious force brought to bear on goods in shipment is that arising from being dropped during handling, followed by shaking or vibration while being carried by truck.

Accidents resulting to damage of goods in Singapore occurs about in about equal frequency during shipment and during storage. This is largely because the high humidity in the storage environment causes the cardboard to lose rigidity and buckle, and because stacks of the boxes collapse. Damage to metal, by rusting, is also common.

During cargo handling careless operation of forklifts often leads to damage by ripping of boxes, caused by them being pierced with tines of the fork. Sleeve sheets are used for some electric and electronic products, and some cargo handling is done using push–pull forks.

(4) Packaging line work

Packaging is the last step in the process of making electric and electronic products.

The steps on the packaging line comprise (1) protection of product surfaces by application of polyethylene film or other materials, (2) fitting styrofoam pieces to the product so that it may be kept steady, (3) inserting the styrofoam–supported product into its box, (4) sealing of the box, and (5) placing the box on a pallet. Much of this work must be done by hand, as automation in this area has not made much progress. On the production line as well much work is still done by hand, but the industry is moving toward study of fully–automated production.

(5) Packaging technology

1) Container design

In the case of electric and electronic products, packaging cost (materials and labor) is not even 1% of total production cost but even at that rate large–scale producers in Singapore have an annual expense for packaging that is (in yen equivalent) hundreds of millions. How to reduce this expense is a matter of some importance to those companies, but because of the frequency of accidents –– caused by defective packaging –– to the products after they have been placed on the market, it also is a matter of great importance that packaging technology be improved, from the viewpoint of protecting the international competitiveness and reliability of Singapore's industry in the world marketplace.

This is why the electric and electronic products industry is seeking to develop optimum packaging, by establishing strict guidelines for container specifications, design, and testing. That is, in the course of shipping a wide range of goods –– from electronic parts to large appliances –– not only to domestic destinations but also foreign countries all around the world, in order to protect the quality of the goods from vibration, shocks or other environmental influences as reliably and as economically as possible, the electric and electronic products companies have developed detailed specifications and test or inspection standards for packaging materials. In order to design containers to comply with these requirements, it is necessary to have shock simulation or replication design technology, and test evaluation techniques, based on the laws of dynamics (see 3.1.3.1(2)), and companies in the West and Japan have acquired these techniques at an early time. In order to make use of these techniques, it is necessary for there to be packaging technicians, testing equipment, and specialized technology, but it can not be said that the electric and electronic products companies in Singapore are satisfactorily established in these respects.

Container specifications for electric and electronic products made in Singapore (for types of usable materials, construction of corrugated board cartons, compression strength, dimensions, shock absorptiveness etc.) as well as the basic design standards (strength level, test items, drop tests,etc.) are often determined by the prime contractor or parent company. In Singapore, detailed designs are made for manufacturing purposes, costs are estimated, and test evaluation of prototypes is made. Also undertaken locally are investigations into damage caused by poor packaging while goods are in the market, and planning of countermeasures.

Nevertheless, with regard to the presence of specialists, it is unusual for there to be specialized packaging technicians at manufacturing concerns, and technical personnel in the quality control area or in the production area are simultaneously responsible for packaging. A shortage of specialized knowledge results from this, and in turn this shortage means longer times are needed to take such measures as are required, in addition to which test equipment is limited. As a consequence, most of this work is turned over to packaging material makers or container fabricators. Electric and electronic products companies will confirm whether the sample containers delivered to them are made of materials that insure the functions needed are performed, do drop tests, and vibration tests, in order to judge if the sample is adequate.

Among the corrugated board carton makers some have an affiliation with TAPPI and have installed machinery --- equal to that seen in the West -- for testing the strength and quality of liner, and for subjecting sheets of corrugated board to tests of various kinds. Further, among the formers of shock absorbing materials, several possess machinery for drop tests and acceleration tests that are the equal of the best found elsewhere. These makers undertake production of cartons and shock-absorbing materials to meet the specifications of the users, perform tests in the presence of the users, and make test results available to them. Technical information from the industrially advanced countries is available to some of them through sources such as raw material importers (e.g., companies importing beads for styrofoam) and these companies can prepare conceptual designs of containers (by means of corrugated board strength calculation using the Macky method, shock absorbency calculation using acceleration velocity-stress curves, etc.) to comply with users' requests.

Packaging industry firms that have this sort of technology and equipment, however, are limited to some of the larger companies. Moreover, even among the relatively advanced makers of packaging materials, and users, there is an insufficiency of quality control techniques, and applications technology (applications know-how). And among the MNCs, at the parent companies where basic packaging specifications are prepared, there is not much knowledge of the special conditions in Singapore regarding technology, climate, and physical distribution of goods.

Many problems arise in connection with packaging technology as a result of this. In many cases, and excluding some of the large companies, strength testing equipment is not adequate, and there often are defects in corrugated board cartons as well as formed shock absorbing materials. As a result of these defects that arise in the production process, mechanical strength that the packaging materials should have is reduced when the cartons are fabricated or shock-absorbing pieces are formed. Moreover, the hygroscopicity of corrugated board and decline in its strength under ambient conditions of high temperature and high humidity results in failure to obtain the performance anticipated when packaging materials specifications have been determined on the basis of a theory-based design approach.

Even among MNCs or joint ventures in the electric and electronics industry, although the companies possess some equipment, they deal with failures or problems that happen when goods are sent to market on a case by case or ad hoc basis. That is, they try little more than to enlist the cooperation of the materials makers, do drop tests and make and remake prototypes as their effort at achieving improvements, but stop short of improving quality control, or undertaking a basic study of shock absorbing materials by use of measurements of product strength and external forces encountered during the phase of distribution. Because of this, under present conditions it is difficult to judge whether packaging is providing an optimum protective function, or too much, or whether the packaging is suitable in light of expectable problems that may arise after the product is shipped to market.

2) Packaging tests

More electric and electronic products made in Singapore are exported than are sold domestically, and much of the exports go to West Europe or the US, involving long shipping distances. Further, conditions related to physical distribution in Singapore, such as cargo handling and the environment in storages (high temperature and humidity) are bad.

In such circumstances, it is necessary to identify problems related to either the products or their packaging quality, and to perform packaging tests that can enable prevention of damage to the goods after being shipped to market. Such tests must reproduce within a laboratory the conditions that the goods and their packages would be exposed to. These conditions will not be the same as those in Europe, the US or Japan.

Some Singaporean companies undertake tests. Most of them are drop tests using containers with goods inside to simulate shocks imparted during handling, or vibration tests to simulate motion during shipping. There are few companies, however, that conduct load compression tests under conditions of high temperature and humidity.

Singapore has not adopted industrial standards for packaged goods testing. Companies use their own methods and standards for judging quality. In addition to company standards, there is some use of international standards (of the ISO or International Electrotechnical Commission, etc.) and of globally used standards (ASTM, MIL, etc.) as well as standards specified by users.

(6) Measures Related to the environment

Production of styrofoam in Singapore is on the order of 1,000 tons/month (by way of comparison, production in Japan is more than 20,000 tons/month) and as about 90% of this is used for shock absorbing materials for electric and electronic products, most of it is exported.

The environmental problem that arises in connection with electric and electronic products is how to dispose of the styrofoam packing or other shock absorbing material after delivery of the product to its final user. Escalation of use of these materials is a problem in most countries, as intermediate and final processing facilities are not adequate.

Concern over packaging pollution among Singapore's electric and electronic products industry is low in comparison to the level evident in Japan and the US. Relatively little of these materials are discarded in Singapore and there are only a few companies that recycle them. However, companies specializing in exporting to the Western countries are obliged to conform to environmental standards and practices in those countries as well as Singapore, and have collected necessary information from within Singapore and abroad. Some makers have replaced use of styrofoam with corrugated board or other paper materials for small items such as telephone sets.

3.1.3.3 Special conditions related to packaging in Singapore

(1) Diversity in the distribution system

The distribution system for electric and electronic products in Singapore is complicated as a result of Singapore's position as an international and regional distribution center.

For example, in the case of a Japanese-owned factory producing color TVs and TV monitors, picture tubes are imported from the company's own plants in Japan and Canada, and products of the factory are provided as OEM equipment to other companies in the same group but in Korea and Singapore. Electronic circuit printed boards are brought in as semi-finished products from the company's plants in Thailand and Malaysia, but are also being produced in Singapore. Of the finished products (TVs), 95% are exported under the company's own brand, to the US, Canada, Australia, New Zealand, Thailand, Hong Kong, Malaysia, the UK, Germany and other countries. In addition, some are supplied to another company in the industry as OEM products. Moreover, electronic circuit boards are not only used in the company's plant but also are, on occasion, exported as semi-finished goods to nearby countries and Japan.

Electric and electronic products production in Singapore, as this example shows, has a high degree of horizontal division of labor and, in accordance with that, complexity arises in the overall distribution process.

In general, export shipping is done on either an urgent or regular basis. In the former case, air cargo is used, and for the latter, ships. More volume is carried by ships than by air.

In the case of urgent shipments, the products are loaded individually on trucks, transported to Changi International Airport, and then loaded as air cargo.

In the case of ordinary shipments, products are collected not only at the production site (factory) but also at company-owned warehouses and contracted warehouses, from which they are sent to the factory for loading in containers. The containers are carried by truck trailers to the port and loaded into container carrying ships.

Some small products such as structural parts for ICs and CRTs are normally shipped by air.

In the case of maritime shipment, international standard containers (40 ft) are generally used, from the point of origin to the ultimate destination. There also is a trend for shipments to be made in unit loads. When products are shipped to Canada and the U.S., door-to-door transport of the containers is standard, with overland transport accomplished by use of rail or truck trailers from the port of entry.

There is, in addition, some reloading of containers in Singapore, from large container carriers originating in Japan, to smaller container carriers that will transport the containers to nearby countries.

(2) Higher precision of products

MNCs tend to use Singapore not merely as an overseas production point but also as a key location for marketing, services, product development and R&D in connection with Southeast Asia. In connection with this there is a trend evident toward the production of goods that have high growth potential, that have high returns on investment, and are high-tech type products. That is, labor-intensive appliance production is shifting to adjacent ASEAN countries, and increased use is being made of Singapore as a location for mass production, automated lines, and for high value-added products such as telecommunications equipment (facsimile machines, printers, cordless telephones, etc.), computer devices, semiconductor parts and the like.

The importance of packaging is increasing as a result of these changes.

These products incorporate high-precision integrated circuitry, sensors, connectors and other electronic devices, and mechanisms that are extremely sophisticated owing to diversification of functions of equipment, and hence they are extremely sensitive to shocks and vibration. Moreover, because these are made to be extremely light in weight and small or thin, often they are not provided with adequate soldering, support screws, stiffening ribs or special processing. Accordingly, it is frequent that the materials do not have a high level of strength, and these products are much less sturdy than the traditional home appliances.

Therefore, it is necessary to undertake repeated drop and vibration tests and measurements, so that the products' strength can be properly determined for purposes of packaging design.

It has become inadequate to use the methods of the past, whereby the strength of a similar product was measured, drop and vibration tests were performed using the packaged product, and changes were made on the basis of test results until, through trial and error, a design could be developed.

3.1.3.4 Issues related to packaging

(1) Improvement of packaging technology

1) Delay in improvement of packaging management arrangements

The status of packaging of electric and electronic products in manufacturing companies, and the locus of responsibility for it and corresponding authority, is generally not clear, and as a result there is a tendency for packaging technology, equipment, effectiveness of managerial control and maintenance to be deficient. The reasons for this are several. First, packaging has little direct relation to new development of electric and electronic products, or sales or contribution to profits from such products. Also, the basic technology is at a mature level. Problems were not evident in the past because of reliance on years of experience of technical personnel or craftsmen and that was sufficient.

These points are evident in Singapore just as in other countries.How to eliminate the lag in technology related to packaging, equipment, and managerial control, how to improve technology, and how to diffuse technology and retain it in corporations over time are important issues.

2) Deficiencies in the approach to optimum packaging design

In order to provide optimum protection for electric and electronic products, it is necessary to collect and study data on the allowable shock products can take, the height from which a product in its container may be dropped during distribution, and other basic data, and on the basis of the values thereby attained, use a design approach incorporating the theory of dynamics to the problem of shock and vibration.

In Singapore's electric and electronic products industry, however, very few establishments have testing equipment that can determine how much shock a product can receive, or, that is, its strength. In addition, there are almost no records of the extent of actual vibration and shock imparted to products while they are being shipped. The present situation is one in which strength of products made in Singapore is estimated using data from the parent company for similar products made in the past, and packaging design specifications are prepared on that basis.

As there is no test benchmark data for Singapore for the force brought to bear on the products is made of the standards developed by the parent company under conditions that simulate the distribution environment, and foreign or international standards such as those of the ISO. It is not clear whether these test standards accurately represent actual conditions in Singapore.

Further, often the development of packaging design is done by a local packaging company's making of a prototype, that is subjected to the requisite strength tests, and the prototype is changed until it passes the tests. This trial and error approach is a waste of time and money. Further, because shipment is then done without there being assurance from a theoretical approach, it is not possible to make a well-founded revision of the design when there is an accident to cartons after the goods have been shipped in them to the market.

To obtain the optimum package design, it is necessary to collect and study the required basic information (product strength, predictable external forces, etc.) to confirm the maximum shock that must be absorbed by packaging materials, and decide on the specifications for the container on that basis.

3) Deficiencies in dealing with optimization of the product/container system cost

In transport containers for electric and electronic products, it is necessary to consider not only the strength of the products, their form, dimensions and weight, but also the environmental conditions during storing and transporting the goods. Therefore, when the product and the package are designed, it is necessary to seek optimization by an overall approach that takes both product and package into consideration, rather than to design them separately.

For example, if there is a weak portion of the product, or a part of it that protrudes, the packaging design that provides protection for that part will often result in increasing the dimensions of the overall package more than would otherwise be required. This then reduces efficiency in transport, handling and storage, and in overall terms costs are increased.

Package design that shall be seen in the future will have been redefined as "an integrated product/package system" and this system will be what provides the necessary strength. In order to accomplish this at the lowest possible cost, it will be necessary to design the product and its package so as to balance their strengths. This in turn requires the cooperation of product designers and packaging engineers from the stage of development of the products, and design of the product so that it has adequate strength not only for use but also for withstanding the environment during its distribution phase.

(2) Ensuring a supply of packaging equipment and technical personnel

To attain the optimum shipping container, it is necessary to have the proper equipment and knowledgeable, trained personnel so that a design approach grounded in theory may be used. Even though a company's parent firm may have such equipment and personnel, the local companies have only limited equipment, and few specialists in packaging.

This is a consequence of a kind of division of labor wherein reliance is placed on the parent firm for main packaging specifications and setting of conditions, while in Singapore, emphasis is placed on purchasing packaging materials that conform to the specifications and maintaining quality standards. In actuality, however, a variety of problems that the parent company has not envisaged occur and must be confronted by the Singaporean company, including many instances of damage to the products after they have been shipped from the point of production.

The major causes of these problems, in addition to 1) failure to obtain basic data regarding product strength and environmental forces during the distribution process, include 2) the high temperature and humidity in Singapore, and 3) inability to purchase packaging materials as required by designs, due to quality deficiencies in the locally procurable materials, not to speak of 4) these problems are not fully and adequately perceived by the parent companies, resulting in a lack of progress in developing countermeasures.

These problems are also ascribable to deficiencies in acceptance inspection in Singapore of materials, in packaging test standards, and in the arrangements for quality control such as analysis of rejects or failures. Therefore, need exists to promote greater awareness in Singapore of the importance of packaging management, and acquisition of adequate equipment and technology.

a) Required Equipment

- –Quality testing equipment for materials and supplies procured from local packaging materials vendors (rupture test equipment, crushing equipment, etc.)
- –Packaged product testing equipment to ascertain the extent that protective functions are being provided (vibration, drop, crushing test equipment)
- –Equipment for measurement of product strength and the strength of forces acting on it from the environment during distribution (product drop shock test equipment, transport environment measurement system, etc.)

b) Required Technology

- –Technology for measurement and analysis of ambient temperature and humidity conditions and change in the properties of materials due to defective manufacturing, as well as technology for improvement of the quality of materials, and supervision of materials vendors
- –Technology for packaged products test equipment and acceleration measurement equipment; technology for analysis of problems that occur after shipment by the producer, and for improvement of the packaging on that basis
- –Shock–absorbency design technology for product strength measurement, vibration and shock measurement, and optimal–cost design of protective packaging

(3) Promotion of standardization

1) Increased use of unit loads, and standardization of pallets

Most of Singapore's output of electric and electronic products are exported, and are shipped to a large number of countries.

In order to improve efficiency in exporting to a large number of companies, the major electric and electronic products companies are making greater use of door to door, integrated multi-mode transport. This integrated transport, combining use of truck trailers, ships, and rail, has the effect of lowering shipping cost and shortening shipping time, making it easier to ship to distant points all over the world. In order to secure these advantages, however, packaging specifications must suit the integrated transport system. That is, in order for there to be palletization, pallet dimensions must be standardized, container dimensions must be modularized, and there must be standardization of container markings, packaging test standards, design standards and so on.

At present, many of Singapore's electric and electronic products companies are using pallets having dimensions that match the 1,000 to 1,200 mm inside dimensions of larger containers used for international shipments. But pallet specifications are prepared by each company individually, and a range of different types of pallets are in use (e.g., different regarding fork insertion place, height, deck board dimensions, etc.). Because of this, there is no standardization so that the pallets can be used when they reach their first destinations from Singapore. Need exists in the case of palletized shipping for there to be modularized package dimensions and standardized pallets, both suitable for container shipment.

Hereafter, in order for there to be greater diffusion of use of unit loads, need exists for cooperation of companies in the distributive area, and promotion of use of pallets that the entire industry in Singapore accepts and are of such types in terms of loaded weight and size as to conform to international standards.

2) Quality standards for improvement of packaging reliability, and standardization of test standards

In order to improve the reliability of Singapore's electric and electronic products and their packages in the international market, rather than rely on design and test standards that are adopted by each company individually, as is now the case, it is necessary to develop the following Singapore standards; and on that basis companies may determine their own standards.

a) Quality and strength standards for all packaging materials to be used in a standard Singapore environment

b) Methods of testing and measuring properties of all kinds of packaging materials
c) Packaged goods test methods
d) Handling instruction markings and indications

Further, it is necessary to also proceed with improvement of standards regarding the following.

a) Mechanization of cargo handling, operation of forklifts, etc.
b) Improvement of protective equipment installed in warehouses
c) Standardization of stacking in storage methods and stacking heights
d) Control standards for warehouse interior environments (temperature, humidity)

(4) Environmental considerations

Even though necessity has emerged for anticipating environmental protection requirements and practices in export destination countries, there has been little real progress in regard to the environment, specifically in relation to reuse and recycling of packaging materials, indication of the contents of resin materials, and separate use of compound materials.

Measures related to the disposal and use of waste packaging materials are being given international attention as a global social issue, and it is also important in the context of complying with international movements based on this that there be no loss of international competitiveness. In this light, necessity exists for environmental affairs activities within each company to be improved, for the quantities of packaging materials consumed to be reduced, for collection, reuse and recycling to be increased, to make greater use of materials that do not create as a great burden on the environment as those they replace, by the industry acting as a body.

3.2 Food Products Industry

3.2.1 Trends in the Food Products Industry Relevant to Singapore

There are three categories of food products industry, from primary industry to tertiary industry, depending on the raw materials and destination of products.

The primary food products industry encompasses commercial production of farm (or marine) products for supply either in final form to the household sector or to the secondary industry, for processing, and almost all food products industries are included in this category. The secondary industry processes products of the primary industry as the former's raw materials for production of an extremely wide range of foodstuffs. Examples include the bakery products industry and the noodle industry, edible oil processing industry, and condiments industry. Tertiary industry used the products of the primary and secondary industries to make even more specialized or special products, and also includes packers and bottlers. Included among the former is the confection industry, and in the latter frozen food companies, prepared foods makers, and beverage makers.

The form of international development first taken by the food products industry began within the primary food products industry when companies belonging to the staple food group -- such as sugar refining or flour milling ---expanded activities to production regions, to export from there to their own countries. Either these production facilities were established in the country of origin of products such as sugar, wheat or coffee, or large distribution facilities were established there, so that large quantities of products could be shipped to the country of consumption.

The next step was when a company had been exporting foodstuffs or food products for consumers, but the market expanded and the number of instances of local production increased. This was the means many of the giant food product MNCs developed their international sales networks.

This movement continued, and to it were added two additional aspects. One was when companies in the secondary or tertiary food products industries, including restaurant or food service operators, that had previously obtained foodstuffs from primary or secondary industry firms, themselves expanded operations to the supplier regions abroad, for processing and export to home-country plants or central kitchens, or for sale as their own products. The other was when companies in the tertiary industry such as bakeries, confection makers or ice cream makers, whose products were not suitable for exportation, expanded overseas to supply local markets.

Through 1990 there were 45 Japanese food products or beverage companies that expanded into the ASEAN region, in a total number of cases of foreign investment of 55.

	Number of Establishment	Number of Cases
Singapore	11	13
Malaysia	5	7
Indonesia	10	12
Thailand	16	19
Philippines	3	4
Total	45	55

During the past decade the increase in Japanese investment has been swift in Singapore and Thailand. There are 13 instances of investment in Singapore, and 8 have been recorded since 1980. Of the 19 in Thailand, 14 were recorded in or after 1984.

3.2.2 Singapore's Food Products Industry

3.2.1.1 Outline

The food industry is the second largest industry in production scale in Singapore, after electric and electronic industry, with a total including beverage industries of S$ 2.5 billion (or about 200 billion yen). Exports amount to about 55% of output, in the case of food industry and 30% for beverage industry. The share of exports in food production has not shown great change over a long period of time, but in the case of beverages the share has increased together with the increase in production, indicating that the beverage manufacturers interested in export have shown rapid growth.

In Singapore, the food industry has acquired a form not seen in other countries, owing to the small scale of the population, the absence of an agricultural sector, and the special characteristics of Singapore's economic environment favorable to distributive activities.

That is, 1) the food products industry, while having the domestic Singaporean market as its main objective, has also been able to use exports to attain a satisfactory scale of business operation, 2) there are Singaporean food products industry firms that provide import and export functions for Malaysia, and 3) there are firms that import food products from Australia, New Zealand or elsewhere, and re-export them to Japan, Taiwan and elsewhere.[5]

The first type of food products industry company owned by local interests has found it necessary to export because the small scale of the domestic market has not been sufficient to attain efficiencies such as that of utilization of production facilities. Moreover, as a result of these companies' small scale and the quality of their products, their lack of ability to sell products under their own brand names, has led to their giving emphasis to having low labor costs, and to doing contract production for other companies. The food and beverage products that are exported, thus, are not maker's brand goods but usually have the brand name of others, the OEM or contracting companies. This sort of food products industry seeks to develop an advantage by Singapore's having 1) access to low-cost raw materials from adjacent or nearby countries, and 2) a relatively inexpensive labor pool, but these are not necessarily advantages in comparison to conditions in adjacent countries.

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[5] Regarding this re-exportation, Singapore defines re-exported food products only as those that have been re-packed, sorted, graded or marked in Singapore.

There are instances when reliance must be placed on foreign workers to satisfy demand, and some of a shift of the production base from Singapore to a nearby agricultural country as a means of acquiring inputs at low cost. Further, these companies do not have technical capabilities that assure them of an edge over competitors through undertaking of technological development.

Makers of foods and beverages that have contract packers have produced fruit juice, sauce, curry, confections, frozen foods and other products. As part of the contract packing arrangement, there are "supply of recipes," "development and improvement of products" or "production on an OEM basis" depending on the case.

Also, among this first type of food products industry company, there are many companies that do not have a foreign-capital affiliation such as mentioned above, but export productions specifically to overseas Chinese markets in Asia or elsewhere but as is mentioned below, these companies too can not be said to have a satisfactory level of international competitiveness.

The third type of food products industry company has actively sought investment by foreign interests. As in the case of major MNCs that have plants here, their strategy in many cases is to use Singapore's advantage as an entrepot and distributive center, to bring together supplies of coffee, milk, oil and other food product inputs, and process them to make food products for commercial use of sale in other Asian countries. Some companies have made Singapore their center of operations for food products industry business.

3.2.2.2 Exports and Imports of foods and beverages

The total value of foods imported by Singapore in 1991 was S$5.022 billion, and the value of exports was S$3.229 billion. The products for which high values were recorded are shown in below. There are only three items for which exports are greater than imports: processed fish products, coffee and condiments, and beverages.

<Exports (FOB)>	<Imports (CIF)>
1.Processed Fish Products	1.Vegetables/Fruits
2.Beverages	2.Processed Fish Products
3.Coffee/Condiments	3.Beverages
4.Vegetable/Fruits	4.Coffee/Condiments
5.Processed Grain Products	5.Processed Grain Products
6.Dairy Products/Eggs	6.Dairy Products/Eggs
7.Processed Meat Products	7.Processed Meat Products
8.Sugar/Confections	8.Fresh Meat
9.Fresh Meat	9.Sugar/Confections

More than 80% of gross imports by this country is re-exported; the re-exports amount to S$2.579 billion. With the exception of processed fish products, all high-ranked export products (beverages, coffee and condiments, vegetables and fruits, and others) are reexport goods. Re-exports of these amount to more than 90% of the value of exports of each item.

Major export destinations are Hong Kong, Japan and Taiwan. There are some degrees of concentration in exports to Hong Kong (processed meat products, dairy products, fruits and vegetables, sugar and confections, processed grain products, etc.), Japan (processed grain products, coffee and condiments, processed fish products, beverages, etc.) and Taiwan (sugar and confections, processed fish products, processed grain products, etc.).

A large share of re-exports go to Malaysia; exports to that country include fruits and vegetables, processed grain products, sugar and confections, processed meat products, beverages, dairy products, coffee and condiments. In terms of quantities, however, there is a tendency for re-exports to exceed pure exports to Japan, the US, Germany and other industrialized nations as well as India, Bangladesh, Saudi Arabia, Oman and some others, while pure exports to Hong Kong and Taiwan are at low levels. In exports to the industrialized countries, a high level is seen for pure exports of beverages, coffee and condiments, and processed fish products.

By product, imports of milk and cream from Australia and New Zealand, and Malaysia, are high. Among gross exports, pure exports, or exports of goods of purely Singaporean origin, account for 50%. Most exports to Taiwan are re-exports; they account for more than 40% of total re-export value.

A third of fish and shellfish imports are of Taiwan-origin goods. Japan is the largest export market, and exports (mostly re-exports) account for 40% of the value of exports. Major export destinations of purely domestic-origin food products are the US, Japan, the UK, Taiwan, Spain and others. Crab and shrimp are imported from Southeast Asia, and exported to the US, Europe and Japan.

Almost all rice imported is from Thailand, and a small quantity is re-exported to Malaysia. Processed grain products are imported from Malaysia, the UK, the US, Australia, Japan and elsewhere. Imports from the US and Australia are primarily wheat and corn products. Major export markets for processed grain products are Japan, Malaysia, Hong Kong, and Taiwan; pure exports account for about 30% of gross exports to Japan but re-exports to Malaysia, Hong Kong and Taiwan also are high.

Vegetables are imported from Asian countries, the US and Australia, and there is some reexportation to Malaysia. Foods made from roots or tubers are imported from China, the US and Japan, and for these too there is some re-exportation to Malaysia.

Fruits and nuts are imported particularly from Malaysia, the US, Australia, China, New Zealand, India, and Thailand. Gross exports are almost entirely re-exports, with Malaysia, India, Hong Kong and Brunei the major destinations. Of imports of products made of fruit, nearly 50% is from Malaysia. More than half of imports are re-exported; the major destinations of re-exports are Japan, Malaysia, the US and Saudi Arabia. Exports of purely domestic-origin products are high in the case of shipments to Hong Kong and Saudi Arabia. Fruit juices are imported from the US, Malaysia, Australia, and Korea, and more than 60% of exports are re-exports, of which 36% is to Malaysia.

Sugar and confections are imported from China, Malaysia, and Japan. More than 70% of gross exports are re-exports, and more than 60% of that is to Malaysia. Exports of purely domestic products are made to Japan, Hong Kong and Brunei. Exports of chocolate exceed imports of that product; purely domestic products have a share of 86% of exports. Of domestically-made products, 70% is shipped to Japan and the major other destinations are Korea, Hong Kong and Taiwan. Among re-exports, the largest share is that to Saudi Arabia, 27%.

The value of exports of spices is greater than the value of imports of that product, and almost all exports are re-exports. Re-export destinations are Malaysia, Bangladesh, Pakistan and the US.

For margarine and shortening also, exports exceed imports. and domestically made products have a share of 90% of gross exports. Exports of domestically made products are sent to Jordan, Syria, Afghanistan and Lebanon.

Exports of non-alcoholic beverages exceeds the value of imports of this item, and domestic products account for more than 90% of the total. Domestic products are exported primarily to Hong Kong, Japan and Brunei. Exports exceed imports also in the case of alcoholic beverages, and 96% of exports are re-exports. 84% of the re-exports are sent to Japan. The major domestic product is beer; it is sold to Malaysia and Japan in particular.

3.2.2.3 Foods and beverages industry within the manufacturing sector

The value of production of foodstuffs in 1990 was S$2.044 billion, while that of beverages was S$0.511 billion, for a total of S$2.555 billion. The total value of production by the manufacturing sector (excluding rubber processing industry) in that year was S$71.333 billion, so that the foodstuffs and beverages industries combined accounted for a share of 3.6%. Comparing the production values to those of 1981, it is found that whereas there have been increases of 21.0% for foods and 56.7% for beverages growth for manufacturing has been 93.9%, meaning a loss of share of nearly 2%, from 5.5%, for foods and beverages.

Output per worker in the foods and beverages industries in 1990 was S$192,600, which was somewhat below the average for all manufacturing, S$230,000. The corresponding values in 1981 were S$167,800 and S$132,500, so the growth for the former has been less than that of the latter.

The total value added of the food products industry in 1990 was S$583 million and that of the beverages industry was S$252 million for a total of S$835 million.

This is quite low compared to the average for all manufacturing, that was S$616 million. The value added per worker in 1981 was S$35,200 in both food products and beverages combined, while the all-manufacturing average was S$34,700. Thus, the improvement in foods and beverages was less than that of the rest of manufacturing.

The value added ratio in foods and beverages combined in 1990 was 28.5%, that was lower than the 30.3% for all manufacturing. The corresponding ratios in 1981 were 21.0% and 26.2%. Here too improvement has been slower in foods and beverages than elsewhere in manufacturing.

The value of direct exports of food products in 1990 was S$1.114 billion while that of beverages was S$0.153 billion, for a total of S$1.267 billion. The corresponding value for all manufacturing was S$47.000 billion meaning that foods and beverages had a share of 2.7%. In comparison to 1981, direct exports of foods rose 27.5%, that of beverages rose 59.4%, but that of manufacturing rose 110.1%. The share thus declined from the 4.3% of 1981.

Equipment investment by the food products industry in 1990 totalled S$114 million and that by the beverages industry totalled S$119 million for a total of S$330 million. The total for all manufacturing in that year was S$4.184 billion, making the share of the former two 8.0%. Comparing these results to those of 1981,there was an increase of only 37.3% for foods and 7.4-fold for beverages, so the share in all manufacturing rose from the 5.00% of 1981.

The number of workers employed in the food products industry in 1990 was 10,615. That in the beverages sector was 2,439, for a total of 13,054. Employment in manufacturing in that year was 351,674, so the share of the former two combined was 3.7%. Comparing this to the situation in 1981, it is seen that there has been a 5.5%

increase for foods and a 10.7% decrease for beverages, so there has been a decline from the level of 4.5% in all manufacturing.

3.2.2.4 Structure of production and distribution

(1) Production structure

According to EDB information,[6] the value of foodstuff production in 1900 was S$2.0044 billion, and the value of beverage production was S$511 million. Subsequent to 1984 when foodstuff production value passed the S$2 billion level, with the exception of 1987 the value has been from S$2 to 2.3 billion. From 1986 to 1989 beverage production increased at more than 100% a year.

The production of major foodstuffs and beverages, in descending order of value, was as follows in 1990.

	million S$
1. Bread, Cakes, Confectionery	398.47
2. Edible Oil Products	398.03
3. Processed Milk	362.24
4. Non-alcoholic Beverages	321.08
5. Alcoholic Beverages	189.56
6. Fish Products	88.31
7. Beehoon, Noodles	56.47
8. Cooked Food Preparations	53.63
9. Sauces	53.52
10. Spices	37.28
11. Meat Products	34.74

The export ratios in 19900 sales were high for both foodstuffs and beverages, at 54.2% and 30.0% respectively. The export ratio of foodstuffs has exceeded 50% every year since 1980. The ratio for beverages was less than 20% up to 1987, but has been at least 30% since 1988. By category, ratios are highest for oils and spices, at 70% or higher; bakery and confection products, processed milk, seafood and sauces, all in the 50-60% range, and carbonated beverages and vermicelli and noodles, at more than 30%.

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[6] EDB, "Report on the Census of Industrial Production." The data in this report is based on 265 food product companies and 14 beverage companies.

There is a considerable difference in scale of companies in the food products industry and in the beverages industry. According to the EDB, beverage sales at a food products company is S$7.76 million while that at a beverage company is S$36.43 million; the former is one-fifth that of the latter. The value of production is less than S$5 million at 76% of the food products companies, and in this sector 12% of the companies produce less than S$0.5 million and only 16% produce more than S$10 million. On the other hand, in the beverages industry there are no companies that produce less than S$50,000 and the number that produce less than S$5 million is relatively low, at 64%. Nearly 30% of all companies have a scale of production of S$10 million or more.

In terms of number of employees too, there is a sharp difference between the food products industry and the beverages industry. In the former the average scale is 40.1 employees while in the latter is 174.2. Foodstuff producers employ less than a quarter of the persons that beverage makers employ. About 70% of the companies that make foods are pettyscale enterprises than have only 30 or fewer employees, and only a tenth of all companies employ at least 100. In terms of the type of product produced, a relatively large scale is evident in milk processing and chocolate manufacturing, where the average number of employees per company is more than 100. On the other hand, among companies manufacturing scafood products, bread and noodles, and vegetable products employment is no smaller than 40 persons per company on average. In the beverage industry, half of the companies employ 30 or fewer persons, and nearly 30% employ 100 or more.

(2) Capital structure

In the food products manufacturing industry more than 7 out of 10 companies are owned by Singaporean interests, and nearly 10% are fully owned by foreign interests. On the other hand, in the beverages industry more than half of all companies are at least partly owned by foreign interests. Only one company is fully owned by non-Singaporean parties; most companies are joint ventures. Japan is the major source of capital for food products manufacturers and nearly 40% of all foreign-affiliated food products companies have received investment from Japan. Investment sources other than Japan include Australia, the UK, and Malaysia. Many cases may be seen of foreign companies contacting with Singaporean companies for production, and these OEM products are made in a wide variety of categories, such as frozen foods, sauces, edible oil, chocolate and confections, milk products and carbonated beverages.

There are but a few companies producing chocolate, fruit juice, edible oils, frozen seafood, simple precooked meals and flavorings, but they have production equipment