(5) Alliance with counterparts in countries having advanced packaging technology

Such basic activities of the Center, as standards testings and a certain areas of contract testings, may be performed by its staff with the planned recruitment and the training programs. However, to keep abreast of rapidly advancing packaging technology, and to provide with appropriate technical guidance and technical information services required in accordance with the sophistication of the industries, the Center is recommended to make most of the support available from the similar organizations in countries with advanced packaging technology through teaming up with these organizations, particularly until the packaging sector in Singapore can develop their ability to be the partner of the Center in developing packaging technology in this country.

5.3.4 Socioeconomic Effects of Packaging Technology Center Development

The project to develop the Packaging Technology Center is expected to generate the following effects. Although the project is not only one way to achieve such goals, but is sure to maximize the effects if properly administered.

(1) Economic effects

1) To encourage import substitution for packaging materials

Quality improvement of locally produced packaging materials will substitute for imported ones that dominate the market. Note that not all the imported packaging materials can be replaced with local products; there must be critical mass to support local production.

2) To achieve cost reduction by decreasing damage to exported goods

Since many products exported from Singapore use imported raw materials and components, the decrease in damage and loss to exported products through improved packaging would lead to the decrease in materials import, thereby to have positive impacts on the country's foreign exchange.

3) To make social contribution through lean packaging

If excess packaging is reduced for locally sold products, in addition to export products, it will contribute significantly to the society by reducing the waste disposal cost.

4) To explore new export markets

Improved packaging can extend shelf life of products, particularly foodstuff, leading to geographical expansion of potential export markets.

(2) Other indirect and intangible benefits

1) Accumulation of advanced packaging technology and promotion of product development

Introduction and diffusion of production technology will replace previous packaging improvement practices based on copying or trial and error with package design and management techniques on a scientific basis. Once advanced packaging technology takes root throughout the country, it will serve as a basis of developing proprietary design, technology, and materials.

2) Streamlining of physical distribution system

Improved and uniform packaging will promote standardization of physical distribution systems and will enable the streamlining of distribution operation, such as integrated transportation.

3) Improvement of packaging quality

Establishment and improvement of testing standard and product specifications for packaging and cushioning materials, together with improvement of testing service, will facilitate specification and certification tests, leading to promotion of certification by a third party organization, and improvement of packaging quality.

4) Contribution to international competitiveness of manufacturing industry

For any country particularly Singapore, the improvement of product quality in terms of performance and precision is essential for the manufacturing industry to raise its international competitiveness. The packaging sector is an important element of supporting such quality improvement. Also the powerful packaging sector will reduce time-to-market for products, which is a critical factor in determining the manufacturer's international competitiveness.

5) Promotion of supporting industries

The packaging industry, particular converters, is made up of relatively small enterprises. Thus, promotion of the packaging sector directly leads to promotion and strengthening of SMEs. This clearly helps ameliorate two major issues facing the manufacturing sector in Singapore, a widening gap between foreign-affiliate corporations and local enterprises, and the lack of supporting industries.

6) Development of the packaging sector to export industry

Neighboring countries face the issues related to packaging, similar to those in Singapore, which are solved by overseas parent companies in the case of MNCs. Once Singapore has the advanced packaging sector, it will be able to meet needs in neighboring countries for improved packaging. For instance, the packaging industry can grow to 1) expand their production bases in neighboring countries, 2) export packaging materials, and 3) extend consulting service to the users in neighboring countries. At the same time, the Packaging Technology Center is expected to provide the packaging industry and users in neighboring countries with the following services: a) research and study on transportation and distribution environment, b) development test, c) standards tests and quality certification tests, and d) human resource development.

Table 5-1 Items to be managed in Product Quality in Food Industry

Breakdown of Quality	Items to be managed
Quality of Materials	Raw materials used
	Migration of substances
	Range/stability of quality characteristics
Quality of Processing	Printing
	Processing including lamination
	Mixing of insects
	Attachment of foreign matters
	Microbes

Table 5-2 Services to be provided by the Packaging Center

Services	Items
Standards and Certification	– Availability of Singapore Standards and other overseas national and international standards on packaging – Guidance and assistance in various SISIR's Certification Mark Schemes (e.g. UN Registration Mark, SISIR Certification Mark, Good Manufacturing Practice and the SISIR ISO 9000 Certification Scheme.) – Calibration of measuring and manufacturing equipment – Consultancy and training on quality assurance system
Testing and Analysis	– Ability to perform physical, chemical, environmental and other specialized testings to evaluate packaging protection, performance and compatibility to product – Expertise to develop testing methods and standards for packaging
Food Science and Technology	– Assistance in selecting suitable packaging for food products – Consultancy in food processing technology (e.g. blast freezing, canning, aseptic processing, etc.) – Product formulation and development – Pilot plant facilities for canning and aseptic processing – R & D project (e.g. shelf-life extension, MAP, etc.)
Chemical and Pharmaceutical	– Assistance in selecting and evaluating packaging for chemical and pharmaceutical products – Evaluation of packaging for transport of dangerous goods (e.g. chemical, solvent, etc.)
Electronic and Electrical Technology	– Evaluation of packaging for electronic and electrical products with regard to transportational and environmental issues – Evaluation of electrostatic resistivity of packaging material
Material Technology	– Assistance in selecting and evaluating packaging material – Optimization and identification of packaging material – Material failure analysis (e.g. tear, corrosion, contamination, etc.)
Production and Process	– Development and evaluation of production process including plant layout and monitoring and control system – Automation of packaging process to ensure efficient process flow – Computer-integrated manufacturing (CIM) consultancy – Industrial planning
Design and Fabrication	– Designing and fabricating machines and equipment for special requirements
Industrial Design	– Through SISIR's strategic cooperation with frogdesign's Global Creative Network (a world-renown industrial design company), we can refer clients to a source of award winning, world class packaging concepts
R & D	– Co-operative research programme to evaluate and develop packaging technology and material – R & D joint project with other sciences (e.g. Food Science, Materials, etc.)
Marketing & Commercial	– Assistance in feasibility study, strategy formulation and business planning for packaging manufacturers – Providing market research, trend analysis and other vital information for business – Identification of new packaging product applications
Information Center	– Maintains up-to-date information in technical and commercial development of packaging technology, market trends and regulations – Offers a wide range of technical reference, journals, patents, regulations and annual reports of local and overseas organizations, trade leaflets, catalogues and directories
Consultancy and Training	– Assistance in selecting and marketing prototype packaging, field testing and scale-up production – Seminars and training for packaging technology – Provides a one-stop packaging consultancy service – Assistance in solving engineering and technical problems related to packaging

Source: The Packaging Center Brochure

Table 5-3 Major Equipments for Packaging Testing at SISIR

- ELECTRONICS TEST CENTER -

Type of Test	Name of Equipment	Test Characteristics	Capacities (internal dimensions, max. force, weight of specimen)
Environmental Test	Weiss Technik high temperature change rate	-70 to 180℃ 15% to 95% R.H.	79 x 84 x 74cm
	BMA walk-in temperature/humidity chamber	-20 to 100℃ 10% to 95% R.H.	209 x 204 x 216cm
	Walk-in temperature chamber	27 to 56℃	3.2 x 2 x 4m
	3 Table temperature humidity chambers	-70 to 150℃ 30% to 98% R.H.	
	2 Heraeus Voetsch temperature humidity chambers	-80% to 180℃ 10% to 98% R.H.	74.5 x 88.0 x 76.5cm
	Heraeus Voetsch low pressure chamber	atmospheric pressure to 1 mbar	60 x 70 x 80cm
Vibration Test	RMS high frequency vibrator	5Hz to 5kHz	5kg = 30g 10kg = 17.5g
	LDS random and sine vibration	5Hz to 3,000Hz	Maximum Force: 2,722kgf Velocity: 1.5m/s Displacement: 38mm Acceleratoin: 60kg
Drop Test	LAB drop tester	Drop height: 1.5m	specimen: 45kg
Shock Test	LANSMONT Model 95/115		Max. load: 1,000kg
	LAB shock tester	Half sine 100g 6ms	Max. load: 14kg Max. size of specimen: 25 x 25cm
Electrostatic Tests	ETS 406 C, static decay meter	NEPA Codes 56A MIL-STD-81705 B	
	ETS 805 IC tube resistivity meter	ASTM-D-257	
	Electrostatic discharge tester for IC		

Source: LNE report

– PAPER AND PAPERBOARD LABORATORY –

Name of Equipment	Remarks
TMI compression tester	For RCT, ECT
2 Burst terters (for paper) (TMI and Frank)	
2 Burst testers (for corrugated board) (TMI and Frank)	
Whiteness and brightness tester	
Instron tensile tester	Maximum load: 25kN Velocity: 500mm/min
Climatized room	Machinery and control system to be improved in order to maintain standard conditions

– POLYMER TECHNOLOGY CENTER –

Selection of equipments which can be used for packaging materials testing

Name of Equipment	Remarks
Infrared spectrophotometer with high temperature hot cell accessories	
ZWICK type 1445 Universal testing machines (with environmental chamber from –40 to 150℃)	Max. load: 1,000daN Velocity: 500mm/min
Dart tester (free falling weight machine)	
Slip and blocking tester	

- FOOD TECHNOLOGY CENTER -

Selection of Equipments which can be used for packaging and packaging materials testing

Type of Test	Name of Equipment	Remarks
Chemical Analysis (migrants, monomers, solvents odours)	Spectrophotometer UV/VIS atomic absorption and	To be adapted to packaging problems
	Gas chromatographs (EC)	
	High performance liquid chromatographs (HP LC)	
	GC/LC Mass spectrophotometer	
Analysis of Plastic Components of Laminates	Infra–red spectrophotometer	
Permeability Tests	Oxygene permeabilimeter Oxtran 100	To be adapted in order to test not only packaging materials but ready to use packagings
	CO2 permeabilimeter Permatran C 2a	
	Water vapor permeabilimeter W1A Oxtran	
Sensoric Test	Sensoric analysis room	To be adapted to packaging problems

- CHEMICAL TECHNOLOGY CENTER -

Selection of equipments which cen be used for packaging materials testing

Name of Equipment	Remarks
Atomic absorption spectrophotometer	
High pressure liquid chromatographs	
Gas–liquid chromatographs	
GC–LMC Mass spectrometer	
GC Fourier transform infrared spectrophotometer	
UV–visible spectrophotometer	

Table 5-4 Government Development Assistance For Local Enterprises

Government Agencies:	AAC	EDB	EPC	NCB	NPB	TDB	Poly-technics	SISIR
Financial Assistance		×						
Tax Incentives		×				×		
Development Programs								
Local Industry Upgrading Program		×						
Automation	×	×						
Computerization			×	×				
Productivity & Training		×		×	×			
Technology							×	×
Business & Export Development		×			×	×		

Notes:

AAC: Automation Applications Center
EDB: Economic Development Board
EPC: Enterprise Promotion Centers Pte Ltd
NCB: National Computer Board
NPB: National Productivity Board
TDB: Trade Development Board

Table 5-5 Testing Items on Food Packaging to be handled by the Packaging Center

Field	Characteristics for Evaluation	Evaluation Items
Content Preservation	Permeability	WVTR
		Oxygen
		Nitrogen
		CO2
		Absorb Content
		Elution
		Ingredient
	Mechanical Strength	Tensil Strength
		Elongation
		Tear Strength
		Impact Strength
		Drop Strength
		Pressure Strength
		Stick Strength
		Flexo-Crack Strength
		Anti-Vibratoin Pinhole
		Lamination Strength
		Cold Tolerance
		Heat Tolerance
		Water Tolerance
	Tolerance to Content	Fat Permeability
		Oil Tolerance
		Anti-Stress Cracking
		Chemical Tolerance
		Adhesive Affinity
		Microbe
Mechanical Functionarity	Seal Strength	High Temperature
		Low Temperature
		Drenched
		Hot Tuck Distance
	Electrostaticity	Surface Resistance
		Static Attenuation Drop
	Slipping	Static Friction
		Kinetic Friction
		Blocking
		Curl
		Pitch Stability
		Dead Holding
		Hot Lamination Strength
		Heat Shrinking
Processing/Distribution	Laminate Strength	Water Proof
		Hot Water Proof
		Retorting Proof
		Content
	Others	Half MW Thickness
		γ-ray Proof
		Ingredient Disorption
		Hazyness
		Gross
		Image Clarity

Table 5-6 Standards for Food Packaging Materials of Plastics in Japan

(Unit: ppm)

Classification & Plastic					Individual Standard									
Test Item	Test Method			General Standard	PVC	PE/PP	PS	Hot Water Use PS Foam	PVDC	PET	Poly-methyl Meth-acrylate	Nylon	Poly-methyl Pentene	Plastic Containing Form-aldehyde
Quantitative Analysis:														
Cadmium/Lead	Polarography or atomic absorptiometric analysis			100	100	100	100	100	100	100	100	100	100	100
Dibutylate of Stannum	Paperchromatography				100									
Creosol Phosphate Ester	Gas chromatography				1000									
VC Monomer	Gas chromatography				1									
VDC Monomer	Gas chromatography								6					
Volatiles (5 compound) 1)	Gas chromatography						5000	2000 2)						
Barium	Atomic absorptiometric								100					
Extraction Test:	Extraction at:	(℃)	(min.)											
Heavy Metals	4% Acetic Acid 3)	60	30	1	1	1	1	1	1	1	1	1	1	1
Antimony	4% Acetic Acid	60	30							0.05				
Germanium	4% Acetic Acid	60	30							0.1				
Volatile Residual 5)	n-Heptane	60	30		150	150 4)	240	240	30	30	30	30	120	
	20% Ethanol	60	30		30	30	30	30	30	30	30	30	30	
	Water 3)	60	30		30	30	30	30	30	30	30	30	30	
	4% Acetic Acid 3)	60	30		30	30	30	30	30	30	30	30	30	30
Potassium Permangante Consumption	Water 3)	60	30	10	10	10	10	10	10	10	10	10	10	
Phenol	Water 3)	60	30											ND 6)
Formaldehyde	Water 3)	60	30											ND 6)
Methyl Methacrylate Monomer	20% Ethanol	60	30								15			
ε-caprolactam	20% Ethanol	60	30									15		

Notes: 1) 5compounds: styrene, toluene, ethyl benzene, iso-propyl benzene and n-propyl benzene.
2) Content of styrene or ethyl benzene shall be less than 1,000ppm respectively.
3) If used at temperature over 100 ℃, extraction shall be carried out at 95 ℃ for 30 minutes.
4) If used at temperature over 100 ℃, the value shall be less than 30ppm.
5)
- Oil and oily foods: n-Heptane
- Alcoholic beverage: 20% Ethanol
- Other than above
  - over pH5: Water
  - pH5 or lower: 4% Acetic Acid

6) Limit of detection shall be 40ppm for phenol and 4ppm for formaldehyde.

Table 5-7 Training Course for JPI Package Consultants

Subject	Course
General	General Theory
	Packaging Management
	Physical Distribution Management
	Packaging Systems and Processes
	Package Design
Materials	Carton Box
	Finished Paper
	Plastic Film
	Plastic Container
	Metal Container
	Glass Container
	Corrugated Fiberboard
	Sealing/Tying Materials
	Quality Evaluation of Packaging Materials
Transport Packaging	Distribution Environment
	Export Packaging
	Corrosion Preventive Technology
	Moisture Proof Technology
	Wooden Box Packaging Plan
	Packaged Freight/Containers Tests
	Automation of Packaging
	Assembly Packaging Technology
	Cushioning Packaging (Basic Designing)
	Cushioning Packaging (Application)
	Shock Test Technology (Sample Tests)
	Case Study/Light Cargo Package Plan
	Case Study/Heavy Cargo Package Plan
Consumer Packaging	Market Research
	Product Planning
	Display and Layout
	Color
	Sanitation/Safety of Packaging
	Food Packaging
	Preservation and Distribution of Food
	Printing
	Pharmaceuticals Packaging
	Consumer Packaging Machine
	Case Study/Package Design
	Case Study/Food/Pharmaceuticals Package Design

Table 5-8 Example of Keywords related to Packaging in "JICST Database"

Packaging printing
- NT Seal printing
- BT Printing
- RT Offset printing
  - Gravure printing
  - Flexo printing
  - Packaging material processing
  - Marking

Pakcaged freight
- BT Freight

Packaging machine
- NT Outer packaging machinery
  - · De-palletizer
  - · Palletizer
  - · Labeller
  - Inner packaging machine
  - · Filling machine
  - Packing machine
- BT Machine
- RT Conveying equipment
  - Printer
  - Feeder
  - Pneumatic conveyor
  - Conveyer
  - Washer

Packaging technology
- UF Capping
- NT Wrapping
  - Can
  - Tying/bundling
  - · Bundling
  - · Tying
  - Packing
  - Box packaging
  - Bottle packaging
  - Sealing
  - Bag packaging
  - Marking
  - Labelling
- RT Packaging production process
  - Packaging production line

Packaging production process
- BT Production process
  - · Process
- RT Packaging technology

Packaging materials
- UF Packaging waste
- NT Casing for meat
- BT Material
- RT Fiberboard
  - Multiple corrugated material
  - Plastic film
  - Packaging paper
  - Laminated paper

Packaging material processing
- BT Processing
- RT Cutting
  - Folding
  - Adhesive
  - Painting
  - Lamination
  - Press
  - Packaging printing

Packaging material processing machine
- NT Carton box processing machine
  - Can making machine
  - Bag making machine
  - Bottle making machine
  - Corrugated fiberboard processing machine
- BT Machine
- RT Cutter

Packaging industry
- BT Industry

Packaging paper
- NT Kraft paper
  - Grease-proof paper
- BT Paper
- RT Painting
  - Painting material
  - Packaging material

Packaging test
- BT Test
- RT Food inspection

Packaging waste
- USE Packaging material
- ANI Solid waste

Packaging auxiliary material
- NT Cap seal
  - Closure
  - · Aerosol valve
  - · Crown cork
  - · Cap
  - · Cork
  - · Lid
  - Tying/bundling material
  - · Pressure sensitive tape
  - · Band
  - · String
  - Label
- RT Material
  - Sealing
  - Palstics
  - Hermetrical sealing

Packaging container
- BT Container
- RT Transporting container
  - Solid waste
  - Wast disposal

Packaging production line
- BT Production line
- RT Packaging technology

Notes:
- BT Broader Term
- NT Narrower Term
- RT Related Term
- UF Upper Reference

Source: JICST

Table 5-9 Number of Trainees from the S.E. & S.W. Asian Countries attended the International Packaging Technology Course

Year:	1978	79	80	81	82	83	84	85	86	87	88	89	90	91	92	Total
Afghanistan		1														1
Bangladesh		1	1	1	1	1		1			1	1				8
India	1		1	1	1	1	1		1	1	1	1	1	1		12
Indonesia	2	2	1		2	2	1	1	2	1	2	1	1	2	2	22
Lao										2						2
Malaysia	1	1	1		1	1							1			6
Myanmar		1														1
Nepal		1	1	1			1									4
Pakistan		1	1												1	3
Philippines	1	1	1	1	1		1	1	1	1	1	1	1	1		13
Singapore	1	1	1		1		1						1			6
Sri Lanka			1	1	1	1			2						1	7
Thailand	2	1	1	2	1	1	1	1	2	1			1	1		15
Sub-total	8	11	10	7	9	7	6	4	8	6	5	4	6	5	4	100
Total incl. Other Countries	8	15	18	15	18	15	11	13	17	15	14	13	15	9	9	205

Table 5-10 Recommended Manning Plan for the Packaging Center

Program		Manager	Senior Staff (Scientist)		Staff (Engineer)			Assistant Staff (Technician)		
			A	B	A	B	C	A	B	C
1	Accumulation of packaging technology at the center	◎	●	●	○	○	○			
2	Transfer of technologies through joint research		◎	◎	●	●		○	○	
3	Collection and accumulation of packaging data		◎	◎	●	●		○	○	
4	Development of technology through own research		◎	◎	●	●		○	○	
5	Collection/dissemination of technical information	◎					●			○
6	Organizing societies for the study of technology	◎	○	○	○	○	○			
7	Stepping up of efforts against environmental issues	◎	△	△			●			○
8	Support for development of the packaging sector		◎	◎	●	●		○	○	
9	Promotion of standardization in packaging	◎	△	△			●			○
10	Development of standards testing system	◎	●	●	○	○	○			
11	Human resource development	◎	△	△			●			○
12	Training center for S.E./S.W. Asia regions	◎	△	△			●			○
13	Testing center for S.E. & S.W. Asia regions		◎	◎	●	●		○	○	

Note: ◎ Program manager, ● Key staff, △ Supporting staff, ○ Assistant staff

Table 5-11 Staff Training Plan for the Packaging Center

	Subject		Required period for the training	Training completed	Minimum requirement for: Manager	Senior staff/ Staff	Assistant staff
1	Packaging technology in general	Basic Standardization Standard development	1 month 2 months 2 years	2 weeks	×		
2	Physical distribution in general *1)	Basic Physical distribution technology	1 month 2 years	3 weeks	×		
3	Transport packaging materials	Basic Quality control	2 months 1 month	3 weeks	×	×	×
4	Transport packaging technology *2)		3 months	3 weeks		×	
5	Transport packaging design *3)		6 months	6 weeks		×	
6	Package testing *4)		3 months	3 weeks	×	×	×

Notes:

*1) including pallet & containers

*2) Corrosion preventive technology, moisture proof technology, collective packaging, etc.

*3) Cushioning packaging design, corrugated container packaging design, etc.

*4) Methodology, equipment operation, analysis, and evaluation

Table 5-12 Testing Machines and Measuring Instruments for Transportation and Distribution

No	Description	Uses	Applied Standards
1	Compression Tester*	Compression test for packages and containers	ISO 2872, JIS Z 0212 ISO 2874, JIS Z 0200
2	Vibration Test System*	Vibration test for packaged freights	ISO 2247, 8318 JIS Z 0232
3	Shock Test System	Shock test for packaged freights and products	IEC 68-2-27, JIS C 0041 ASTM D 3332
4	Drop Tester*	Drop test for packaged freights	ISO 2248, JIS Z 0202 JIS Z 0200
5	Electric Hook*	Drop test for large packaged freights	ISO 2248 JIS Z 0202, JIS Z 0200
6	Incline Impact Tester*	Horizontal shock test for packaged freights	ISO 2244 JIS Z 0205
7	Bump Tester	Bump test for packaged freights	IEC 68-2-29 JIS C 0042
8	Acceleration Measuring System*	Acceleration measuring for 2-7 item	IEC 68-2-27 JIS C 0041
9	Constant Temp.-humidity Chamber*	Predisposition for 1-7 item and environmental test for temperature and humidity	ISO 2233, JIS Z 0203 JIS C 0010
10	Constant Low Temperature Chamber*	Predisposition for 1-7 item and environmental test for temperature and humidity	ISO 2233 JIS Z 0203
11	Water Spray Test Chamber	Water spray test for packages and containers	ISO 2875 JIS Z 0216
12	Dynamic Compression Tester	Dynamic characteristic test for cushioning materials	ASTM D 1596 JIS Z 0235
13	Distribution Environmental Recording System*	Distribution environment (acceleration, thermo-humidity) measuring, analysis	ISO 4180/2
14	Scale	Measuring mass for packaged freights	
Total Cost (CIF)		208,174,000 yen (2,974,000 S$)	

Note: * indicates testing instument equipped in the Packaging Technology Center.

Table 5-13 Testers and Measuring Instruments for Packaging Material Quality Control

No	Description	Uses	Applied Standards
1	Ring Crash Tester	Test for crush of paperboard	JIS P 8126
2	Mullen type Bursting Tester	Test for bursting strength of paper and paperboard	ISO 2758 JIS P 8131
3	Elmendorf type Tearing Tester	Test for tearing strength of paper and film	ISO 1974 JIS P 8116
4	Strograph	Test for tensile strength of paper and paperboard	ISO 1924, JIS P 8113 JIS Z 1702
5	Bekk Smoothness Tester	Test for smoothness of paper and paperboard	JIS P 8119
6	Gurley type Densometer	Test for air permeability of paper and paperboard	JIS P 8117
7	Folding Endurance Tester	Test for folding endurance of paper and paperboard	ISO 5626 JIS P 8115
8	Puncture Tester	Test for puncture of paperboard	ISO 3036 JIS P 8134
9	Adhesion Tester	Test for adhesion of corrugated fiberboard	JIS Z 0402
10	Precision Sample Cutter	Accurate cutting of test specimens	JIS P 8113
11	Abrasion Resistance Tester	Test for abrasion resistance folding endurance, crush of paper	JIS P 8136, JIS P 8114 JIS P 8126
12	Friction Tester	Determining coefficient of friction of paper and plastics	JIS P 8147 ASTM D 189
Total Cost (CIF)		21,433,000 yen (306,000 S$)	

Table 5-14 Testing Instrument and Functions required for Testing of Food Packaging

Evaluating Function	Major Test Item	Testing Instrument
1. Quality of Material	· Composition · Structure	· Gas Chromatographs * · Infrared Spectrophotometer
2. Safty of Material	· Compound · Extraction · Migration	· Voratile Residue Tester · Gas Chromatographs *
3. Physical Property of Material	· Tensil Strength · Burst Strength · Compression Strength · Folding Strength · Puncture Strength · Tear Strength	· Tensil Tester · Abration Tester · Shock Tester · Burst Tester · Tear Tester · Ring Crush Tester
4. Functional Property		
1) Mecanical	· Slipablity · Dead Folding · Hinging · Packaging Machine Adoptability	· Friction Tester · Hinge Tester
2) Physical	· Gas Permeability · Water Vapor Transmission · Chemical Compound Permeability · Optical · Thermal Resistance	· Gas Permeability Tester * · Water Vapor Transmission Tester · Spectrophotometer · Carolimetric Tester
3) Chemical	· Chemical Resistance · Anti-rusting	
4) Biological	· Contamination · Anti-bacterial	
5. Physical Strength of Package/Container	· Compression Strength · Pressure Strength · Seal Strength	· Pressure Tester · Tensil Tester
6. Functional Property of Package/Container		
1) Mechanical	· Sealing · Packaging Machine Adoptability · Opening	· Torque Meter · Tensil Tester
2) Physical	· Leakage/Pinhole · Gas Tight · Heat Sealing · Gas Barrier · Moisture Absorption	· Pinhole Tester · Gas Permeability Tester * · Sealing Strength Tester · Tensil Tester
3) Chemical	· Flavor Retention · Anti-weather	· Weather Tester
4) Biological	· Insect Infestation	· Insect Infestation Test Box
7. Quality Preservation for Contents	· Tamper Proof · Deterioration	· Environmental Simulator · Testing Instrument to determine deteriorations
8. Transportation of Package/Container	· Anti-vibration · Anti-shock · Anti-dropping · Anti-pinhole · Anti-climate · Handling	· Vibration Tester
9. Marketing Property of Package/Container	· Consumer Appealing · Displaying · Labelling	
10. End Use Property	· Easy Opening · Re-sealability · Handling · Storaging · Dispensing	
11. Disposability	· Re-usability · Recyclability · Incinerability · Bio-degradability	

Note: * Testing instrument equipped in the Food Technology Center, SISIR

Table 5-15 Projected Revenue of the Packaging Technology Center (Base Case)

	Year of Operation:	1	2	3	4	5	6	7	8
Fees for contract testing	(f×g)	106,000	125,000	150,000	176,000	211,000	250,000	294,000	352,000
Number of electronics firms	(c)	272	284	296	309	322	336	351	366
Number of electrical firms	(d)	135	136	137	138	139	140	141	142
Number of tests per firm	(e)	0.33	0.37	0.43	0.49	0.57	0.65	0.75	0.86
Number of tests	(f):(*1)	33	39	47	55	66	78	92	110
Fee rate	(g)	3,200	3,200	3,200	3,200	3,200	3,200	3,200	3,200
Fees for contract researches	(a×b)	179,000	205,000	230,000	282,000	333,000	410,000	461,000	563,000
Number of research contracts	(a)	7	8	9	11	13	16	18	22
Fee rate	(b)	25,600	25,600	25,600	25,600	25,600	25,600	25,600	25,600
Entry fee for joint researches	(h×i)	0	54,000	54,000	54,000	107,000	107,000	107,000	107,000
No. of participant firms	(h)	0	10	10	10	20	20	20	20
Fee rate	(i)	5,360	5,360	5,360	5,360	5,360	5,360	5,360	5,360
Entry fee for short-term seminars	(m×n)	42,000	49,000	58,000	68,000	80,000	93,000	110,000	129,000
Number of electronic/electrical firms	(c+d)	407	420	433	447	461	476	492	508
Number of food/beverage firms	(j)	276	275	273	272	271	270	269	268
No. of chemical/pharmaceutical firms	(k)	199	204	209	215	220	225	231	237
Number of participants	(m):(*2)	323	379	444	522	612	718	844	992
Fee rate	(n)	130	130	130	130	130	130	130	130
Entry fee for training courses	(p×q)	0	0	72,000	86,000	99,000	118,000	137,000	161,000
No. of participants	(p):(*3)	0	0	27	32	37	44	51	60
Fee rate	(q)	2,680	2,680	2,680	2,680	2,680	2,680	2,680	2,680
Total revenue		327,000	433,000	564,000	666,000	830,000	978,000	1,109,000	1,312,000

Notes: See Table 5-16.

*1) (c+d)X(e)X0.5, with maximum 184 including joint research (one joint research is equivalent to 8 contract testing)

*2) (((c+d)*0.53+j*0.5+k*0.63)*0.45*1.5)*(1.15)^(n-1)

*3) (((c+d)*0.27+j*0.25+k*0.25)*0.3*1.12)*(1.15)^(n-1)

Table 5-16 Assumptions for Projected Revenue of the Packaging Technology Center

Revenue	Assumptions for projection of number of tests/participants		Assumptions for calculating the rates		
	Potential users	Basis for projection of annual no.	Rates prevailing in Japan	assumed rates(*1)	(Ref.) Estimated costs(*2)
Fees for contract testing and contract researches	240 electronics firms with average annual growth rate(AAGR) at 4.3%, and 132 electrical firms with AAGR at 0.7%	5 contract testings/ 1 product development; 0.065 product developments/ 1 firm with AAGR at 15%; rate to contract to SISIR as contract testing at 25%, and 25% as contract researches	¥300,000	S$3,200(*3)	Equipment/facilities S$3,340, Manpower related costs S$1,780, Total S$5,120
Entry fee for joint researches	10 firms/project	Maximum 2 projects/year due to limitation of number of testing staff, starting from 2nd year of the operation.	¥5,000,000/ project	S$53,600/ project	S$40,960/ project
Entry fee for short-term seminars	372 electronic/electrical firms with AAGR at 2.8%, 279 food/beverage firms with AAGR at -0.4%, and 185 chemical/pharmaceutical firms with AAGR at 2.5%	Rate of firms interested in participation to seminars: food/beverage 50%, electronic/electrical 53%, chemical/pharmaceutical 63% with AAGR at 15%; Average no. of participants: 1.5 persons/firm with AAGR at 15%	¥12,000	S$130	S$72/participant assuming 120 participants/seminar, and man-day requirement of 3 M-days for senior staff, 6 M-days for staff, 6 M-days for assistant staff; Reward for lecturers S$4,200.
Entry fee for training programs	the same as the above	Rate of firms interested in participation: food/beverage 25%, electro/electric 27%, chemic/pharmaceutic 25% with AAGR at 15%; No. of participant: 1 persons/firm for large scale firms, and 0.3 for SMEs (0.38 on the average) with AAGR at 15%. From 3rd year.	¥250,000 (for 10days course)	10days course S$2,680	S$960/participant assuming 45 participants/course, and man-day requirement of 10 M-days for senior staff, 15 M-days for staff, 30 M-days for assistant staff; Reward for lecturers S$28,000.

Notes: The incremental services by the project to develop the Center, only.

*1) around 0.75 times of the rates prevailing in Japan

*2) see next page.

*3) Rate for the contract research is assumed 8 times of that of contract testing, though, actually, it will vary depending on the size of research.

Explanatory note for Table 5-16:

The following estimates the costs required for packaging test based on the normal testing practices.

In the case of distribution environmental test, the test itself will be completed usually within 0.5 days, though it varies depending on the number of testing items included. All the testing equipment used for this test will be occupied during this period exclusively for this purpose. In addition, the product to be tested are kept in the climatic simulation chamber for 24 hours as a preparation treatment. Thus, the testing period in total is around 1.5 days including the preparation treatment. (Other tests can be undertaken simultaneously using equipment other than the above.) Further, before the test is carried out, detailed discussion is held to determine the testing method and testing items. Generally speaking, a report is compiled to summarize the testing result after the testing. Thus, one set of test normally takes 1 week (or 5 working days) including preparatory treatment (20 degrees C and 65%RH), vibration test, drop or inclined plane test, and compression test, according to "General testing method for evaluation of packaged cargo; JIS Z0200". Testing organizations ask their customer to allow them to take 2-3 weeks in such case, taking into account the time for coordination work and waiting time, etc.

Since the test is assumed to be undertaken by a crew consisting of a staff and an assistant staff, one contract testing requires 3 man-days x 2 (6 man-days in total), on the basis of the above. A joint research is estimated to take 8 times of that of a contract testing.

Each staff can spend 60% of their working hours to contract testing and/or joint researches. This is the maximum level of operation when taking into account the scheduling of working hours of the crew and machine operation. The remaining 40% of working hours is used for own research, training, or other tasks.

Therefore, assuming full operation at 240 working days per year, one man-day costs as follows:

(Unit: Singapore dollar)

	Monthly base salary (a)	1 year salary (b)=(a)X12	w/ bonus & CPF (c)=(b)X1.77	w/ overhead cost (d)=(c)X2.5	Man-day cost (d)×0.6/240days
Senior staff	4,100	49,200	87,084	217,710	544
Staff	2,225	26,700	47,259	118,148	295
Assistant staff	1,300	15,600	27,612	69,030	173

(continued on the next page)

Thus, one contract testing costs:

Costs for senior staff and staff	($544+$295)/2 x 3days
Costs for assistant staff	$173 x 3days
Total:	$1,780/contract testing

The following estimates machine costs for testing. One testing crew can handle maximum 46 tests in one year, assuming that as discussed in the above, one contract testing takes one week on the average, 240 working days (or 48 weeks) a year with two weeks spent for maintenance a year. Since there are 4 crews in the Center, they can undertake maximum 184 tests a year. One test exclusively use machines for 1.5 days. If the four crews undertake tests at this level, the equipment will almost be fully utilized. (The tests which does not use the climatic simulation chamber, can be undertaken in addition to the above.) If the pay operation rate of the equipment is assumed 70%, pay operation time of the equipment for the tests other than contract testing and joint research, is 14.3% (or 10% of 70%), thus, costs to be burden by the contract testing and joint research are the remaining 85.7% of the total costs. Therefore, machine cost per contract testing is:

S$717,200 (total of depreciation expenses, utility costs, and maintenance costs) x 0.857/184 tests =S$3,340/test

A joint research costs 8 times of a contract testing cost.

Providing that only two testing crews undertake these tests, the maximum number of tests to be handled is decreased to 92, and the machine cost increases to:

S$717,200 x 0.857/92 tests =S$6,680/test

(Explanatory note completed)

Table 5-17 Projected Costs and Expenses for the Packaging Technology Center

(Unit: S$)

Year of Operation:		1	2	3	4	5	6	7	8
Direct Labor Cost	(a)	333,000	333,000	333,000	507,000	507,000	507,000	507,000	507,000
Overhead Cost	(b)	500,000	500,000	500,000	761,000	761,000	761,000	761,000	761,000
Maintenance Cost	(c)	0	16,000	33,000	49,000	66,000	82,000	98,000	98,000
Other Operation Costs	(d)	20,400	20,400	48,400	48,400	52,600	80,600	80,600	80,600
Operation Cost Total		853,400	869,400	914,400	1,365,400	1,386,600	1,430,600	1,446,600	1,446,600
Depreciation	(e)	656,000	656,000	656,000	656,000	656,000	0	0	0
Total		1,509,400	1,525,400	1,570,400	2,021,400	2,042,600	1,430,600	1,446,600	1,446,600

Notes: (a)

	Monthly base salary	No. of staff	Total
Manager	4,000	1	4,000
Senior staff	4,100	2	8,200
Staff	2,225	3	6,675
Assistant staff	1,300	3	3,900
Secretary	1,100	1	1,100
Total	-	10	23,875
Yearly total with bonus & CPF			507,105

(Bonus & CPF: 77% of base salary)

(b) 150% of direct salary

(c) 0.5% of total machinery and equipment cost in the 2nd year of operation, and the rate increases by 0.5% every year up to 3%.
Total estimated cost for machinery and equipment: $3,280,100 (see Tables 5-12, 5-13).

(d) $60/sq.m-year for utility costs; and payment for outside lecturers (S$4,200/seminar, S$28,000/training course).
One seminar up to 300 participants, and one course up to 40 persons.

(e) 5-year depreciation with straight line method, without salvage value.

Table 5-18 Financial Projection for the Packaging Technology Center (1)

(Base Case)

Year of Operation:	1	2	3	4	5	6	7	8
Fees for contract testing	106,000	125,000	150,000	176,000	211,000	250,000	294,000	352,000
Fees for contract researches	179,000	205,000	230,000	282,000	333,000	410,000	461,000	563,000
Entry fee for joint researches	0	54,000	54,000	54,000	107,000	107,000	107,000	107,000
Entry fee for short-term seminars	42,000	49,000	58,000	68,000	80,000	93,000	110,000	129,000
Entry fee for training courses	0	0	72,000	86,000	99,000	118,000	137,000	161,000
Total revenue (a)	327,000	433,000	564,000	666,000	830,000	978,000	1,109,000	1,312,000
Direct Labor Cost	333,000	333,000	333,000	507,000	507,000	507,000	507,000	507,000
Overhead Cost	500,000	500,000	500,000	761,000	761,000	761,000	761,000	761,000
Maintenance Cost	0	16,000	33,000	49,000	66,000	82,000	98,000	98,000
Other Operation Costs	20,400	20,400	48,400	48,400	52,600	80,600	80,600	80,600
Operation Cost Total (b)	853,400	869,400	914,400	1,365,400	1,386,600	1,430,600	1,446,600	1,446,600
Balance [(a)-(b)]	-526,400	-436,400	-350,400	-699,400	-556,600	-452,600	-337,600	-134,600
Depreciation	656,000	656,000	656,000	656,000	656,000	0	0	0

Note: Based on the revenues in Table 5-15 and the costs & expenses in Table 5-17.

Table 5-19 Financial Projection for the Packaging Technology Center (2)

(Costs & Expenses Based on Current Operational Condition)

Year of Operation:	1	2	3	4	5	6	7	8
Fees for contract testing	106,000	125,000	150,000	176,000	211,000	250,000	294,000	352,000
Fees for contract researches	179,000	205,000	230,000	282,000	333,000	410,000	461,000	563,000
Entry fee for joint researches	0	54,000	54,000	54,000	107,000	107,000	107,000	107,000
Entry fee for short-term seminars	42,000	49,000	58,000	68,000	80,000	93,000	110,000	129,000
Entry fee for training courses	0	0	72,000	86,000	99,000	118,000	137,000	161,000
Total revenue (a)	327,000	433,000	564,000	666,000	830,000	978,000	1,109,000	1,312,000
Direct Labor Cost	183,000	183,000	183,000	270,000	270,000	270,000	270,000	270,000
Overhead Cost	275,000	275,000	275,000	405,000	405,000	405,000	405,000	405,000
Maintenance Cost	0	8,000	17,000	25,000	34,000	42,000	51,000	51,000
Other Operation Costs	20,400	20,400	48,400	48,400	52,600	80,600	80,600	80,600
Operation Cost Total (b)	478,400	486,400	523,400	748,400	761,600	797,600	806,600	806,600
Balance [(a)-(b)]	-151,400	-53,400	40,600	-82,400	68,400	180,400	302,400	505,400
Depreciation	340,000	340,000	340,000	340,000	340,000	0	0	0

Notes: 1) Based on the revenue in Table 5-15.

2)

	Monthly base salary	No. of staff	Total
Manager	4,000	1	4,000
Senior staff	4,100	1	4,100
Staff	2,225	1	2,225
Assistant staff	1,300	1	1,300
Secretary	1,100	1	1,100
Total	–	5	12,725
Yearly total with bonus & CPF			270,279

3) Total estimated cost for machinery and equipment: $1,698,000

4) Other assumptions for costs & expenses are the same as that of Table 5-17.

Table 5-20 Financial Projection for the Packaging Technology Center (3)

(Revised Case)

Year of Operation:	1	2	3	4	5	6	7	8
Fees for contract testing	106,000	125,000	150,000	176,000	211,000	250,000	294,000	352,000
Fees for contract researches	179,000	205,000	230,000	282,000	333,000	410,000	461,000	563,000
Entry fee for joint researches	0	54,000	54,000	54,000	107,000	107,000	107,000	107,000
Entry fee for short-term seminars	42,000	49,000	58,000	68,000	80,000	93,000	110,000	129,000
Entry fee for training courses	0	0	72,000	86,000	99,000	118,000	137,000	161,000
Potential additional revenue	0	31,000	55,000	73,000	80,000	87,000	95,000	103,000
Total revenue (a)	327,000	464,000	619,000	739,000	910,000	1,065,000	1,204,000	1,415,000
Direct Labor Cost	204,000	204,000	204,000	378,000	378,000	378,000	378,000	378,000
Overhead Cost	306,000	306,000	306,000	567,000	567,000	567,000	567,000	567,000
Maintenance Cost	0	10,000	21,000	31,000	41,000	51,000	62,000	62,000
Other Operation Costs	20,400	20,400	48,400	48,400	52,600	80,600	80,600	80,600
Operation Cost Total (b)	530,400	540,400	579,400	1,024,400	1,038,600	1,076,600	1,087,600	1,087,600
Balance [(a)-(b)]	-203,400	-76,400	39,600	-285,400	-128,600	-11,600	116,400	327,400
Depreciation	411,000	411,000	411,000	411,000	411,000	0	0	0

Notes: 1) Based on the revenues in Tables 5-15 and 5-21.

2)

	Monthly base salary	No. of staff	Total
Manager	4,000	0.5	2,000
Senior staff	4,100	2.0	8,200
Staff	2,225	2.0	4,450
Assistant staff	1,300	2.0	2,600
Secretary	1,100	0.5	550
Total	-	7.0	17,800
Yearly total with bonus & CPF			378,072

3) Total estimated cost for machinery and equipment: $2,055,000

4) Other assumptions for costs & expenses are the same as that of Table 5-17.

Table 5-21 Potential Additional Revenue for the Packaging Technology Center

		1	2	3	4	5	6	7	8
Membership fee for research association	(m×n)	0	18,000	30,000	38,000	39,000	40,000	41,000	41,000
No. of electrical/electronics firms	(a)	407	420	433	447	461	476	492	508
No. of food/beverage firms	(b)	276	275	273	272	271	270	269	268
No. of chemical/pharmaceutical firms	(c)	199	204	209	215	220	225	231	237
No. of participants	(m):(*1)	0	122	199	254	259	265	270	276
Fee rate	(n)	150	150	150	150	150	150	150	150
Contract testing fee from overseas clients	(g×h)	0	13,000	25,000	35,000	41,000	47,000	54,000	62,000
No. of electrical/electronics firms in Malaysia	(d)	265	278	292	307	322	338	355	373
No. of transport equipment firms in Malaysia	(e)	145	152	160	168	176	185	194	204
No. of tests per firm	(f)	0.33	0.37	0.43	0.49	0.57	0.65	0.75	0.86
No. of tests	(g):(*2)	0	10	18	26	30	35	40	46
Fee rate	(h)	1,350	1,350	1,350	1,350	1,350	1,350	1,350	1,350
Total		0	31,000	55,000	73,000	80,000	87,000	95,000	103,000

Notes: These revenues are assumed from the 2nd year with materializing rates at 50%, 80%, and 100% respectively in the 2nd year, 3rd year and 4th year & onwards.

*1) (aX0.53+bX0.5+cX0.63)X0.5 [50% of firms in electrical/electronics, food/beverage, and chemical/pharmaceutical industries interested in short-term seminars]

*2) (d+e)X(f)X0.5X(1/4)X0.95^(n-2) [Electrical/electronics and transport equipment firms in Malaysia. The test contracting rate is assumed one fourth of that of Singapore, with annual decreasing rate at 5%.]

Figure 5-1 Organization of SISIR

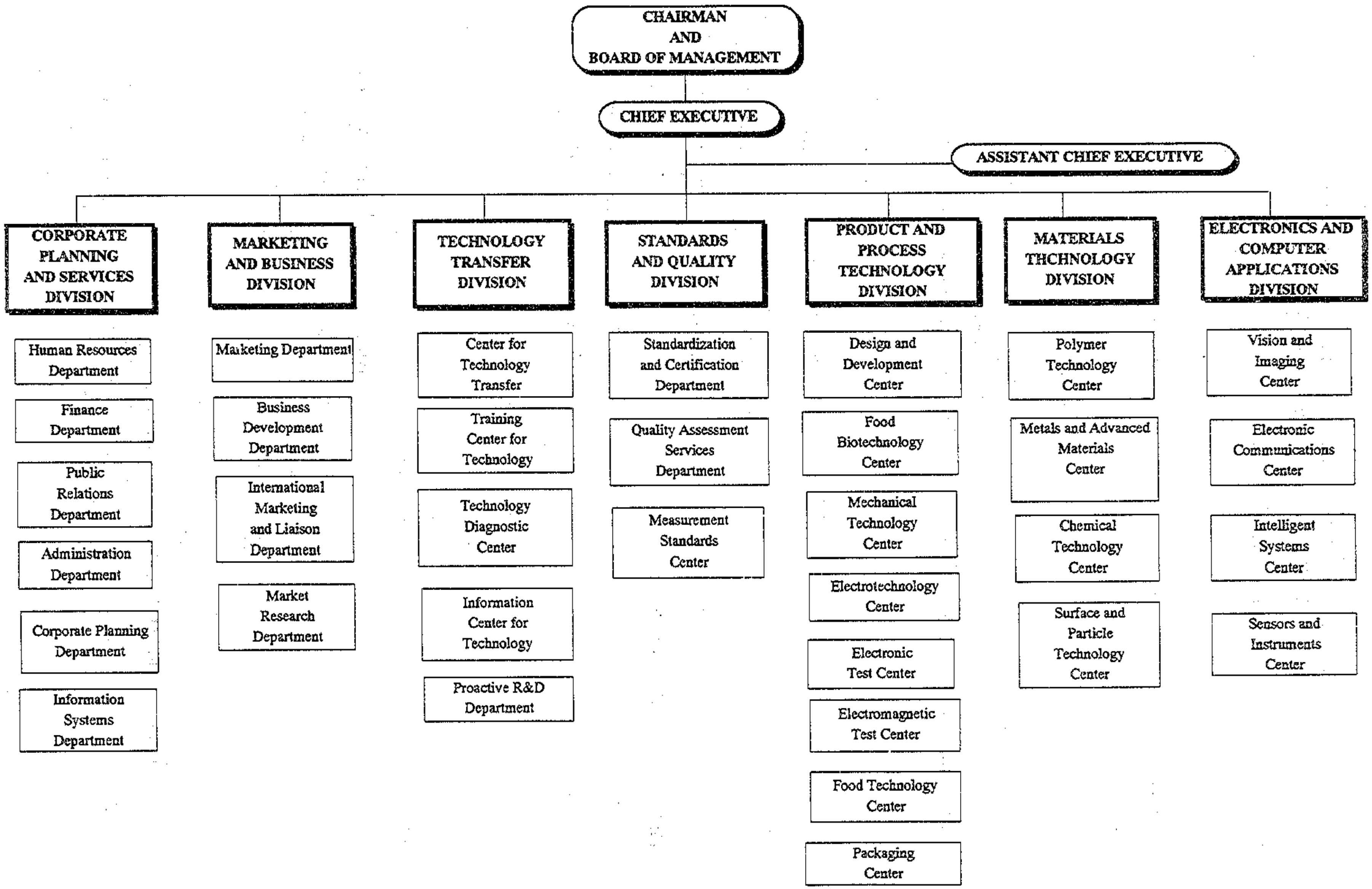
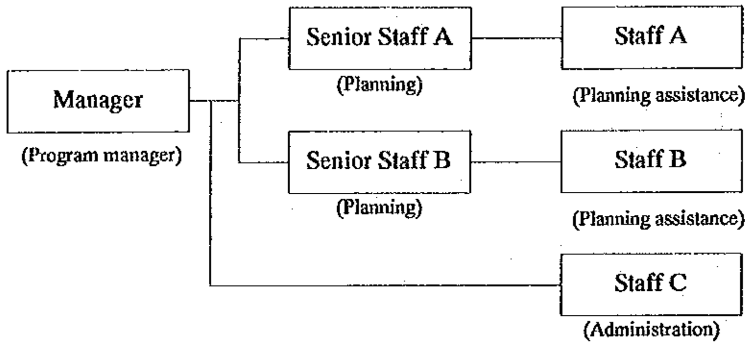
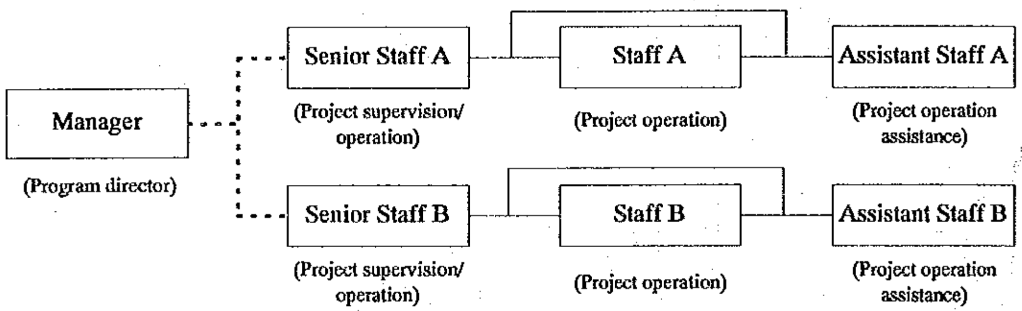


Figure 5-2 Recommended Organization Chart for the Program Implementation by the Packaging Center

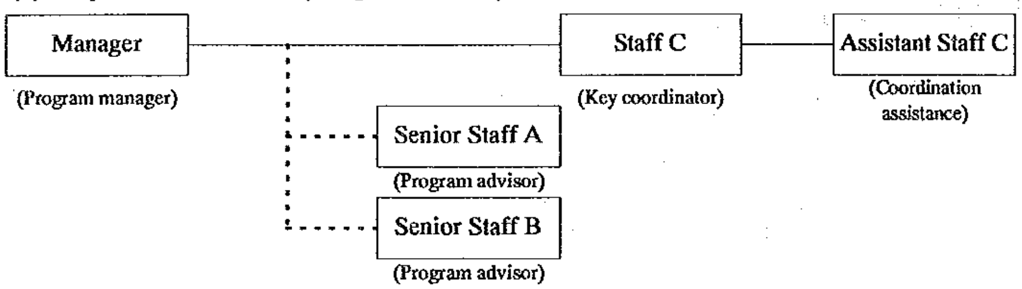
(1) Development planning (Programs 1 &10)



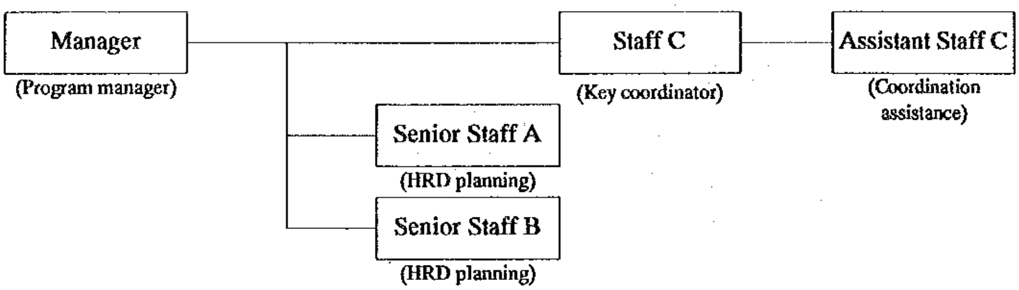
(2) Technology development & technical assistance (Programs 2, 3, 4, 8 & 13)



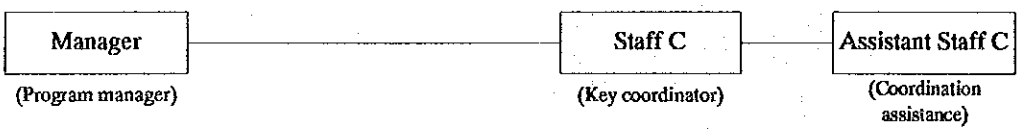
(3) Project coordination (Programs 7 & 9)



(4) Human resource development (Programs 11& 12)



(5) Information service and marketing (Programs 5 & 6)



ANNEX

DETAILED EVALUATION REPORT ON PACKAGING MATERIALS AND PACKAGING DESIGN CAPABILITY OF SINGAPORE

1. Beverage Can Carton Cases

1.1 Purpose

The purpose was to conduct tests to determine how the structure of a carton case for carbonated beverages in cans influences the effects of the transportation environment (humidity, vibration), and to evaluate the packaing materials and package design technology.

1.2 Samples

a. Four carton cases each holding two dozen 350ml cans (Chinese fabrication)
b. One carton case holding two dozen 350ml cans (Japanese fabrication)

1.3 Equipment

a. Climatic simulation chamber
b. Vibration machine
c. Acceleration measurement system

1.4 Method

1.4.1 Preparatory Steps

Considering the transportation environment when goods are shipped by truck in Southeast Asia, the sample was placed in a climatic simulation chamber where 40 deg. C and 80% RH were maintained for 12 hours.

1.4.2 Vibration Test

1.4.2.1 Logarithmic frequency sweep test (Figure 1-1)

(1) Scope

1) Testing was performed on the basis of vibration test method A-1 (logarithmic frequency sweep), as per JIS Z 0200-87, that specifies evaluation test methods.

This test provides a method for reproducing the vibration that a package is subjected to during transportation, and is widely used. This was also used to determine the resonance frequency of the package in transit.

2) Test conditions were set as a peak accleration of +1.2G as peak acceleration, 5–100Hz as range of oscillation, and excitation time of 20min, on the assumption of a trip by truck over a distance of 1,000km.

3) Five cartons were stacked and held to the vibration table by a rubber belt. An acceleration pick–up sensor was affixed to the upper part of a can in the center of the uppermost case, the acceleration measurement system was connected to an amplifier, and acceleration waveform (waves) were observed using an the measurement system's oscilloscope, that also received an acceleration signal from the vibration table.

(2) Results

1) There was no damage to the test samples.

2) By means of simultaneous observation of the acceleration of the uppermost carton on the vibration table, it was found that there was resonance of about 13 times the 0.5G at the table top at 20Hz, or about 6.4G.

1.4.2.2 Constand frequency test (Figure1–2)

(1) Scope

1) In order to evaluate the quality of the packaging of the sample on the basis of the test results obtained in the above–described test, severe conditions of vibration resonance frequency were avoided and conditions were set at peak acceleration of 1.2G, frequency steady at 15Hz, for a period of 30 minutes.

2) The five cartons were stacked, on top of a Japanese–made beer case to which they were secured using gummed tape, the entire being held to the vibration table by a rubber belt.

(2) Results (Figure 1–2)

1) There was no deformation of carbonated apple drink cans on the topmost level.

2) There was no deformation of thje lower beer cans.

3) Contents escaped from most cans of carbonated apple drink in the middle three cases, at the part scored for the tab.

1.5 Overall Evaluation

Comparison was made of the quality of Japanese- and Chinese-made beverage cans and their packaging using vibration tests.

Japanese-made beer cans, being on the lowermost level, were subjected to the most severe conditions from the static load weight above and dynamic load weight, but there was no deformation of either the cans or the case. The explanation for this can be sought in the ways that measures had been taken to prevent a weight from being brought to bear directly on the tab score, namely, thickness of the top parts of the cans, the relatively large height of the upper rim, the difficulty whereby load could be transmitted to the tab-score part of the lid, and the part of the carton end flaps that might come into contact with the tabs had been precut and removed.

The lid of the Chinese-made cans was thin, and the rim height was not great. Further, the materials from which the carton was made were not of good quality, and the static load was transmitted by the flaps to the upper part of the can. Improvements are necessary because damage to even just one can means the marketability of the entire contents of the case is lost.

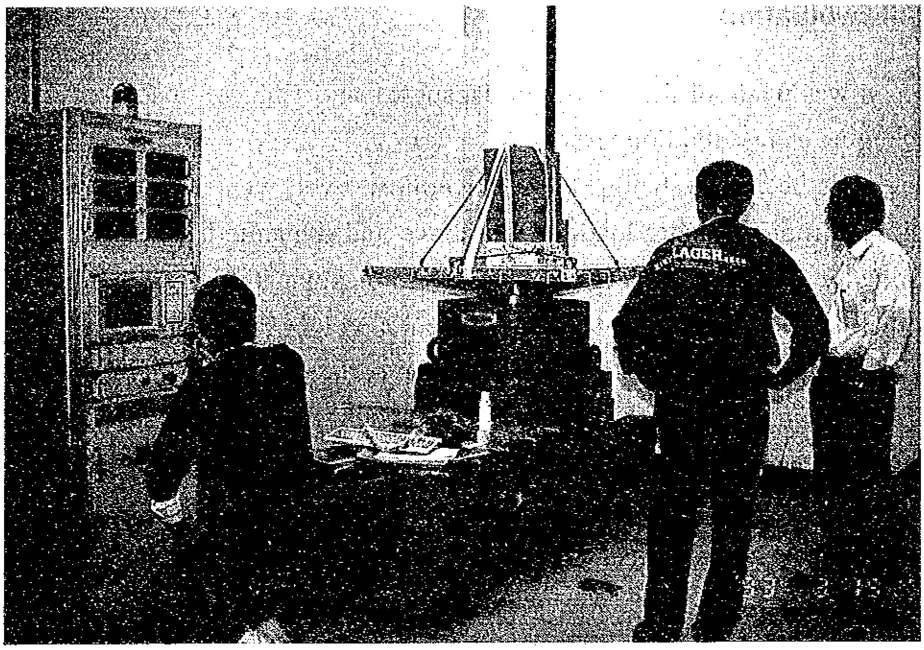


Figure 1-1

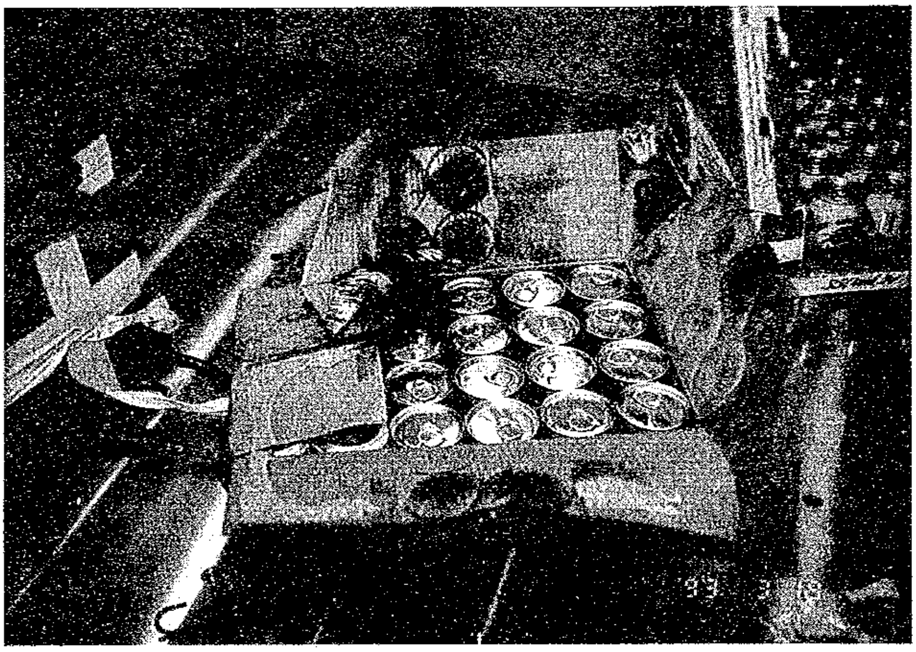


Figure 1-2

2. Color Monitor Packaging (1)

2.1 Purpose

The purpose of this test was by means of drop tests to simulate dropping of the goods during transportation, and horizontal vibration, to evaluate whether the shock–absorptive protective packaging is adequate.

2.2 Samples

a. 14" color monitor, packaged
b. Dummy packaged product for the transportation environment test

2.3 Equipment

a. Drop tester
b. Vibration test system
c. Acceleration test measurement system
d. Personal computer system; acceleration measurement analysis software
e. Distribution environmental record system

2.4 Method

2.4.1 Drop Test (Figure 2–1)

(1) Test items

1) Narrow–line alignment cross marks were made on the surface of the picture tube of the 14" color monitor and on the case, to determine if the monitor moved when the package was dropped.

2) A triaxial acceleration pickup was attached to the picture tube surface, and records were made of measurements, by use of the acceleration test measurement system and a computer monitor.

3) Drop testing was performed on the basis of methods given in JIS Z 0200–07. The drop tester was used for one corner drop, three edge drops and six flat face drops, all from 60cm.

(2) Distribution environmental record system

1) The test package was a wooden box (360 x 300 x 300mm, 10kg) containing a corrugated carton provided with 30–times polystyrene foam corner pads for protection.

2) Drop tests were from 50cm, on two flat faces, edge, and corner; the acceleration was measured and transmitted to a computer for analysis of the data.

(3) Results

1) There was no damage to the monitor and no movement of the picture tube. There were cracks, however, that appeared in the corner parts of the cushioning material (polystyrene foam, 50 times foaming).

2) Acceleration data obtained by drops and use of the distribution environmental record system were analyzed and it was found that there was little deviation. (Figure 2-4).

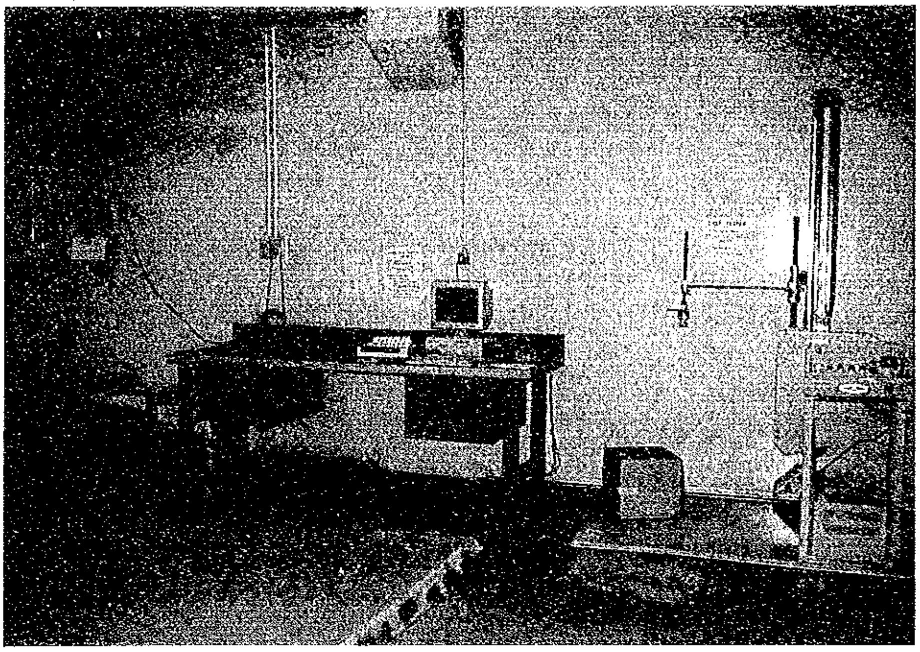


Figure 2–1

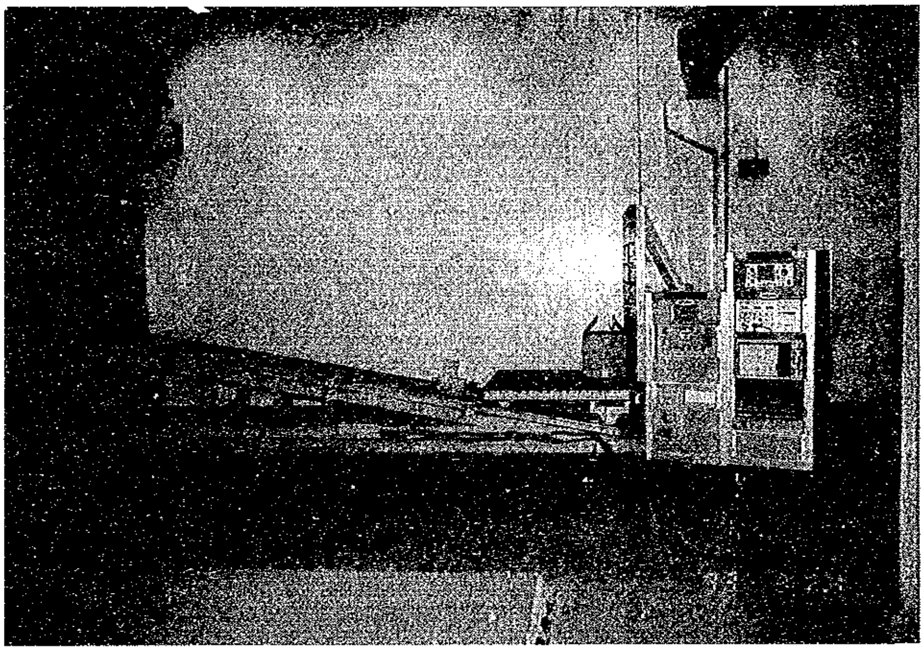


Figure 2–2

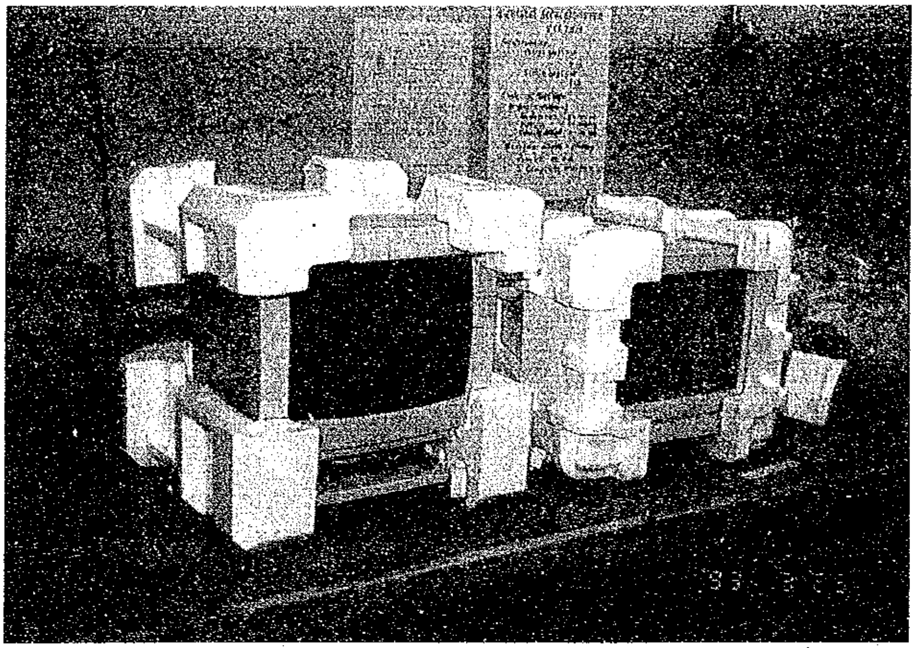


Figure 2–3

★★★ DROP HEIGHT & DIRECTION (peak value) ★★★

FILE NAME A00004
SECTION YAP 50CM DROP
NAME & MODEL DER 100 2048 200G
NOTES

START DATE 1993-03-26 15:20:00
STOP DATE 1993-03-26 15:25:59 e = 0.61

Date	D.H.[cm]	Dir.	Accel.[G]	V.C.[cm/s]
1993-03-26 15:22:29	53	2	76.4	518.3
1993-03-26 15:21:12	52	3	83.2	513.9
1993-03-26 15:22:05	51	2	66.2	508.4
1993-03-26 15:20:47	51	3	68.6	508.1
1993-03-26 15:20:20	49	3	59.2	500.2
1993-03-26 15:21:39	46	2	50.4	483.2

Figure 2–4

3. Color Monitor Packaging (2)

3.1 Purpose

To judge the adequacy of shock absorptive packaging design by analyzing the density of the power spectrum by measurement of vibration of the vehicle, and by random input of that data to the distribution environment record system, random vibrations equivalent to those occurring during actual transportation are reproduced and imparted to the test sample.

3.2 Sample

One packaged 14" color monitor

3.3 Equipment

a. The distribution environmental recording device system
b. Vibration test equipment
c. Acceleration measuring system

3.4 Method

3.4.1 Distribution Environmental Record System

(1) The distribution environmental recording device was installed on the bed of a truck and vibration measurements were made when traversing two sections of road representative of that of Singapore.

(2) The recording equipment provided up to 200 data items to RAM memory in sequence of magnitude of tridirectional set accelerations above a specific level (0.G). These data were converted by computer software to spectroscopically analyze powers vector density (PSD). Results are as shown in Figure 3–1 and 3–2. (Figure 3–3)

3.4.2 Random Vibration Test (Figure 3–4)

(1) The method most widely used in recent years for reproducing vibration imparted by the movement of a transport vehicle is to control the vibration of a vibration table so as to subject the test sample to random vibrations equivalent to the PSD for each mode of transport which are used for distribution of the subject goods. The PSD are analyzed by the test method for random vibration testing of packaged goods given in

ASTM D 4728-91, or by use of actual vibration measurements, in addition to which there is MIL-STD-810D that gives a method for supplementing PSD values that are input from vibration tests. On the basis of this method the vibration control PSD spectrum was created by processing of the PSD data from 3.4.1, and the vibration table was caused to vibrate for 30 minutes with the test sample held by a rubber belt so that it would not fall from the table. Tests were also made for 30 minutes as per Figure 3-5.

3.5 Evaluation

(1) It is necessary to carry out studies, both domestically and at the transportation destination, as the basis for simulation of testing of packages during transportation, in addition to studying the actual conditions such as vibration, shock, temperature, humidity, etc. that are major environmental influences experienced by packages during the distribution phase.

(2) The present tests correspond to preliminary tests for the above. No problems affecting the test samples arose.

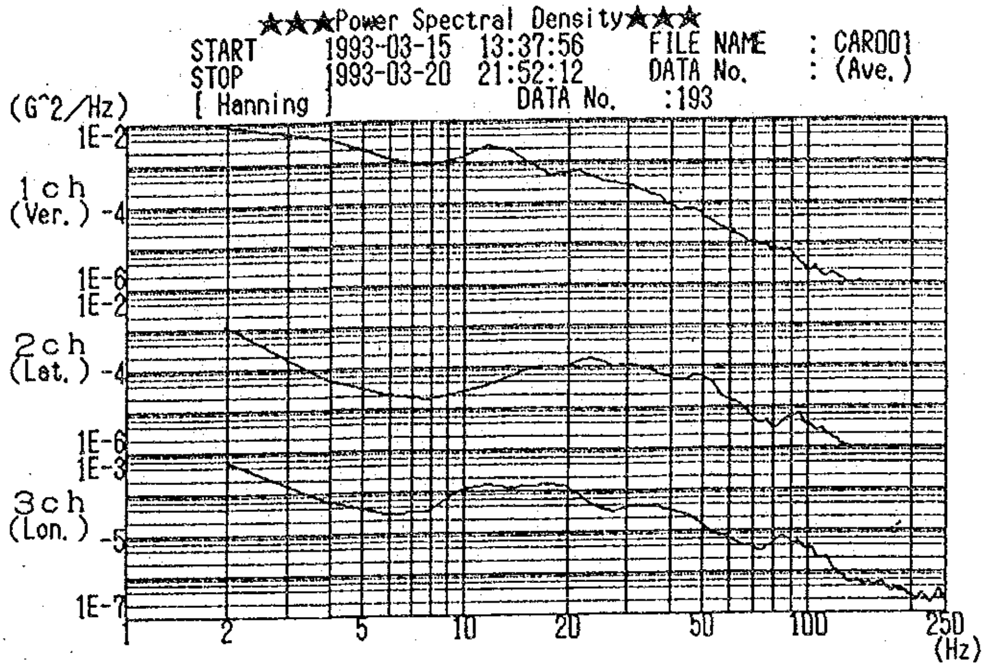
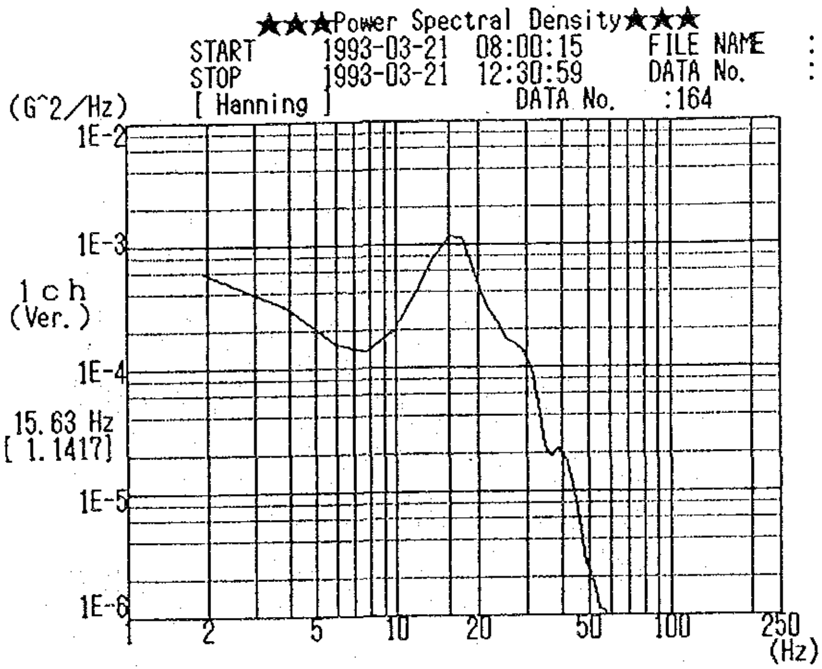


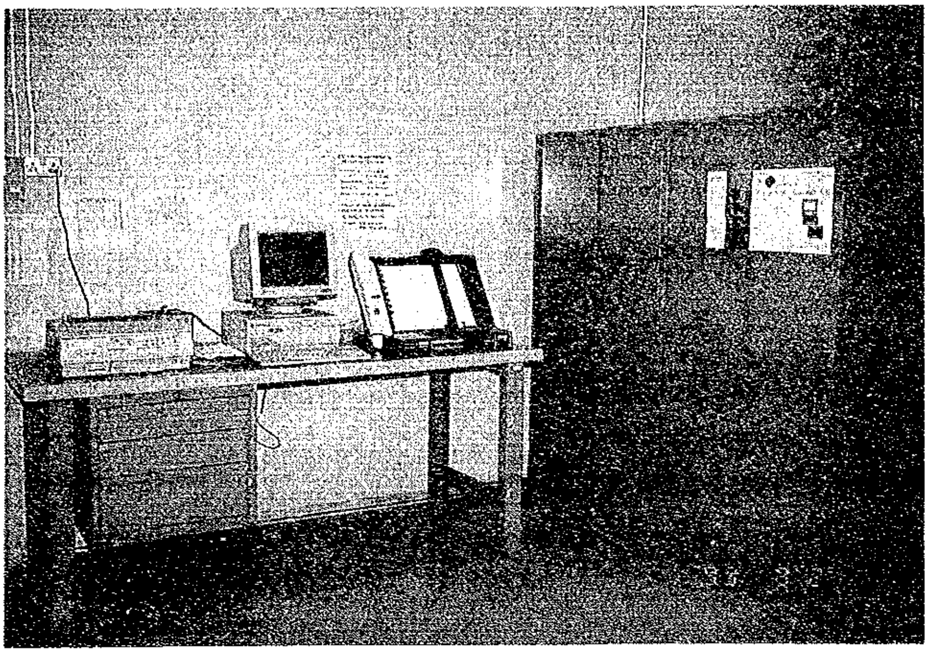
Figure 3–1



×1E-3

Hz	P S D
1.95	0.5769
3.91	0.3079
5.86	0.1562
7.81	0.1328
9.77	0.1981
15.63	1.1417
19.53	0.5514
25.39	0.1663
29.30	0.1351
35.16	0.0228
39.06	0.0220
44.92	0.0082
50.78	0.0021
60.55	0.0005
70.31	0.0003
80.08	0.0002
89.84	0.0001
99.61	0.0001
105.47	0.0001
109.38	0.0000
115.23	0.0000

Figure 3–2



Figre 3–3

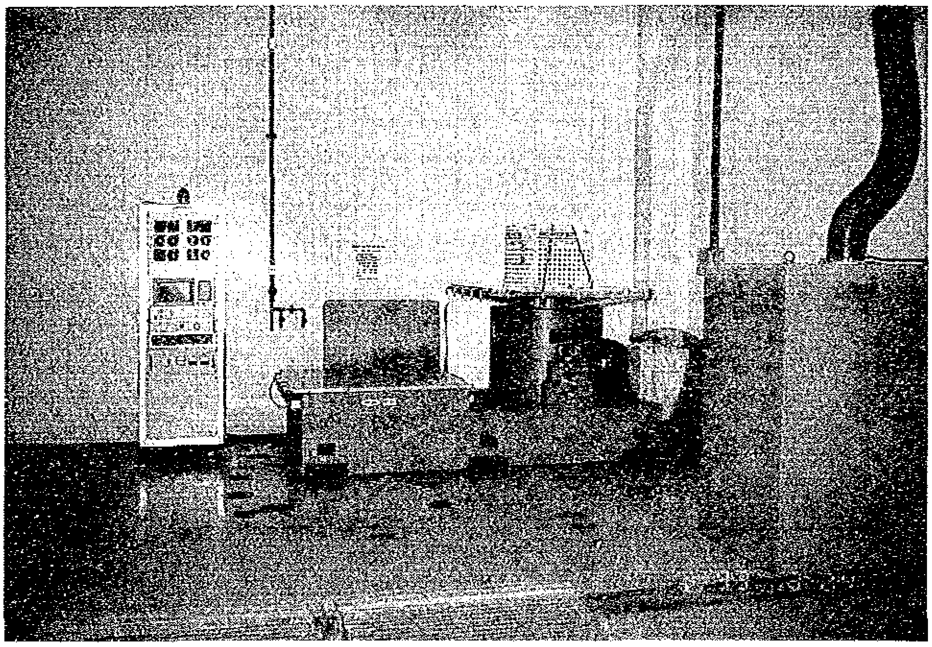


Figure 3–4

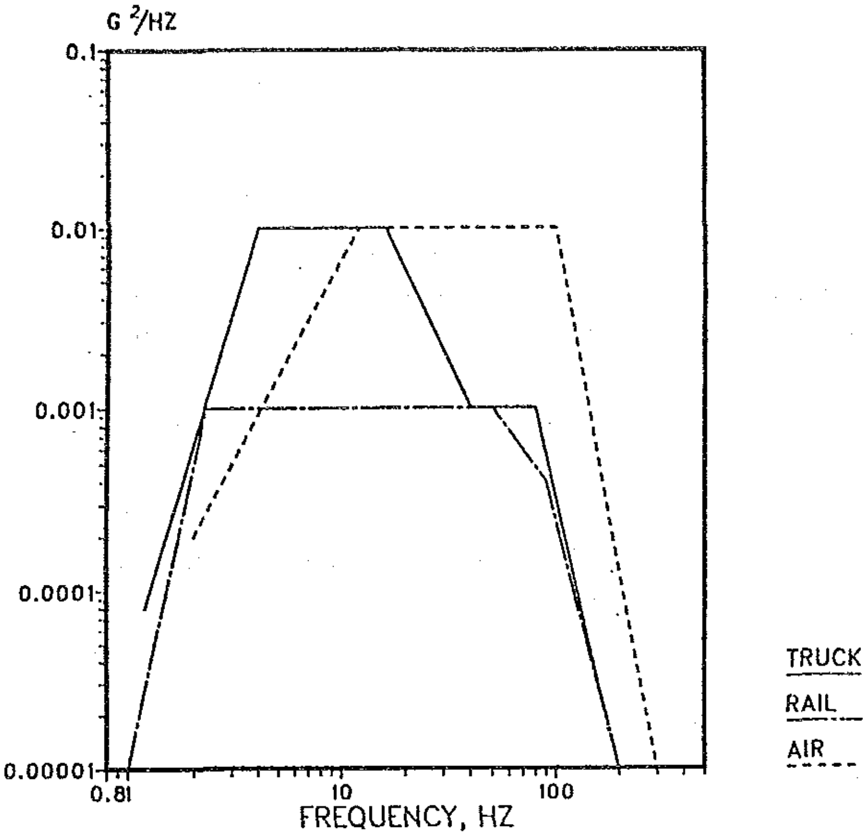

G ²/HZ
0.1
0.01
0.001
0.0001
0.00001
0.81
10
100
FREQUENCY, HZ
TRUCK
RAIL
AIR

Figure 3–5

4. Corrugated Carton Case

4.1 Purpose

The purpose of this test was to determine whether the packaging materials had sufficient strength to withstand the compression that the corrugated carton is subjected to when stacked during actual conditions such as seen when packaged goods are in the distribution phase.

4.2 Samples

Five corrugated carton case (400 x 340 x 340 double wall corrugated)

4.3 Equipment

a. Climatic simulation chamber
b. Compression tester

4.4 Method

4.4.1 Preliminary Treatment

Prior to the compression tests, the transport packages were subjected to environmental condition 5 in JIS Z 0203-87, namely 20 deg. C and 65% RH in a climatic simulation chamber for 24 hours.

4.4.2 Compression Test (Figure 4-1)

(1) Scope

After the packages were removed from the chamber they were submitted to a 10mm per minute of compression by the compression tester, and recordings were made.

(2) Results

By adjustment of the records made following application of the initial load of 40kgf, the average maximum load value of 245kgf was obtained.

4.5 Overall Evaluation

Compression tests are ordinarily performed in Japan as described above, with consideration given to the number of layers of packages stacked in warehouses and during transport. The strength of the samples were about 80% of that of comparable Japanese packages. The ambient temperature in Singapore is 30 deg. C, and the relative humidity is normally an average of 85%, and unless consideration is given to the influence of these conditions when measuring resistance to compression, the results of the above tests are not valid, whereas if they are considered, the strength is taken as half of what it should be. Considerable buckling of packages was evident when conditions in Singaporean warehouses were inspected (Figure 4-2).

It is recommended that this type of test be repeated numerous times with suitable modifications.

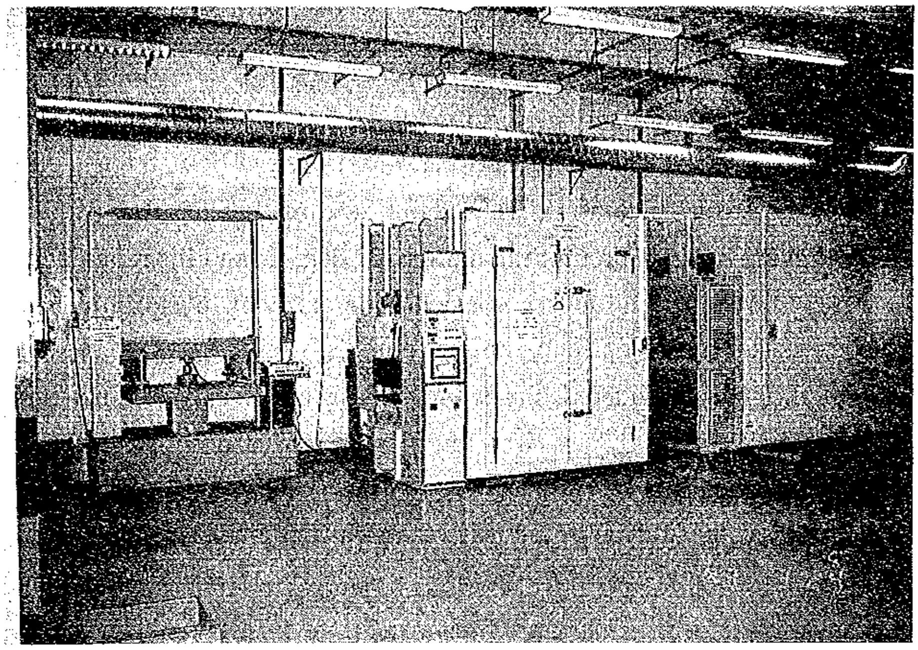


Figure 4–1

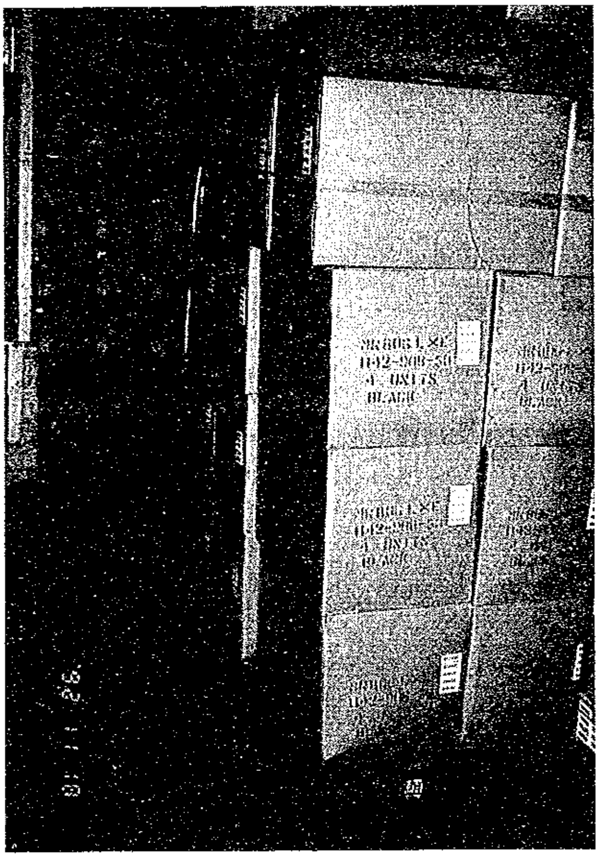


Figure 4–2

5. 3.5" Hard Disk Drive Devices in Packages

5.1 Purpose

To evaluate the suitability of the design and materials for packaging 3.5" hard disk drive devices, on assumption of the conditions that would be encountered in the transportation process.

5.2 Materials and Method

a. Vibration machine and printer

The package was subjected to 5–300Hz, 0.5G of sinusoidal vibration, and the resonance frequency of the frequency of resonance vibration was sought (Figure 5–1: excitation recorded data).

b. Drop tester, personal computer, acceleration measurement system

The packaged HDD device was dropped from a height of 36" and the shock effect was measured by use of the acceleration measurement system (Fig 5–2: acceleration data).

c. Compression tester

The package was subjected to compression to determine the load withstandable before bending, and the displacement (Figure 5–3: load and displacement record).

1 TEST SPECIMEN

TYPE:	3.5" Hard Drive Shipping Carton	REAL [X]	DUMMY [ ]
DIMENSION:	510mm (L)	350mm (W)	250mm (H)
WEIGHT:	Nil		
SAMPLE SIZE:	11 Cartons		

2 TEST REQUIREMENT

STANDARD:	ASTM 999, 775, 642	
PRE-CONDITION:	23 °C	65 %RH
ADDITIONAL REQUIREMENTS:	ɔecification	

Conclusion :

I Vibration Test,

II Dropt Test,

III Compression Test,

were carried out according to ASTM 999, 775, 642 and Peripheral Test specification Requirements.

I Vibration Test for 3.5" HARD DRIVES PACKAGING (

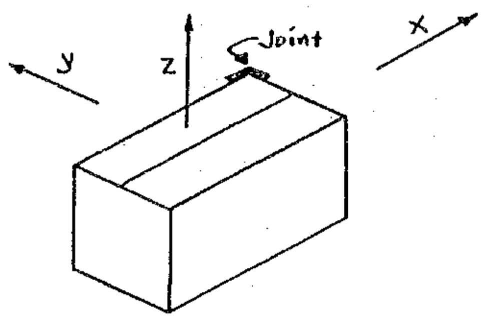
1. Test Results

1.1 Sweep Test

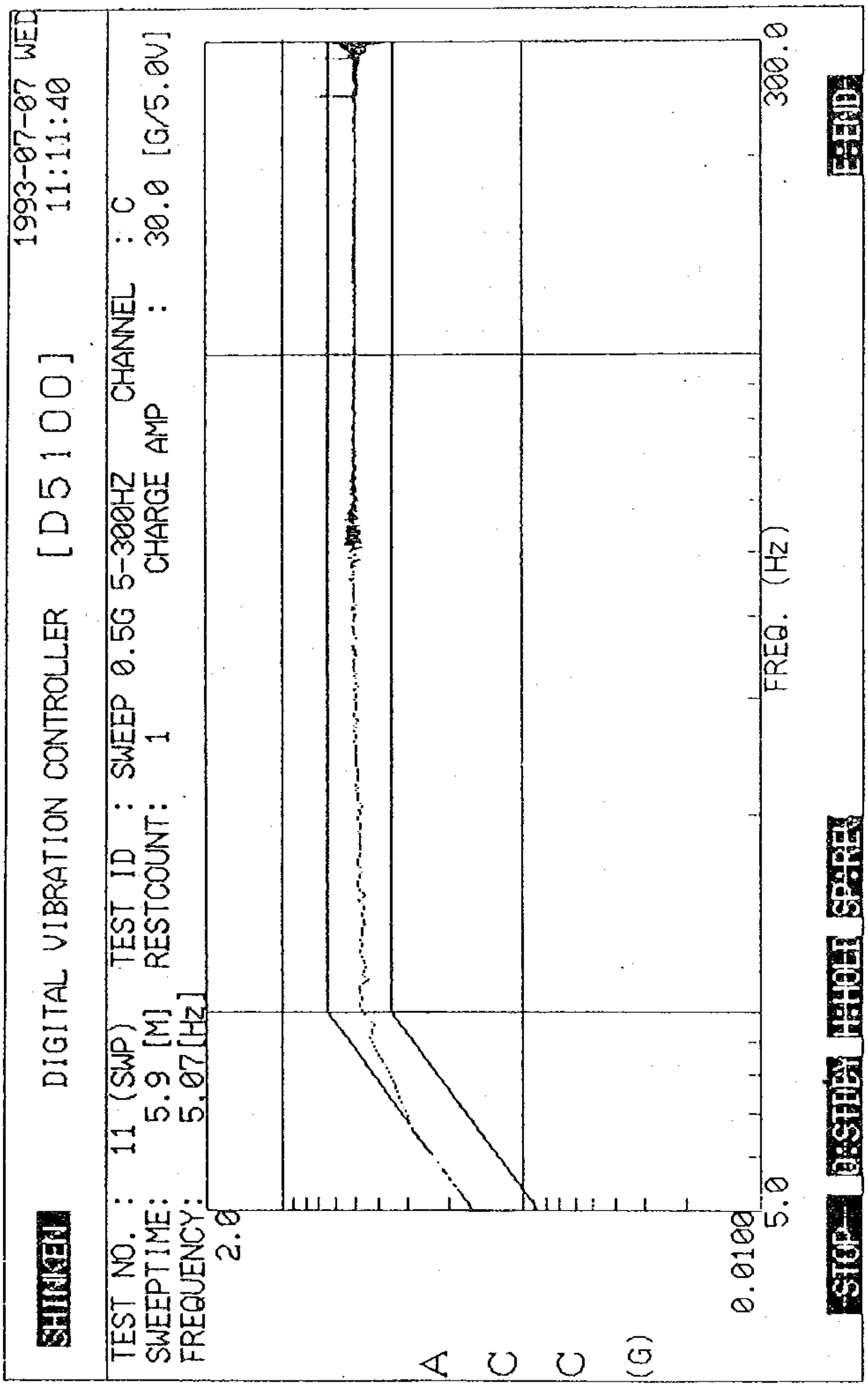
F:ST(OP)

SN		Sample No	Axis of Vibration	Resonance Frequencies/Hz and their respective 'g' value	Remarks
1	)	Box 1	Z	13.00 Hz with 2.00g	Accelerometer attached to drive #5
2	)	Box 1	X	14.00 Hz with 1.06g	Accelerometer attached to drive #5
3	)	Box 1	Y	2.00 Hz with 0.90g 75.0 Hz with 0.97g	Accelerometer attached to drive #5
4	)	Box 2	Z	14.65 Hz with 1.30g	Accelerometer attached to drive #5
5	)	Box 2	X	16.00 Hz with 1.10g	Accelerometer attached to drive #5
6	)	Box 2	Y	18.50 Hz with 0.90g 65.00 Hz with 1.00g	Accelerometer attached to drive #5
7	)	Box 3	Z	18.00 Hz with 1.77g	Accelerometer attached to drive #5
8	)	Box 3	X	18.00 Hz with 1.25g	Accelerometer attached to drive #5
9	)	Box 3	Y	20.00 Hz with 1.06g 80.00 Hz with 0.77g	Accelerometer attached to drive #5

1.2 Orientation of carton Box



1.3 Sweep Test Profile



FoR AXES X, Y, Z OF BOX 123

Figure 5-1

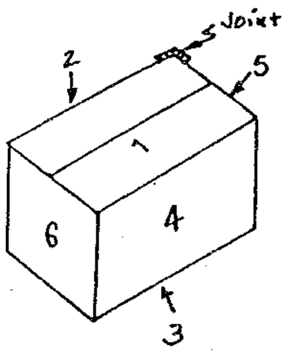
II DROP TEST FOR 3.5" HARD DRIVES PACKAGING

1. Test Results

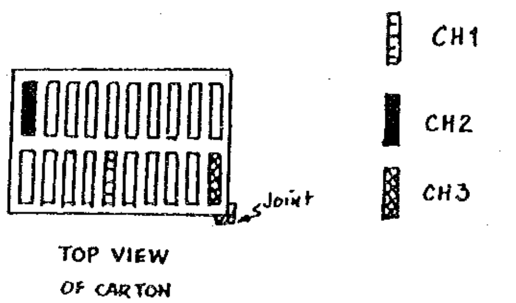
1.1 Table shows drop test results of 36" DROP

SN	Sample No	Drop face	Shock Level/g CH1	CH2	CH3	Remarks
1	Box 4	3	52.5	54.0	48.1	
2		1	44.0	47.9	44.8	- graph not plotted
3		2	45.7	39.7	56.3	
4		4	40.4	45.3	42.9	- graph not plotted
5		5	41.3	29.5	74.2	
6		6	36.9	62.1	40.3	
7	Box 5	3	52.4	46.2	51.3	
8		1	41.8	48.8	47.7	
9		2	55.0	38.5	62.5	
10		4	59.7	56.4	48.7	
11		5	37.6	36.3	68.8	
12		6	38.5	72.1	35.6	
13	Box 6	3	44.1	50.8	54.1	
14		1	45.7	49.3	50.9	- graph not plotted
15		2	39.3	40.2	49.6	
16		4	49.7	51.1	40.2	
17		5	41.7	38.6	71.6	
18		6	40.8	64.1	49.5	- accelerometer of CH1 found off specimen after carton was open after test

1.2 Orientation of Carton Box



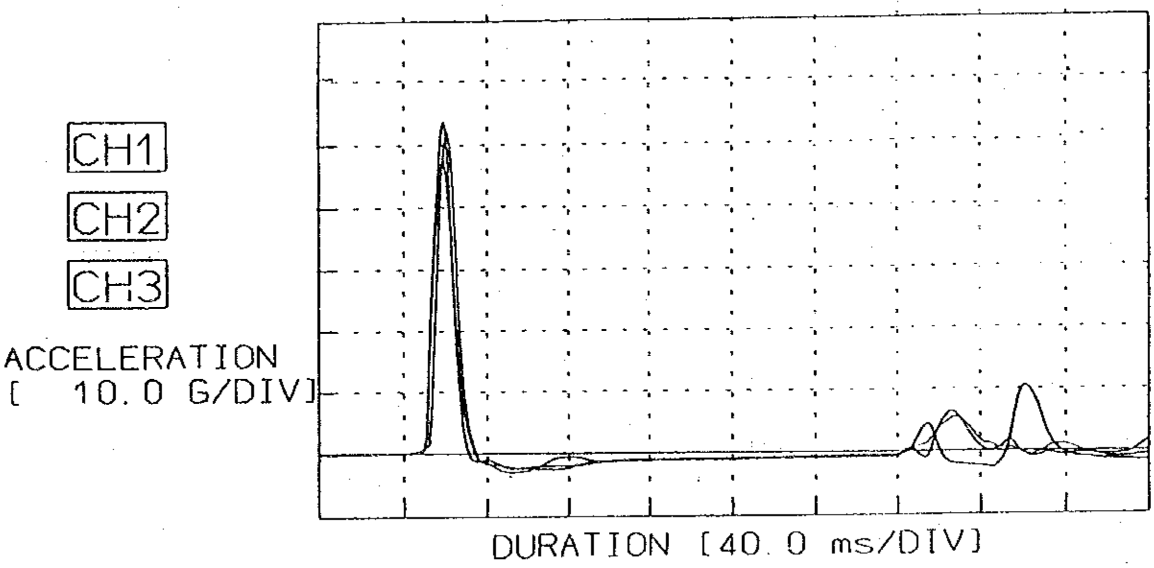
1.3 Placement of accelerometers



SHOCK TEST REPORT

TEST Date: JUL. -20-1993
TEST Time: 13:54:00

FILE NAME: cc43 TEST SPECIMEN : 4



	CH 1	CH 2	CH 3	CH 0
LOWPASS FILTER	0.3 KHz	0.3 KHz	0.3 KHz	1 0 KHz
ACCELERATION DURATION VELOCITY CHANGE	52.5 G 19.10 ms 5.60 m/s	54.0 G 18.20 ms 5.63 m/s	48 1 G 20.50 ms 5.53 m/s	ERROR

DROP HEIGHT : mm GAS PRESSURE : kgf/cm² SPECIMEN WEIGHT : kgf	ACCELEROMETER LOCATION :
RESULTS :	

Remarks : FACE 3 DROP

Figure 5–2

Ⅲ COMPRESSION TEST FOR 3.5" HARD DRIVES PACKAGING ('

1. Test Results

SN	Sample No	Maximum Resistance Load/kg	Derived Deflection/mm*	Remarks
1	Box 7	790	61.2	
2	Box8	770	59.3	
3	Box 9	800	64.3	
4	Box 10	820	61.0	
5	Box 11	755	59.6	
Average		787	61.08	

* Note

1. The X-Y compressive force vs time plotter was set at 50mm/min recording speed against the compressive force.
2. The compression were carried out at fixed rate of 12mm/min.
3. Therefore 50mm distance on the horizontal axis of the compressive force vs time graph represents 12mm of compressive deflection. Hence compressive force vs Deflection graphs were then derived.
4. 'Derived Deflections' were derived from 3.

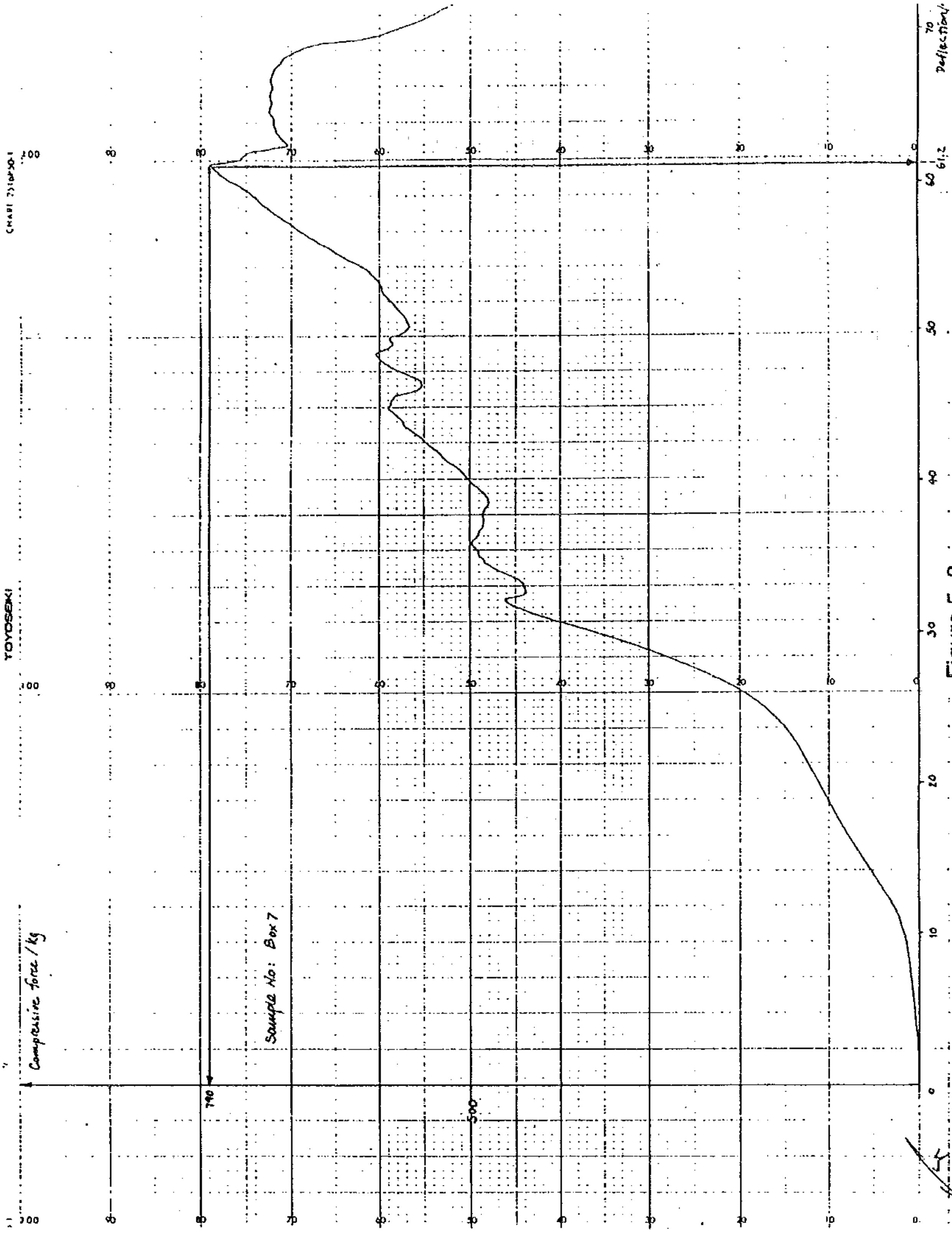

Compressive force / kg
Sample No: Box 7
TOYOSEKI
Deflection
790
500
61.2

Figure 5–3

6. Pallet Using New Materials[1]

6.1 Purpose

To test through actual use pallets made of a newly developed material to evaluate the capability of packaging development.

6.2 Materials and Method

a. Climatic simulation chamber
   Preparatory treatment of materials: 23 deg.C and 65% RH +5 for 48 hours
b. Compression tester
   Test of deformation (bending) under compression
c. Electric hook
   Height of drop: 1.1m (Figure 6–1: record when compression tester was used)

---

[1] Materials not specified here to maintain secrecy for the sake of the company that has developed them.

Laboratory Test

1. *The Laboratory Test on the pallet and wooden pallet consist of the following tests:*

    1.1 Compression Test
    1.2 Drop Test
    1.3 Fork Deflection Test
    1.4 Bending Test
    1.5 Fork slip aand Object slip Test
    1.6 Static Stack Test

2. *Test specimen specifications:*

    2.1 Type of Test specimens:

        2.1.1 Original pallet
        2.1.2 New design pallet
        2.1.3 Wooden pallet

        selected randomly from samples provided by manufacturer.

    2.2 Number of specimens: Various according to test

    2.3 Pre-condition of test specimen : 23°C +/- 2, 65% RH +/- 5% for at least 48 hours.

    2.4 Environment of test : Indoor Laboratory in SISIR premises.

3. *Test Design*

    According to JIS Z0602, Z0606, standard and apparatus requirements.

4. *Other Reference Standards*

    ASTM D1185m ISO8611 & BS2629

5. *Test Apparatus and Requirements*

5.1 Compression Test

- Datum chosen at 0.25 ton for a corner pad

- Maximum load was 1.1 ton for a corner pad

- Deflections (mm) were measured from 0.25 ton load to 1.1 ton (or maximum load which a break occurs less than 1.1 ton)

- 3 original pallets, 1 wooden pallet, 3 new design pallets were required

- Apparatus : a) compression tester
  b) 2 pieces of 200 x 200 x 25mm steel plate
  c) 2 dial guage

5.2 Drop Test

- Drop height - 1.1m for pallet; 0.5m for wooden pallet

- Apparatus : Electric release hook

- 3 original pallets and 1 wooden pallet were required

5.3 Fork Deflection Test

- Static load of 1 ton uniform load was used

- Test duration was 10 minutes

- Creep test of 20 hours was carried on 1st original pallet

- Deflection measurement will be taken at centre and two edge distances between their respective pads and ground.

- A levelled ground was required

- 3 original pallet are required

- Apparatus : a) 2 fork of 100mm x 50mm x 1.5 times pallet length (2.3mm thick)

  b) 1.2m x 1m x 25.4mm steel plate

  c) weight of 1 ton

  d) 3 dial guage

5.4 Bending Test

- Datum chosen at 0.1 ton

- Maxmum load was 1.25 ton

- Deflections were measured from 0.1 ton to 1.25 ton (or maximum load which a break occur less than 1.25 ton)

- 3 original pallets, 1 wooden pallet, 3 new design pallets were required

- Apparatus : a) a compression tester

  b) 2 pieces of dia. 60mm steel pipe (4 mm thickness)

  c) 2 pieces I-beam

  d) 2 dial guage

5.5 Static Stack Test

- Test duration of 6 months

- 3 tier pallets each with 1 ton load monthly measurement of creep

- 3 new design pallets

- Veneer caliper

5.6 Fork slip and Object slip Test

- Obtain angle which object/pallet start to slip
- One new design pallet
- Apparatus : a) 2 pieces of forks

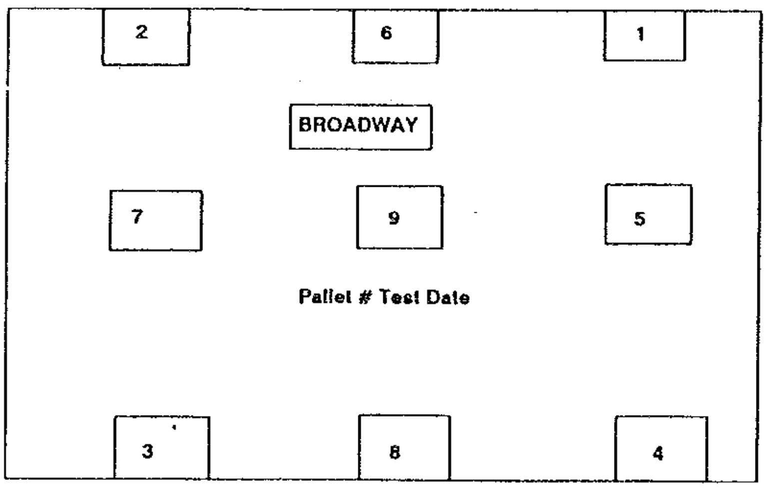
  b) 1 fabricated 30kg object

6. *Laboratory Test Result*

6.1 Compression Test Result of original pallet and Wooden pallet.

SN	TEST DATE	SPECIMEN NO (PALLET)	LOCATION NO	COMPRESSION DEFLECTION 1mm	BREAKING POINT 1 ton	SPECIMEN TYPE	REMARKS
1	23/4	1	1	30.8	0.92	PALLET WITH 9 SUPPORTING PADS	Break/crack length 350mm before limit of 1.1 ton
2	23/4	1	3	28.4	1.10		Break/crack length 190mm
3	23/4	1	4	30.5	1.00		Break/crack length 250mm before limit of 1.1 ton
4	23/4	2	1	28.0	1.10		Break/crack length 250mm
5	23/4	2	3	30.1	0.95		Break/crack length 220mm before limit of 1.1 ton
6	23/4	2	4	30.7	0.95		Break/crack length 140mm before limit of 1.1 ton
7	23/4	2	9	23.7	-		No visual damage
8	23/4	2	5	24.3	-		No visual damage
9	23/4	4	Whole pallet	3.5	-		No visual damage
10	24/4	W1	1	2.1	-	WOODEN PALLET WITH 9 SUPPORTING PADS	No visual damage
11	24/4	W1	2	2.6	-		
12	24/4	W1	3	2.6	-		
13	24/4	W1	4	2.4	-		

Compression Test location on pallet diagram (from. bottom)

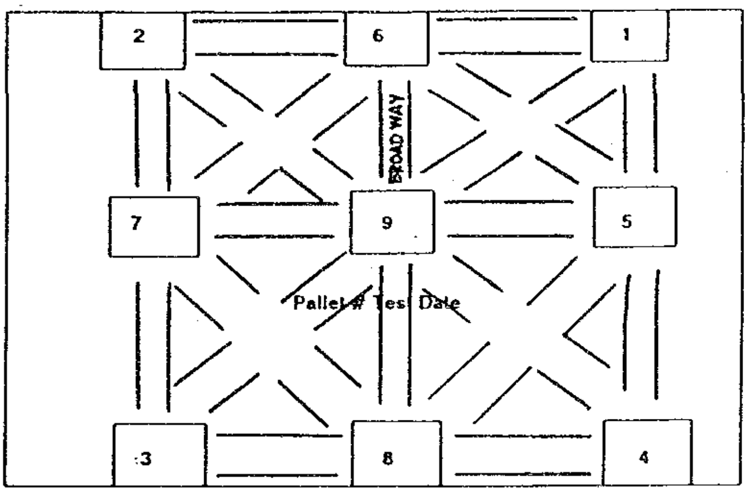


Bottom View

6.2 Compression Test Result of New Design pallet.

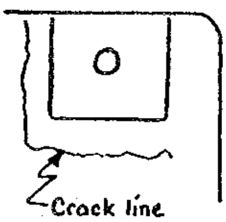
F:D6.2 SN	Specimen No	Type of Specimen	Location No	Deflection/mm	Breaking Point	Remarks
1	N1	NEW DESIGN PALLET	1	58.8	1 ton	26mm crack due to stress concentration
2	N2		2	87.8	Nil	30mm crack due to stress concentration
3	N3		3	57.7	0.95 ton	38mm crack due to stress concentration
4	N4		4	83.9	1.1 ton	38mm crack due to stress concentration

Test Date : 24/6/93



Bottom View

The average breaking strength of the new design pallet is 1 ton accompanied by a crackline formed along the stress concentration area between pad and platform as illustrated by diagram below.



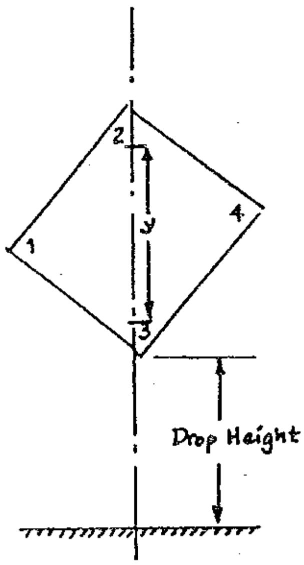
Bottom View
(top right section)

6.3 Pallet Drop Test Result of original pallet.

F:D6.3 SN	Specimen No	Type of Specimen	Drop Ht/mm	Y/mm	Y'/mm	VR/%*
1	5	Pallet	1000	1439	1438	0.069
2	6	Pallet	1000	1439	1438	0.069
3	7	Pallet	1000	1439	1438	0.069
4	W2	Wooden Pallet	500	1493	1485	0.536

* Variation Rate, UR % = $\frac{Y - Y'}{Y} \times 100$

Precondition of specimen for at least 48 hours = 23°C, 65% RH.



Date of Test : 11/05/93

6.4 Fork Deflection Test Result of original pallet.

1. Precondition of specimen : 23°C, 65%RH for at least 48hours
2. Date of test : 25/05/93
3. No. of specimen tested : 3 pallets

SPECIMEN NO 17

F:D6.4 SN	L/mm	δ_1 /mm	δ_2 /mm	δ_3 /mm	Remarks
1	1200	75.1	76.6	75.4	No load
2	1200	67.2	68.5	66.2	600 kg load
3	1200	66.3	66.4	66.6	830 kg load
4	1200	66.6	66.2	66.3	1053 kg load
5	1000	75.3	-	74.2	No load
6	1000	66.0	-	66.5	1053 kg load
7	1200	64.0	65.2	65.5	1053 kg load after 20hrs

SPECIMEN NO 18

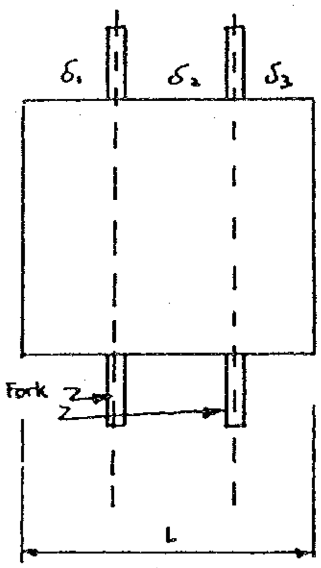
SN	L/mm	δ_1 /mm	δ_2 /mm	δ_3 /mm	Remarks
1	1200	70.5	70.2	70.6	No load
2	1200	66.6	66.3	66.3	1053 kg load
3	1000	71.7	-	70.2	No load
4	1000	66.2	-	66.1	1053 kg load

SPECIMEN NO 19

SN	L/mm	δ_1 /mm	δ_2 /mm	δ_3 /mm	Remarks
1	1200	70.2	70.5	70.5	No load
2	1200	66.6	66.0	66.8	1053 kg load
3	1000	75.3	-	71.3	No load
4	1000	60.4	-	65.6	1053 kg load

Average Test result of specimen #17, #18 & #19

F:D6.4c SN	L/mm	δ_1/mm	δ_2/mm	δ_3/mm	Remarks
1	1200	71.9	72.4	72.2	No load
2	1200	66.6	66.2	66.6	1053 kg
3	1000	74.1	-	71.9	No load
4	1000	67.2	-	66.1	1053 kg
5	1200	64.0	65.2	65.5	1053 kg after 20 hours



Top View of Pallet

δ_1 , δ_2 & δ_3 are distance between respective pallet pad base and ground according to above diagram.

6.5 Bending Test Result of original pallet.

F:D6.5

SN	Specimen No	Type of Specimen	L/mm	Deflection/mm		D %	Remarks
1	8	PALLET	1200	26.6	29.0	2.32	Break at 0.55 ton
2	9			41.0	46.1	3.63	Break at 1.475 ton
3	10			41.2	40.8	3.42	Break at 1.188 ton
4	W3	Wooden Pallet	1100	17.1	16.5	1.40	Break at 2.45 ton
5	11	PALLET	1000	30.8	31.2	2.58	Break at 0.275 ton
6	12			47.2	46.2	3.89	Break at 2.2 ton
7	13			40.1	40.6	3.36	Break at 1.075 ton

Date of Test : 18/05/93

The allowable bending strength of the original pallet is 0.25 ton (average). The graph of bending strength against time of each specimen is available in Appendix B.

6.6 Bending Test Result of new design pallet with sharp angle.

F:D6.6 SN	Specimen No	Type of Specimen	L/mm	Deflection/mm		D %	Remarks
1	N7	NEW DESIGN PALLET	1200	38.2	38.0	3.18	Break at 0.8 ton
2	N8		1200	31.8	32.0	2.66	Break at 0.657 ton
3	N9		1200	37.1	36.0	3.05	Break at 1.025 ton
4	N10		1000	34.0	34.6	2.86	Break at 0.725 ton
5	N11		1000	34.0	32.6	2.78	Break at 0.75 ton
6	N12		1000	30.6	32.8	2.64	Break at 0.775 ton

The allowable bending strength of the new design pallet is 0.75 ton (average). The graph of bending strength against time of each specimen is available in Appendix B.

Practical Usage Test

1. **The practical Usage Test for the pallet consist of the following tests:**

    1.1 Forklift rapid release (drop) test
    1.2 Forklift transportation test
    1.3 Forklift push/pull pallet arrangement test
    1.4 Forklift halfway insertion lift test
    1.5 Forklift carelss insertion test

2. **Test specimen specifications:**

    2.1 Type of Test specimens:

    pallet
    new prototype design
    selected randomly from samples provided by manufacturer

    2.2 Number of specimen : 1 unit, sample #N13

    2.3 Simulated weight on test speciments:

    1008 kg and 1232 kg of copper slag bags (56 kg each bag) were used for practical tests. The load was evenly spaced then plastic shrink wrapped round pallet.

    2.4 Pre-condition of test specimen : None

    2.5 Environment of test : Indoor and outdoor testing ground in SISIR premises.

3. **Date and time of test : 02/07/93 at 1330 hours.**

5. Test Details and Results

5.1 Forklift rapid release (drop) test.
This test was carried out indoor (concrete ground) as well as outdoor (bitumen ground). The pallet with 1232 kg of load was repeatedly lifted by forklift up to a height of 30cm away from ground and followed by a sudden quick release to drop the pallet onto the ground for 5 times indoor. Visual inspection was then carried out on specimen. No damage, crack or deformation was found on specimen. Outdoor test was conducted with the same specimen and load after the indoor test proofed successful. The specimen was repeatedly lifted to height of 153cm away from ground and followed by a sudden quick release to drop the pallet onto the ground for 3 times. Visual inspection was then conducted on specimen. No damage, crack or deformation was found on test specimen.

5.2 Forklift transportation test.
An initial load of 1008 kg was placed on the test specimen. A diesel powered forklift was used for transport simulation test. The objective of this test was to observe the specimen's performance on forklift while it perform the following actions outdoor:

- sudden sideways manuveur at high speed travel
- full speed travel of forklift over uneven bitumen ground
- 5 minutes continous forklift travel
- zig-zag movement of forklift
- emergency braking of forklift at full speed operation

When visual inspection showed no damage, crack or deformation on test specimen after test, the pallet was loaded up to a total of 1232 kg. The same test was repeated again with the forklift performing the same actions mentioned earlier. Final visual inspection showed that the specimen suffered no damage, crack or deformation.

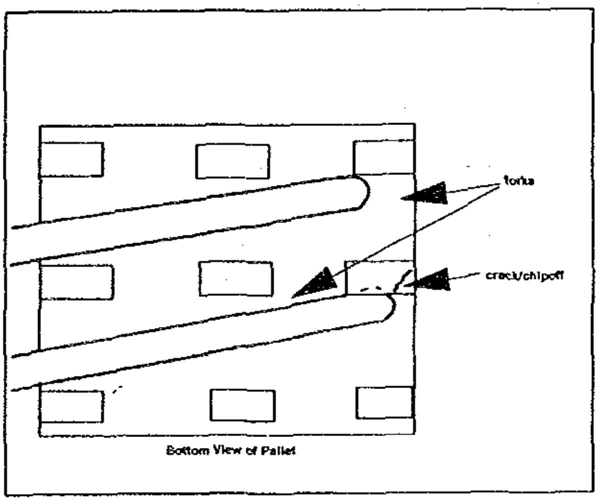
5.3 Forklift push/pull pallet arrangement test.

This test was carried out indoor on concrete ground. The forklift inserted the forks only ½ way below the pallet with 1232 kg load then lift one end of the pallet 10cm above ground with the other end still in contact with the floor, pushing and pulling of the pallet was performed together with sideways movement of the pallet when left and right turn of the forklift was was performed. The test was to simulate pallet arrangement in a warehouse when space limitation is experienced. After testing for a duration of 5 minutes at an area of 6m x 2m, the pallet was lifted for visual inspection. No cracks, damage or deformation was found.

5.4 Forklift halfway insertion lift test.

The forks of the forklift were inserted ½ way under the pallet with 1232 kg load then lifted to a height of 1.5m. No crack or damage was found on pallet although slight deformation (sagging) was visible at the sides of the specimen along the sides of the forklift, but the pallet returned to its original shape immediately after the test.

5.5 Forklift careless insertion test.



Crack and chip off on the far end pallet pad was found when the fork smash deep into the side of the pad then lifted. However the rest of the pallet was not damaged and stability of pallet was not affected after the pallet was lowered back onto the ground. The pallet was fully loaded with 1232kg load throughout the test.

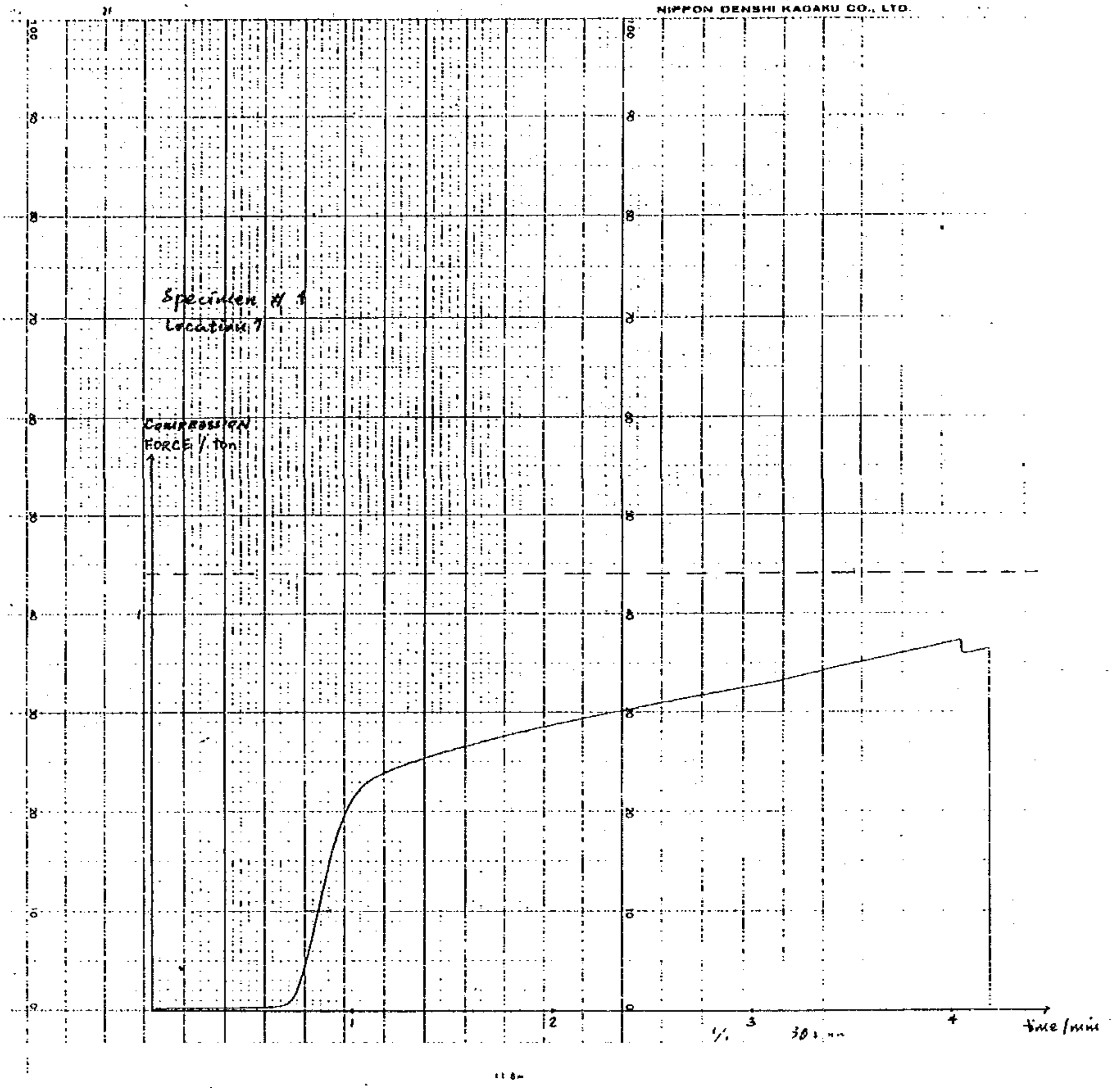

NIPPON DENSHI KAGAKU CO., LTD.
Specimen # 1
Location 7
COMPRESSION FORCE / ton
1
2
3
4
time / min

Figure 6-1

JICA