6.3 General Guideline for the Packaging Design

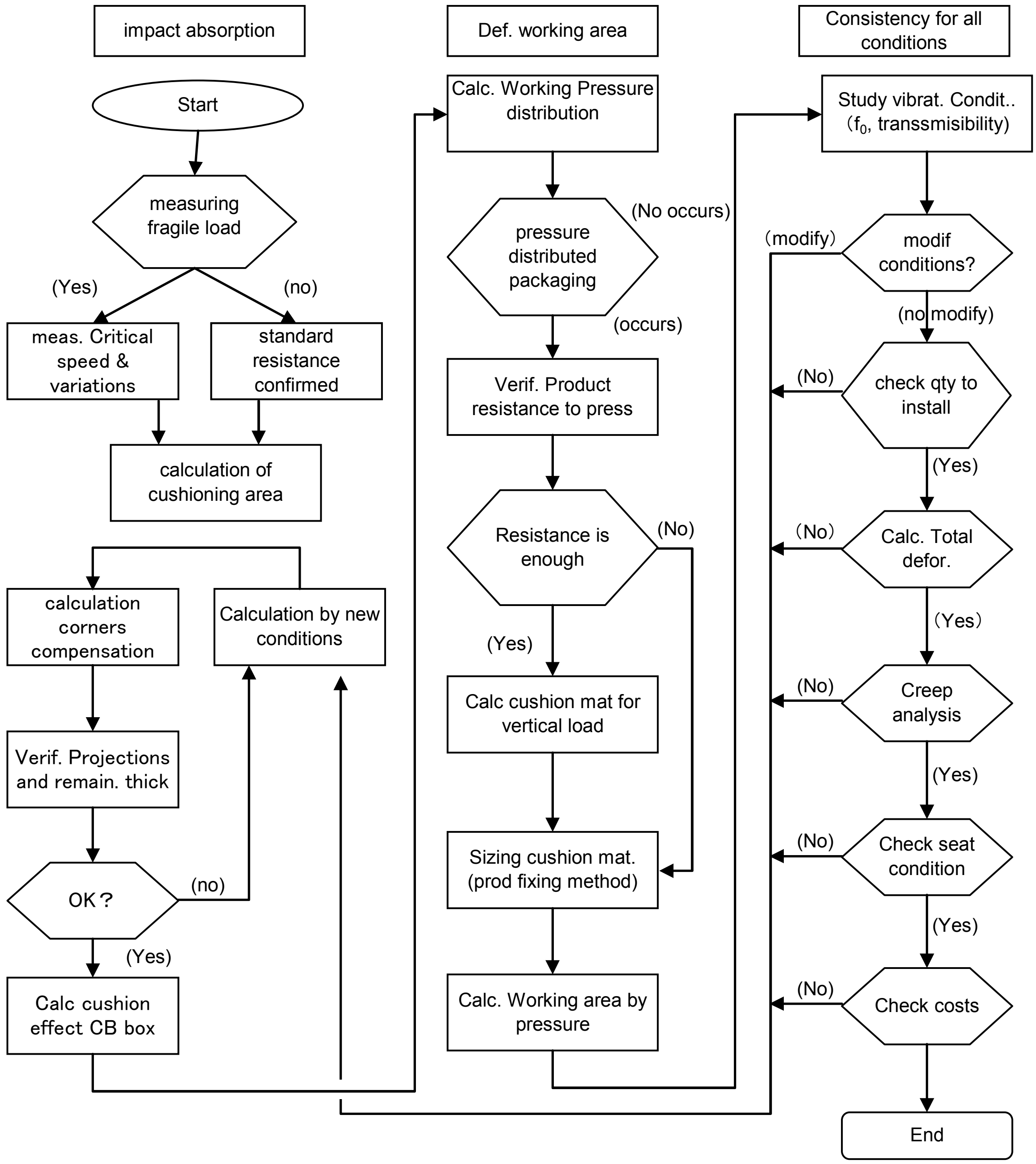
The main objective of the packaging is to protect the product transported from production centers up to the end consumers. Factors which can produce damages on the packaging of the cargo are: the impacts due to drops due handling, the vibrations of the vehicles utilized, the stress produced due to piling on the warehouses, the ambient temperature and humidity variations, etc. Among all the factors, the damages caused by the drop during handling could be the most important one. The part of the engineering which is aiming to give the necessary protection against impacts due to drops is the “cushioning design”. The objective of the design is to smoothing the external impacts and to protecting the products, protecting them so that it does not suffer the load of the impact, making all the system to a point that the impact forces are becoming within allowable values for the product. The “cushioning design” is an engineering field developed basically for industrial products and the steps are structured basically on the following 3 items:

(1) *Cushioning calculation:* Defining the required thickness and areas of cushioning materials

(2) *Defining cushioning materials:* To determine the location points of cushioning materials

(3) *Drawings preparation:* To define the geometrical shapes of the cushioning materials

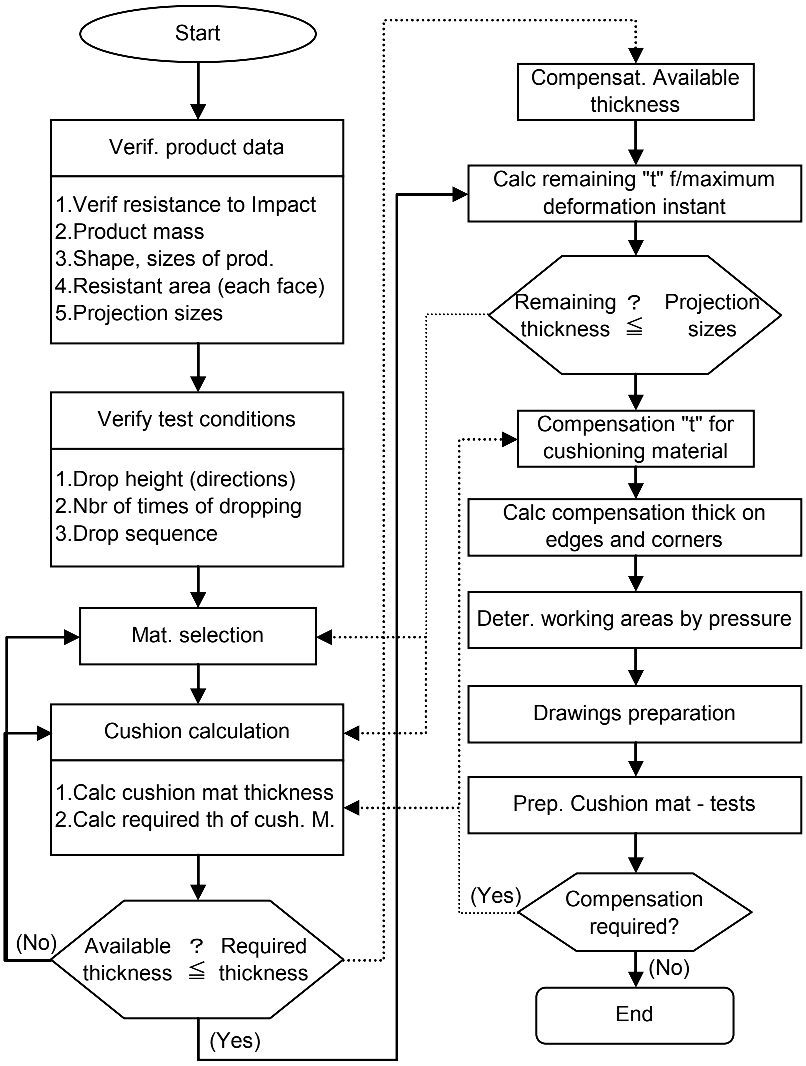
Furthermore, considering the development of all the packaging of a packed cargo, all the steps of the packaging design and cushioning design can be summarized according to the following flow chart.



Source: Kiyohide Hasegawa – "Cushioning packaging Technology- Test Methods" Course XXXIX - Nikkan Publishing Co., 2005

Fig. 6.3-1 Flow Diagram for the Cushioning Design of Packaging

If it is observed the process related to Cushioning Design, the steps can be analyzed on the flow diagram described below. Once the initial conditions for the design are defined, all the processes can be followed up systematically through the related graphics. However, for the study of the drops on corners and edges, since they are no standardized methods, the factors are defined based on experience. Regarding the compensation factors of cushioning characteristics of the materials, such as corrugated board, considering that they are variable depending on the shape of the packaging (boxes) and materials, it is required a certain level of previous knowledge and experience related to cushioning design.



Source: Kiyohide Hasegawa – "Cushioning packaging Technology- Test Methods" Course XXXIX - Nikkan Publishing Co., 2005

Fig. 6.3-2 Flow Diagram for the Cushioning Design

6.3.1 Comparison with JIS Standard

6.3.1.1 JIS Standards referred to industrial packaging

As the official standard for industrial products, JIS is establishing several standards related to packaging and transportation. These standards are classified as: glossary, general rules for packaging, materials – packs, and test methodology. The largest number of standards, among them, is materials-packs and the next one is the test method.

The JIS identification code is described below. The last four digits of the right side is the year of issue, or last revision. These standards are continuously in process of revisions, taking into account the social and environmental needs, the adaptation to new technologies and the coordination with others international standards.

Example:

JIS	Z	0200	:	1999	Packed Cargoes-General Rules for Testing
↓	↓	↓		↓	↓
Initial	Class symble	Std No.		Issue or revision year	Title of Standard

The JIS standards, as general rule, consist of a main text and an explanation, and depending on the subject, it could include a series of normative annex (specification) and reference annex(comments).

Within this structure of the document, the format for the main part and the normative annex are specified by the standard itself, they are constituing the standard as a whole. But the reference annex are not part of the document.

The list of the JIS standards applicable for industrial packaging is as follows:

Table 6.3.1-1 JIS Standards for Industrial Packaging

Sector	Subsector	Code	Title
Packaging glossary		Z 0108 : 2005	Glossary of terms for packaging
		Z 0102 : 2004	Kraft paper sacks – Glossary of terms and types
		Z 0103 : 1996	Glossary of terms used in rust and corrosion preventive technology
		Z 0106 : 1997	Glossary of terms used for pallets
		Z 0104 : 1990	Glossary of terms used in corrugated fibreboard industry
		Z 0107 : 1974	Glossary of terms used in wooden box for packing
		Z 0109 : 1992	Glossary of terms used in pressure sensitive adhesive tapes and sheets
		Z 0111 : 2006	Glossary of terms used for physical distribution
		P 0001 : 1998	Paper, board and pulp -- Vocabulary
General for packaging		Z 0105 : 1998	Transport packages -- Dimensions of transport packages by modular coordination
		Z 0150 : 2001	Packaging - Pictorial marking for handling of goods
		Z 0152 : 1996	Marking for attention in handling of packaged goods
		Z 0161 : 1984	Dimensions of unit load sizes
		Z 0650 : 1995	General rules for unit-load system
		X 0501 : 1985	Symbols for bar codes for common goods
		X 0502 : 1994	Symbols for bar codes for distribution goods
Materials - Packs	Wood	Z 1402 : 2003	Wooden boxes for packing
		Z 1403 : 2003	Wooden framed boxes for packing
		Z 1406 : 1978	Crate plywood boxes
		Z 1407 : 1989	Wirebound boxes
		Z 1408 : 1989	Crates, slatted, wirebound boxes
	Processed paper	Z 1514 : 1994	Polyethylene coated paper
	Corrugated carton & cartons	P 3902 : 2005	Liner boards for corrugated board
		P 3904 : 2005	Corrugating flute sheet paper
		Z 1516 : 2003	Corrugated fiberboards for shipping containers
		Z 1506 : 2003	Corrugated shipping containers
		Z 1507 : 1989	Types of corrugated fibreboard boxes

Sector	Subsector	Code		Title
	Paper sacks	Z 1531-1	: 2004	Kraft paper sacks –Definitions of dimensions and measuring method
		Z 1531-2	: 2004	Kraft paper sacks – Dimension tolerances for common use sacks
		Z 1531-3	: 2004	Sacks – Sampling method for testing empty sacks
		Z 1532	: 1998	Kraft paper sacks - Testing method for bottom pasting strength
		Z 1505	: 2004	Kraft paper sacks - For cement
		Z 1509	: 2004	Kraft paper sacks - For potato starch
	plastics	Z 1702	: 1994	Polyethylene films for packaging
		Z 1706	: 1995	Polyethylene pots
		Z 1712	: 1997	Oriented polypropylene films for packaging
		Z 1713	: 1997	Cast polypropylene films for packaging
		Z 1714	: 1997	Biaxially oriented nylon films for packaging
		Z 1715	: 1997	Biaxially oriented polyethylene terephthalate (PET) films for packaging
		Z 1716	: 2004	Cast polyethylene terephtalate (PET) films for packaging
		Z 1707	: 1997	General rules of plastic films for food packaging
		Z 1709	: 1995	Heat shrinkable plastic films for packaging
		Z 1529	: 2004	Pressure sensitive adhesive films for printing
		K 6734	: 2000	Plastics - Unplasticized poly (vinyl chloride) sheets - Types, dimensions and characteristics - Part 2: Sheets of thickness less than 1 mm
		Z 1533	: 1995	Polyolefine flat yarn for woven cloth
		Z 1534	: 1999	Heavy duty polyethylene sacks
		Z 1711	: 1994	Polyethylene film bags
		Z 1655	: 1993	Plastic returnable containers
	Metals	Z 1520	: 1990	Laminated aluminium foils
		H 4160	: 2006	Aluminium and aluminium alloy foils
		Z 1600	: 2006	Open head steel drums
		Z 1601	: 1994	Steel drums for liquids
		Z 1602	: 2003	18 liter metal cans
		Z 1604	: 1995	Plugs and flanges for steel drums
		Z 1607	: 2003	Metal caps and nozzles
		Z 1620	: 1995	Steel pails
		Z 1571	: 2005	Hermetically sealed metal cans for food and drink
	Cushioning Materials	L 3203	: 2002	Jute felts
	Joint Elements-Sealing materials	Z 1511	: 2004	Gummed paper tapes (for packaging)
		Z 1512	: 1995	Gummed cloth tapes (for packaging)
		Z 1522	: 1994	Pressure sensitive adhesive cellophane tapes
		Z 1523	: 1994	Pressure sensitive adhesive paper tapes
		Z 1524	: 1994	Pressure sensitive adhesive cloth tapes for packaging
		Z 1525	: 1991	Pressure sensitive adhesive polyvinyl chloride tapes for packaging
		Z 1528	: 1991	Pressure sensitive adhesive double face coated tapes
		Z 1541	: 1998	High potential pressure sensitive adhesive double face coated tapes
		Z 1539	: 1991	Pressure sensitive adhesive polypropylene tapes for packaging
		Z 1527	: 2002	Polypropylene band
		Z 1701	: 1995	Rubber band for packaging
		L 2701	: 1992	Manila and sisal fibre ropes (Amendment 1)
		L 2703	: 1992	Vinylon ropes
		L 2704	: 1992	Nylon ropes
		L 2705	: 1992	Polyethylene ropes
		L 2706	: 1992	Polypropylene ropes
		L 2707	: 1992	Polyester ropes
	Materials For	Z 1519	: 1994	Volatile corrosion inhibitor
		Z 1535	: 1994	Volatile corrosion inhibitor treated paper

Sector	Subsector	Code	Title
	hermeticity	Z 1708 : 1976	Sprayable and strippable protective plastic coatings
		Z 1705 : 1976	Corrosion preventive greaseproofed barrier materials
		Z 2246 : 1994	Shore hardness test - Test method
		Z 1901 : 1998	Pressure sensitive adhesive polyvinyl chloride tapes for corrosion protection
		Z 1902 : 2000	Petrolatum tapes for corrosion protection
		Z 0701 : 1977	Silicagel desiccants for packaging
Packagin Specifications		Z 0301 : 1989	Method of moisture-proof packaging
		Z 0302 : 1955	Water proof packaging
		Z 0303 : 1985	General rule for corrosion preventive packaging method
		Z 0305 : 1998	Chemical cleaning of steel products
Testing Methods	Materials -containers	Z 0402 : 1995	Test method for adhesion of corrugated fibreboard
		Z 0403-1 : 1999	Corrugated fibreboard --Part 1: Determination of flat crush resistance
		Z 0403-2 : 1999	Corrugated fibreboard - Part 2: Determination of edgewise crush resistance
		K 6767 : 1999	Cellular plastics - Polyethylene - Methods of test
		K 6768 : 1999	Plastics - Film and sheeting - Determination of wetting tension
		K 7112 : 1990	Plastics - Methods of determining the density and relative density of non-cellular plastics
		K 7114 : 2001	Plastics - Methods of test for the determination of the effects of immersion in liquid chemicals
		Z 0221 : 1976	Method of water permeability test for packing material
		Z 0235 : 2002	Cushioning materials for packaging -- Determination of cushioning performance
		Z 0240 : 2002	Structural cushioning materials for packaging -- Determination of cushioning performance
		Z 0208 : 1976	Testing methods for determination of the water vapour transmission rate of moisture-proof packaging materials (dish method)
		Z 0237 : 2000	Testing methods of pressure-sensitive adhesive tapes and sheets
		Z 0238 : 1998	Testing methods for heat sealed flexible packages
		Z 0218 : 1997	Gummed tape - Testing methods for adhesive strength
	Cargo & packs	Z 0119 : 2002	Mechanical-shock fragility testing methods for packaging and products design
		Z 0170 : 1998	Unit loads - Stability testing
		Z 0201 : 1989	Methods of designating on component parts and points of containers when testing
		Z 0200 : 1999	Packaged freights - General rules of testing
		Z 0202 : 1994	Packaged freights - Method of drop test
		Z 0203 : 2000	Packaged freights - Conditioning for testing
		Z 0205 : 1998	Packaged freights - Method of horizontal impact tests
		Z 0212 : 1998	Packaged freights and containers -- Method of compression test
		Z 0215 : 1996	Testing method of stitch strength for sewn kraft paper sacks
		Z 0216 : 1991	Water spray test for packages and containers
		Z 0217 : 1998	Kraft paper sacks - Method of drop test
		Z 0222 : 1959	Method of permeability test for moisture proof packing case
		Z 0232 : 2004	Packaged freights - Method of vibration test

Within the frame of the Study, and according to the results of data analysis of collected data during the Transportation Environmental Surveys, it is expected the issue of the MERCOSUR Standard (Draft) through the developments of the improvements of packaging design and the Model Project (Transportation Survey by using the new improved packaging). The draft of the standard is based on the JIS standards and is shown in the chapter 6.

6.3.1.2 Evaluation of Dairy Products Packaged for Transportation, based on JIS, ISO Standards

(1) Reference Values for Evaluation of dairy products packaged for transportation (Draft)

The reference values, by applying the JIS, ISO and others standards, are as follows.

Tests for Packed dairy products (Evaluation of dairy products packaging)

JIS Z 0232 (2004) ISO 8318 (2000) , ISO 13355 (2001)

Packaged freights – Method for Vibration Test

Random Vibration

Test conditions	* Use accelerations RMS (G^2/Hz) totals and PSDs obtained by Transportation Environment Surveys in MERCOSUR. * Perform the tests within safety limits of accelerations (m^2/s^2).
PSD	G^2/Hz (m^2/s^2)
Total rms acceleration*	m/s^2 (G)
Vibration period	min (depending on transportation vehicle and distances)
Vibration direction	Vertical (ISO 8318, ISO 13355 standards does not consider horizontal vibrations)
Frequency range	Hz

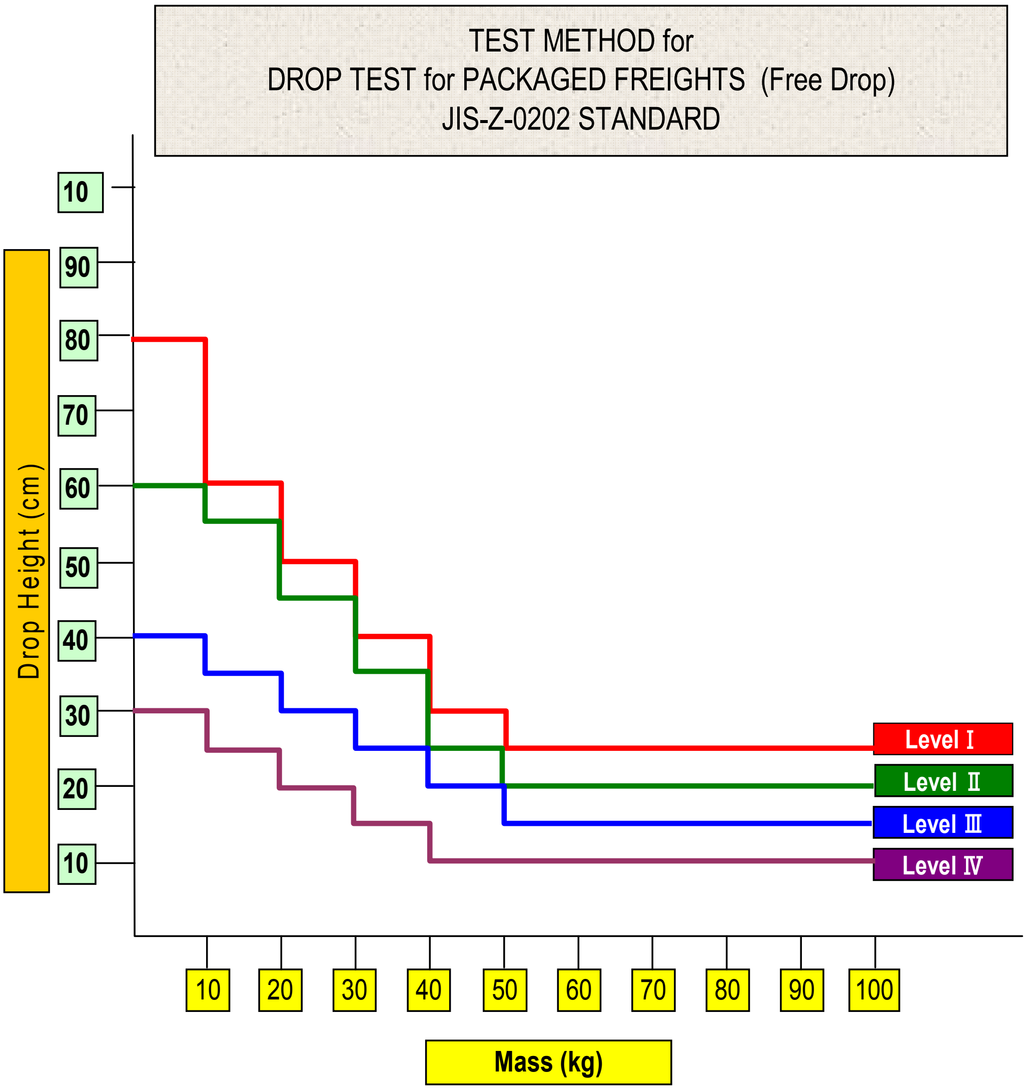
*The rms value is related to the total route.

Classsification of Distribution Conditions (preliminar)
(Reference for Evaluation tests by "Grades" <progress report>)

Unit: %

	A (Good)	B (Medium)	C (Bad)
Grade 1	100	—	—
Grade 2	80	10	10
Grade 3	60	20	20
Grade 4	40	30	30
Grade 5	20	40	40

Source: JICA Study Team



Sub-divisions depending on transportation conditions:

LEVEL Ⅰ Re-piling times is high, and possible high external extreme loads.
LEVEL Ⅱ Re-piling times is high, and possible relatively high external loads.
LEVEL Ⅲ Re-piling times and external loads are normal level, as expected.
LEVEL Ⅳ Re-piling times is low, and they are expected no extreme loads.

JIS Z 0202 (1994) ISO 2248 (1985) , ISO 8568 (1989)

Packaged Freights – Drop Test

Free Drop Test

Mass (kg)	Drop Height (cm)			
	Level Ⅰ	Level Ⅱ	Level Ⅲ	Level Ⅳ
Up to 10	80	60	40	30
From 10 up to 20	60	55	35	25
From 20 up to 30	50	45	30	20
From 30 up to 40	40	35	25	15
From 40 up to 50	30	25	20	10
From 50 up to 100	25	20	15	10

Note: In case of mass higher than 100kg, it is recommended the bottom and side edge test.
For specimen of 50kg to 100kg, this test is accepted.

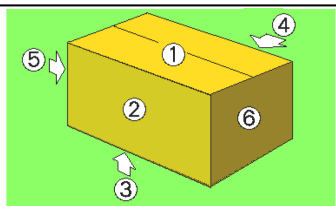
Drop test with bottom impact and side edge

Mass (kg)	Drop Height (cm)			
	Level Ⅰ	Level Ⅱ	Level Ⅲ	Level Ⅳ
More than 50 up to 200	50	40	30	20
More than 200 up to 500	40	30	20	15
More than 500 up to 1000	30	20	15	10

Drop sequence and number of times

Sequence	Portion to be impacted (face Nbr)	Test times
1	Bottom adjacent corners Ex. Corner 2-3-5	1
2	Side adjacent edges E. Edge 3-5	1
3	Bottom-side face edge E. Edge 2-3	1
4	Front face-Side face edge E. Edge 2-5	1
5～10	All 6 faces	6
	Totals	10

Note:
1. Tests can be partially eliminated, depending on type of packaged freight.
2. The test sequence can be modified, prior agreement with the test requester.
3. For the selection of the corners and edges to be tested, they will be chosen the wake ones.



JIS Z 0212 (1998) ISO 12048 (1994) IS0 2234 (2000)

Compression test for packaged freights and containers

(a) Test according to JIS Z0212

The tests are performed by using test apparatus as per JIS Z0212 and Method A.

Note: The Method A is a compression test, and basically investigates the damages on products caused by compression loads.
It is recommended as quantity of specimen more than 3.
The Method B is a compression test to investigate the resistance to compression of the secondary packaging, such as empty cardboard boxes.
It is recommended as quantity of specimen more than 5.

【Method A】

The specimen must be conditioned before the test, according to JIS Z0203. In this case, the temperature and humidity of the conditioning process is determined depending on the purpose of the test. The compression direction will be selected according to the faces to be under compression due to stacking, and the loading speed will be as per following formula, where is indicated the load and a increasing speed of 10±3mm per minute, recording the observed values immediately. The specimen quantity must be more than 3 pieces.

$$F = 9.8 \times K \times M \times (n-1)$$

***F* : Load (N)**
***K* : Load factor (See table below)**
***M* : Specimen mass (kg)**
***n* : Maximum number of stacked boxes on transport (box nbr)**

Load Factor

Classification depending on the load	Classification by packaging characteristics		
	When the external packaging has no possibility to absorb moisture, or it is not considered	When the external packaging has possibility to absorb moisture	When the external packaging has high possibility to absorb moisture or the product is liquid
When the load is supported by external portion of the package (such as cardboard boxes)	4	5	7
When the load is supported by the content, the isolation materials, the container and external packaging as a whole	2	3	4
When the load is supported by the content and external packaging, but it is not necessary to consider the load on the last one	1	1	1

Note: Adjustments of Load Factor of ±1 is allowed, depending on the distribution conditions (time, humidity, vibrations)

JIS Z 0203 (2000) ISO 2233 (1994)

Packaged Freights - Test Conditioning

Temp. & Humidity condition	Temperature		Humidity
	℃	K	%
A	-55	218	-
B	-35	238	-
C	-18	255	-
D	5	278	85
E	20	293	65
F	20	293	90
G	23	296	50
H	27	300	65
I	30	303	90
J	40	313	-
K	40	313	90
L	40	328	30

Notes about【Method A】and【Method B】

Method "A": In measuring compression, the initial reading (datum point) shall be taken at an initial load according to following table

Datum Points

Unit: N (kg)

Applied load range	Datum point
More than 100 (10) Up to 200 (20)	10 (1.0)
More than 200 (20) Up to 1 000 (102)	25 (2.6)
More than 1 000 (102) Up to 2 000 (204)	100 (10.2)
More than 2 000 (204) Up to 10 000 (1020)	250 (25.5)
More than 10 000 (1020) Up to 20 000 (2041)	1000 (102)
More than 20 000 (2041) Up to 100 000 (10204)	2500 (255)

Method "B": In measuring compression, the initial reading (datum point) for cardboard boxes at initial load shall be according to following table.

Unit: N (kg)

Corrugated cardboard boxes single liner	196N (20kgf)
Corrugated CB boxes multiple flutes	392N (40kgf)
Other cases	Agreed between parties

(2) Reference Values for Packaging Evaluation of Dairy Products (Draft)

Introduction

The Japan's regulations referred to health safety of "Dairy products containers" are based on two aspects, according to the "Normative Reference for Containers" of the Edible Products Hygiene Law.

1 General and particular rules of Regulation No.370 of Ministry of Health and Welfare.

2 Particular Normative: a. Containers for Dairy products, and b. Containers for general food products, according to Ordinance No. 52 of Ministry of Health and Welfare.

Particularly, the resistance tests are regulated as per item 2) indicated above, according to the ordinance about dairy products for following products: milk, processed milk, special milk, pasteurized lamb milk, low fat milk, controlled powder milk (for infants), cream, fermented mil, yoghurt, and beverage milk.

(a) Seal resistance test

(b) Pin hole tests

(c) Bursting resistance test

(d) Puncture test

It is aiming to keep the physical resistance of containers to vibrations- impacts, impacts due to drop, compression shocks during the transportation from factory up to end of user, ensuring the quality of the product.

Proposal

The packaging for dairy products for transportation does not use cushioning materials, since they are placed on boxes or baskets. Particularly, for the vibration tests it is necessary a quality control, such as verification of leaks, to confirm the damage level of containers.

As examples, 1) A route with several portions with bad roads C type, such as grade 4 or 5 in the distribution process, or 2) when according to the transportation conditions the selected load severity is high as per JIS Z0202, (specially if the product is liquid, or containers with aluminum foil cap for yoghurts or beverage milk, fermented milk as liquid yoghurt) to get a proper container design for “adequate seal resistance” and “easy opening” of “universal design” aiming to ensure quality up to the consumer, it is fundamental the “resistance test” established by the ordinance of dairy products of Japan.

Concretely, for the MERCOSUR market, the aluminum seal cap is strongly adhered to the container, so that leaks are avoided during transportation, but frequent faults are observed when opening.

Also, regarding to the vibration tests and drop tests according to JIS-Z standards, it is specified the “recording data” (deformations, damages, cracks, leaks etc and descriptions) so that, after those tests, it will incorporated another test of “pin hole test” for the complete test of containers.

On the other hand, regarding to the MERCOSUR region, we would like to propose a study for analyze the introduction of reference values, such as the case a of “seal resistance test” or “bursting test” for cardboard containers, for packaging evaluation for transportation, equivalent to the ordinance for dairy products of Japan.

Standard for dairy products (as per Ordinance of SWM)

Applicable products	Test item
Milk, processed milk, special milk, pasteurized lamb milk, low fat milk, cream.	Seal Resistance Pin hole test Bursting test
Fermented milk, yoghurt, beverage milk.	Seal Resistance Pin hole test Bursting test or resistance to puncture *1

Reference value of standard

Test item		Conditions	Reference Value	Remark
Resist. test	Seal resistance	13.3kPa Maintain 10sec.	No leaks	
	Pin hole test	Put in methylene blue 30 min.	No marks in wax paper	
	Bursting resistance *1	Cold product ≦ 300ml	≧196kPa	(Stored in ambient temp *2 392kPa)
		Cold product > 300ml	≧490kPa	(Stored in ambient temp*2 784kPa)
	Puncture Res.*1		≧ 9.8N	

(Note) *1 For fermented products, select one of the tests (Bursting test or Puncture Resistance)

*2 Applicable to containers with aseptic products.

Note: The above indicated standards are applied for containers made of combination of cardboard, plastics ,Al/PE, PE, PS, PET or aluminum foil cap for sealing.

Introduction of the Reference Values for Resistance Tests for Evaluation of packaging for transportation of dairy products in MERCOSUR (Draft)

(1) The evaluation method for leaks by using methylene blue during 30 min (pin holes) can produce stains in hands, floor, due to their marking power. For this reason, it is proposed to introduce the submersion test by using the “acryl vacuum tester”. By using this device, the pin holes can be checked quickly and effectively, and this test will replace the “pin hole test”. This test will be performed after vibration test and impact tests.

(2) The seal resistance test is considered as item 1 of evaluation of ”dairy product container”.

(3) It will be analyzed the incorporation of “bursting test” for cardboard made containers for milk and their sub-products.

Test item		Conditions	Reference V	Remark
Resist. test	Seal resistance	13.3kPa (0.1357 kgf/(m^2) (100mmHg) Maintain 10sec.	No leaks	
	Pin hole test	Put in methylene blue 30 min.	No marks in wax paper	
	Bursting resistance *1	Cold product ≦ 300ml	≧196kPa (2kgf/cm2)	(Stored in ambient temp *2 392kPa) (4kgf/cm2)
		Cold product > 300ml	≧490kPa (5kgf/cm2)	(Stored in ambient temp*2 784kPa) (8kgf/cm2)
	Puncture Res.*1		≧9.8N (1kgf/cm^2)	

(Note) *1 For fermented products, select one of the tests (Bursting test or Puncture Resistance)
*2 Applicable to containers with aseptic products.

(3) Japan Regulation No.52 (Dairy Products) of Ministry of Health, Work and Social Welfare – Motions for their modification

The regulation have been officialy promulgated on 1951, and it was modified few times after their issuance. However, in practice, it was observed that this regulation has not the same guidelines compared with other international regulations in this matter.

The Dairy Product Regulation of Japan, has been conceived on a basis considering the milk product and other by-products as “food product for infant and convalescent persons”.

Through the years, the food products have been diversified and in paralell with the development of containers and industrial equipment for packaging, the necessity to establish common standards related to packaging and equipment are aroused. These standards must cover all type of food products, not only dairy but also others products, aiming to provide to public a good level of safety for all products.

According to the regulations actually in force, they are not suitable to cover the needs for all types and shape of packaging of products and also for the transportation mode actually applied. However, these standards are specifiying same aspects of resitance tests.

Therefore, it is expected that these standards would be modified partially, including the chapter of resistance tests for packaging.

6.3.2 MERCOSUR Standardization Association AMN – Structure and Functions

6.3.2.1 Situation of the AMN Function

(1) AMN

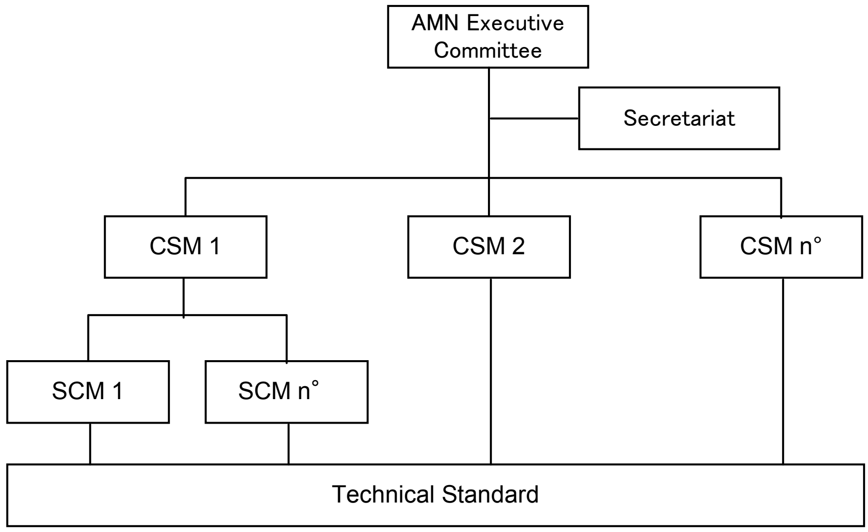
The MERCOSUR Standardization Association was established on June 01 1996, by the MERCOSUR Council SGT 3, under the document number No. No. 268974/96（CNPJ 01295577/0001-30 and CCM 2483930-2). On the other hand, on April 04, 2000, the same

Mercosur Council, through the SGT assigned this association the mission of regulating all MERCOSUR standards, under the name of AMN.

(2) The member institutes of the AMN in each country

Argentina : IRAM (Instituto Argentino de Normalización y Certificación)
Brasil : ABNT (Asociação Brasileira de Normas Técnicas)
Paraguay : INTN (Instituto Nacional de Tecnología y Normalización)
Uruguay : UNIT (Instituto Uruguayo de Normas Técnicas)

The structure of the organization and relationship with each institute is as follows:



Notes
CSM: Mercosur Sectors Committes. Representing the National Standard organizations
SCM: Mercosur Sectors Sub-Committes
Source: AMN, JICA Study Team

(3) Sectors covered by the Mercosur Sectors Committees (CSM)

CSM 01 - MERCOSUR Sectors Committee for Electricity
CSM 02 - MERCOSUR Sectors Committee for Steel Industry
CSM 03 - MERCOSUR Sectors Committee for Electronic and Communications
CSM 04 - MERCOSUR Sectors Committee for Toy Industries
CSM 05 - MERCOSUR Sectors Committee for Cement and Concrete
CSM 06 - MERCOSUR Sectors Committee for Machinery and Mechanical Equipment
CSM 07 - MERCOSUR Sectors Committee for Automotive
CSM 09 - MERCOSUR Sectors Committee for Plastics for Construction
CSM 12 - MERCOSUR Sectors Committee for Cellulose and Paper
CSM 13 - MERCOSUR Sectors Committee for Quality
CSM 16 - MERCOSUR Sectors Committee for Environment Management
CSM 17 - MERCOSUR Sectors Committee for Accessibility

CSM 18 - MERCOSUR Sectors Committee for Graphics Technology
CSM 20 - MERCOSUR Sectors Committee for Clinical Analysis and In Vitro Analysis
CSM 21 - MERCOSUR Sectors Committee for Plate glass
CSM 22 - MERCOSUR Sectors Committee for Conformity Evaluation
CSM 23 - MERCOSUR Sectors Committee for Tourism
CSM 24 - MERCOSUR Sectors Committee for Nondestructive Tests

(4) The role of the CSM (MERCOSUR Sectors Committees)

The AMN is in charge to issue the standards through the CSM which are representing each manufacturing/technology sector. The CSM has the authority to lead the studies and process for proposing a standard according to a work plan of sector developments. The standards prepared by the CSM are defining the priorities of standards against the National Organizations of Standards (ONM), and are approved by the representatives of each country. The AMN is responsible for the execution of the activities of the CSM, and in case that they can not accomplish their duties; they are subject to sanctions which can be severe up to the suspension of the activities or the closing of the committee. On the other hand, the CSM are allowed to establish the Sub-Committees (Subcomites Sectoriales Mercosur - SCM) in order to support their activities.

(5) Objectives of the Standards

1) Standardization: To streamline the procedures of promotion of services and manufacturing.
2) Economic efficiency: It supports the increasing of variety of manufactured goods, decrease the process of applications. At the same time, it also gives better cost conditions and provides a better market conditions for products and for consumers.
3) Communication: It increases the reliability of services and manufacturing fields, and giving more efficient information for manufacturers and end users.
4) Safety and Health: Provides for the healthy life to the people.
5) Consumer Protection: It gives the society how to validate the quality of goods and services effectively.
6) Avoidance of technical and commercial barriers: As for products and services from 3rd countries, the standards are mean to be a tool for avoiding the disputes originated from the application of foreign standards, and it activates the foreign trade.

(6) Information of Institutionalization

Based on the MERCOSUR meeting held by sub-group SGT-3 on Montevideo on Oct 30 and Nov 01, 1991, organized by the Standardization Committee of MERCOSUR, the

Committee of Standardization CMN was officially established. This committee is a non-government, non profitable organization, structured as civil association. For the CMN, after the conclusion of the agreement of April 04, 2000, the CMN was renamed the AMN. This organization is the special committee of MERCOSUR, assigned for the administration of the standards, having autonomy. Furthermore, objectives of the association are to promote and develop of the standards, based on activities as described below.

- Economy and Trade Integration: The AMN has the benefit, in exchange for the technical cooperation concerning the services of transportation and goods, under the point of view of science, technology, economic and social.
- The betterment of quality for goods and services in MERCOSUR countries should be put high priority, having as a main axis the development of production and technologies.
- The AMN, having the guideline issued by CSM who are "representatives" from industry side, is promoting the activities of planning, is managing the evaluation process and defining the standard programs divided by sectors, and the control of the issuing of standards to be approved by AMN. Up to today, evaluations of 439 standards have been carried out, and more than 600 items are being considered for approval.

(7) Contact with SGT of MERCOSUR (Sub-Group of Tasks)

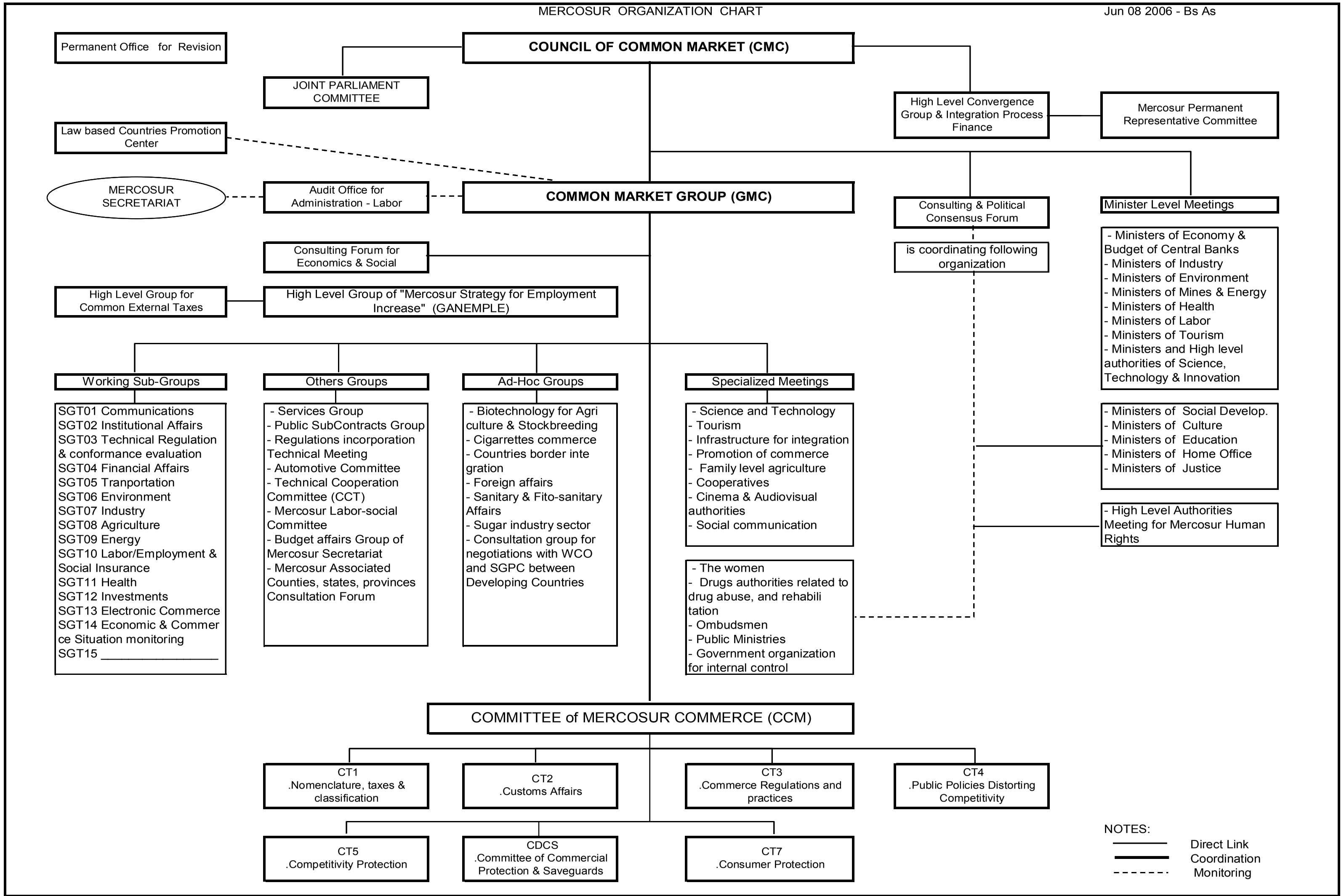
The AMN is an civil institution, and it has not any direct relationship with MERCOSUR organization, as indicated above.

Regarding to the MERCOSUR Common Standards, the AMN is not receiving any indication or influence from MERCOSUR organization, as indicated in Chapter 8. However, it is possible to establish technical level relations with MERCOSUR CCT (Technical Cooperation Committee) such as SGT3 (Technical Regulations and Conformance Evaluation Task Group), or the SGT5 (Transportation Task Group). They are all integrated in the area of GMC (Common Market Group) who are developing technical discussions, as necessary.

The activities of these Task Groups are centered in periodical meetings with the attendance of the MERCOSUR 4 Member Countries, 4 times in a year, and rotating the country each time.

This organization is working for standards, separately from the AMN, and their discussions are centered –let say- in the applicability of penalties in case of infrigement of the rules.

Also, every 6 months the Minister level official meeting is held. As reference, the MERCOSUR organization chart is included in the next page, on the most recent version.



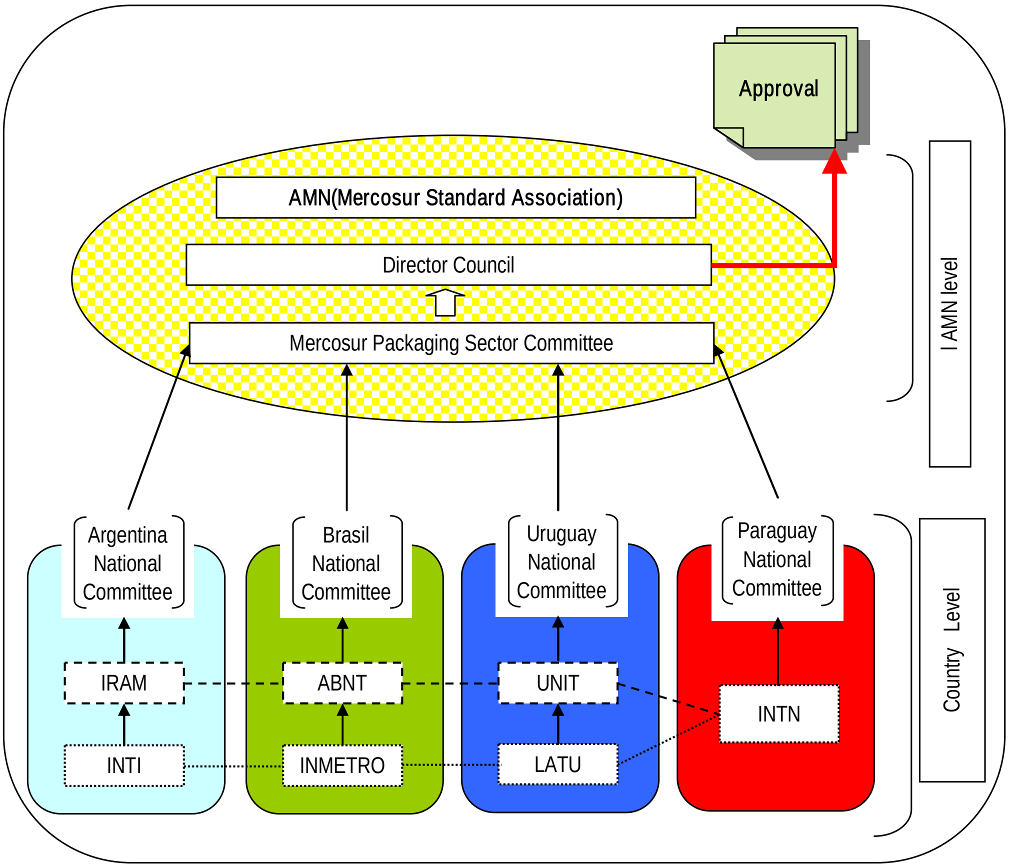
Source: MERCOSUR

Fig. 6.3.2-1 MERCOSUR Organization Chart

6.3.2.2 Procedure for the Approval of a Common MERCOSUR Standard

One of the aims of the Study is the preparation of a MERCOSUR Packaging Design Standard (preliminary version) and to make a proposal. One of the objective aimed jointly by the counterpart institutes of the 4 Countries is to submitting officialy this document as a proposal to the Mercosur Normalization Association (AMN) in order to get the authorization to make official this document.

The following flow diagram (Fig. 6.3.2-2) shows steps to follow in order to submit the standard (Gudeline) for approval.



Source: JICA Study Team

Fig. 6.3.2-2 Diagram of the Approval Process of Standards, from Each Country up to AMN

According to the AMN, normally for a presentation of a new standard, the application must be submitted by one of the AMN member institutions to the related CSM (Mercosur -Sector Committee), in this case to the Packaging Sector Committee. Once submitted the proposal, it is analysed by all the National Committees.

In each of the countries, the coordinator is the institute having the role of secretariat. These are respectively: IRAM in Argentina, AMNT in Brazil, UNIT in Uruguay, and INTN in Paraguay.

After that, in a period defined from the date of submittal according to AMN regulations, AMN issues a statement in writing (there is a standard form) for further higher level applications, or, for comments.

Once the AMN issued their statement, the CSM –in this case the Packaging Sector Committee, expected to be established promptly- will take into consideration the new MERCOSUR Standard and will make the consultations with the private sector. For this purpose, they will organize consultation meetings for study and analysis, the factibility of application, giving priority the application at national levels considering the other existing standards.

Once approved by the Sectoral Committee, the regulation is finally voted in the AMN Directive Council, formed by 4 representatives, one from each of the Countries.

One year-time is usually elapsed from the submittal of a Standard to its final approval.

Furthermore, the standards approved by AMN up today, the major portion is related to proposals from Brazil and Argentina, and only few from Paraguay and Uruguay. Regarding to this matter, the percentages of quantity of standards issued per country are: Brazil 60%, Argentina 30%, Paraguay 5% and Uruguay 5%.

The number of approved and under study standards per each institution, starting from the date of establishment of AMN on 1996, is indicated in the following Table.

According to AMN, the intensity of activities on this matter varies, depending on the related CSM sectorial committee. In the practice, if it is observed the number of standards approve by each commitee, the leader is CSM-02 (Steel Industry) with 198 cases, followed by CSM-05 (Cement and Concrete) with 72, and then followed by CSM06 (Machinery and Mechanical Equipment) with 70 cases, which is indicating the prevalence of the industrial manufacturing sector.

In the contrary, they are cases such as CSM23 (Tourism) recently established, which has no records of issuance of any document at the moment.

Table 6.3.2-1 Issued Standards to AMN（July 2006）

Mercosur-Sectors Committee (CSM)		Institution	Nbr Std (existing)	Waiting for final Approval	In progress	Proposed
General			1	0	0	0
CSM 01	CSM Electricity	ABNT	51	0	7	162
CSM 02	CSM Steel Industry	IRAM	198	4	104	185
CSM 03	CSM Electronic and Comm.	ABNT	0	0	0	51
CSM 04	CSM Toys industries	IRAM	7	0	0	0
CSM 05	CSM Cement and concrete	ABNT	72	0	2	22
CSM 06	CSM Machinery and M.Equip	ABNT	70	1	3	44
CSM 07	CSM Automotive	IRAM	42	2	4	65
CSM 09	CSM Plastics p/Civil Constr.	ABNT	4	0	1	12
CSM 12	CSM Paper and Celulose	ABNT	29	0	1	1
CSM 13	CSM Quality	IRAM	12	0	0	8
CSM 16	CSM Environment Managment	ABNT	5	0	0	2
CSM 17	CSM Accesibility	IRAM	0	0	0	34
CSM 18	CSM Graphics Technology	ABNT	5	0	0	3
CSM 20	CSM Clinical Analisis & I.Van	ABNT	7	0	0	7
CSM 21	CSM Plane Glass	ABNT	5	0	0	2
CSM 22	CSM Conformity Evaluation	IRAM	3	3	4	8
CSM 23	CSM Tourism	ABNT	0	0	0	0
CSM 24	CSM Non destructive Tests	IRAM	3	0	0	7
Totals			514	10	126	613

Source: Asociacion Mercosur de Normalizacion AMN

In addition, it is recommended that “MERCIS E 000: Packaging Terms” and “MERCIS E 200: Rule of Test Method” shown in “6.3.3 MERCOSUR Standard (Draft)” shall be created and submitted in Spanish and Portuguese between counterparts when they apply to AMN in the near future.

6.3.3 MERCOSUR Standard (Draft)

6.3.3.1 Method of Designating Component Codes of Packaging

1. Scope

This Standard specifies the method of designation of codes on packaged freights and containers utilized in the tests.

2. Normative References

The meaning of the main terms used in this Standard are defined in MERCIS E 000.

3. Methodology of Code Assignment

3.1 Rectangular Parallelepiped containers

The rectangular parallelepiped shaped containers are placed in the normal position of transportation condition. However, in the case that the transportation conditions are not clearly defined, and if union lines (of extension bracket) are present, the extensions must be located at the right side. The codes will be positioned as indicated below, with the test executor facing the holding face (See Fig. 1).

(Faces) The faces are identified by numbers: upper side 1, right side 2, bottom 3, left side 4, front face 5, and back face 6. Also, in case that the packaging or product has a front side and back side, the first will be identified as 5 and the second as 6.

(Edges) The edges are identified by the numbers of the component faces, separated by a hyphen. In this case, the numbers are ordered from lower to higher. Example: edge 2-3

(Corners) The corners are identified by the numbers of the component faces, separated by a hyphen. In this case, the numbers are ordered from lower to higher. Example: corner 2-3-5

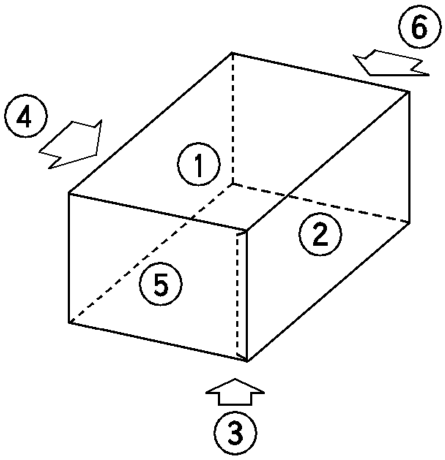


Fig.1 Code designation for rectangular parallelepiped shaped containers

3.2 Circular Cylindrical Containers

The circular cylindrical containers have codes according to the following method (see Fig.2).

(1) The cylindrical face (encircling portion) and the perimeter of the circular top face are divided by two right angled lines, designating those points by numbers, as 1,3,5 and 7. Moreover, the points of the lower circle will be designated as 2, 4, 6 and 8. In this case, if some union line is present, this will be designated as 5-6. Also, in case that the union lines are multiple, they must be arranged so that one of the options has the code 5-6.

(2) Generatrix. The generatrix parallel to the cylinder axis are designated by numbers as 1-2, 3-4, 5-6, and 7-8. In case that a union line exists, this will be designated as 5-6.

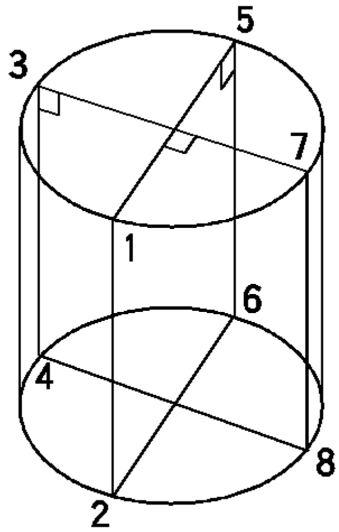


Fig 2- Code designation for cylindrical containers

3.3 Other Shaped Containers

For the other shapes of containers, codes will be designated according to clause 3.2 or 3.3.

6.3.3.2 Packaged Freights－Conditioning for Testing

Introduction

This Standard has been prepared based to a translation, without any modification of ISO 2233 Standard (Packaging-Complete, filled transport packages and unit loads - Conditioning for testing), issued on 1994 as 3rd revision, maintaining the technical concepts and the standard format.

1. Scope

This Standard specifies the methodology of conditioning for drop tests, compression tests and vibration tests of packaged freights.

This conditioning procedure can be applied on the elements to be tested, whether on the products to be a part of packaged freight or the materials of the packaging.

2. Principles

The packaged freights will be under the designated temperature and humidity conditions during a certain period of time.

3. Temperature and Humidity Conditions

From the Table 1 indicated below, one or more than 2 suitable conditions must be selected.

Table 1

Temp and humidity conditions	Temperature		Relative humidity %
	deg C	deg K	
A	－55	218	－
B	－35	238	－
C	－18	255	－
D	+5	278	85
E	+20	293	65
F	+20	293	90
G	+23	296	50
H	+27	300	65
J	+30	303	90
K	+40	313	－
L	+40	313	90
M	+55	328	30

4. Allowable Values

4.1 Temperature

4.1.1 Deviation between the peak values

Regarding the temperature-humidity conditions of A, B, C and K, the maximum allowable range for 10 sequential values of temperature distributed around the specified point is ±3 deg C for a period of at least 1 hour.

For the others temperature-humidity conditions, the maximum allowable range is ± 2 deg C.

4.1.2 Deviation of average values

The average value must be within a range of ± 2 deg C against the selected values of Table 1, for all the temperature-humidity conditions.

Notes:

1. In the case of applying the condition D, care must be taken to avoid reaching the dew point.
2. The allowable maximum temperature range does not always correspond to the temperatures which allow keeping the required level of relative humidity. Therefore, in order to apply the required temperatures corresponding to the allowable humidity levels, it is necessary to reduce additionally the temperature range.

4.2 Ambient relative humidity

4.2.1 Regarding the temperature-humidity conditions, which later define the humidity levels, the maximum allowable variation range for 10 sequential values of temperature, distributed around the specified relative humidity, is ±5 % for a period of at least 1 hour minimum.

4.2.2 Average values variation

Regarding the all temperature and humidity conditions, the average value must be within ± 2 % against the selected values of Table 1.

Notes:

3. The average values of relative humidity will be taken from at least 10 sequential read values per hour, or they can also be taken from continuous type recorders.
4. Regarding the peak values of humidity of conditioning chamber, the maximum variation is defined as ±5%, but in the case of modern developed conditioning chambers, this value can be maintained within ±2%.

For almost all packaged freights, the reaction against variations of outdoor ambient humidity is relatively slow compared with the variations of relative humidity of the conditioning chamber. Also, even in the case that high variation of humidity occurs, due to opening of conditioning chamber door, if the average humidity on this stage or during the tests is kept below ±5%, it can be considered that the moisture content in the packaging material is not affected.

5. Equipment

5.1 Preconditioning chamber

On the working space of the preconditioning chamber, the temperature and humidity are recorded continuously, and it is required to maintain the control conditions indicated in the clause 4. The working space is the area where the control conditions are maintained, and they are determined by each preconditioning chamber.

5.2 Drying chamber

The drying chamber must be capable to reduce the moisture content in the materials utilized for packaging, below a required value, depending on the conditioning treatments.

5.3 Measuring and recording devices

The measuring and recording devices must have enough sensitivity and stability; accuracy of 0.1 deg C for temperature and 1% for relative humidity. For the purpose of this standard, if the period between readings is equal or less than 5 minutes in each measurement value, the recording device is considered as continuous type.

The recorder device must accomplish, in order to take correct records, the accuracy mentioned above, and additionally it must have a response time of 4 deg C per minute for temperature, and 5% per minute for relative humidity.

6. Procedure

The appropriate temperature, relative humidity for transportation and storage of sample packaged freight are selected.

The packaged freight is placed on the working space of the preconditioning chamber and minimum time periods are selected among 4, 8, 16, 24, 48, 72 hours, 1, 2, 3, or 4 weeks, in which the specified conditions will be maintained.

The packaged freight must be placed so that more than 75% of the surface of upper side face, side faces and bottom face has direct contact with the environment of the preconditioning chamber.

Once the packaged freight is placed in the chamber, the ambient is returned to the specified conditions. After 1 hour, it is considered that the time counting for conditioning is started.

In case that the materials used are paper or cardboard having curves of moisture content with hysteresis, it is occasionally required a freight drying period before the conditioning process.

This previous treatment requires placing the freight in the drying chamber for more than 24 hours, and the transition to the conditioning ambient conditions must be done gradually, meanwhile the packaged freight should adsorb the moisture to counterbalance.

The previous drying process is not necessary in case that the specified relative humidity is below 40%.

7. Test Method

For the preparation of packaged freights test reports, previously preconditioned according to the statement of this standard, the following items are defined for drop tests, compression tests and vibration tests.

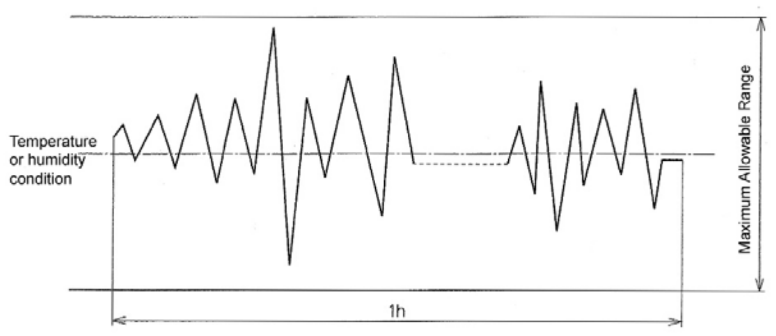
a) MERCIS standard number.

b) Temperature and humidity conditions (see Table 1) and applied conditioning time.

c) Temperature and humidity values of testing ambient, at the time of testing.

ANNEX-A (Specification) Measurement of temperature and relative humidity

When the temperature and relative humidity are measured by using continuous type recorders, they are shown as cyclic variations. Therefore, it is necessary to verify the correct values shown by these characteristic curves. The Annex A Figure 1 shows an example of typical curve.



ANNEX-1 Fig-1 Temperature or relative humidity variations per hour

All the peak values must be within specified maximum allowable range of variation. Also, the average of measured values must be within the specified range for averages.

6.3.3.3 Packaged Freights and Containers - Method of Compression Test

1. Scope

This Standard specifies a method for testing the resistance to compression of packages and containers made by metals, wood, corrugated cardboard, laminated paper, plastics and the combination of these materials, by using compression testers.

Notes: 1. This method may be appropriate for testing the resistance to compression of freights, when the package and contents are stacked and subjected to compressive forces during the transportation and distribution process, and also for testing the resistance to cargo handling by using side clamp hooks. However, the method stated in the Annex is appropriate for evaluating actual transportation conditions.

2. The numbers and units stated in this Standard, and indicated between keys { } are usual values and units, and they are mentioned as an example.

2. Normative References

The following Standards, through reference in this text, constitute provisions of this Standard. These reference Standards are valid of applying the most recent editions.

MERCIS E 001 Method of Designating on Component Codes of Packaging

MERCIS E 002 Packaged Freights – Conditioning of Testing

3. Apparatus

3.1 Compressor Tester

The equipment must accomplish the following conditions:

a) The compression platen must be dimensioned so as it can support with enough margins the test specimen.

b) The compression speed is fixed at a rate of 10±3mm per minute. In case that the resistance to deformation of the specimen is particularly high, the compression speed must be slightly reduced.

c) It is recommended to adjust and calibrate the compression tester, by appropriate methods, at least once a year.

3.2 Recording device

The recording device must be suitable for indicating the full range of the deformations of the specimen and compression platen, and the accuracy must be ±2% for applied maximum load, and ±1mm for the maximum deformation of the compression platen.

3.3 Means of measuring package dimensions

The measuring devices to determine the dimensions of the packages must have an accuracy of ±1mm.

4. Test Specimen

The products or materials subject to test must be as follows:

a) The designation on components of the specimen must be according to MERCIS E 001. The packages other than cylindrical or rectangular parallelepiped shape samples shall be designated by suitable method, according to the reference Standards.

b) The recommended quantity of specimens to be tested is more than 3 (three) for Testing Methods A and B, and more than 5 (five) for Method C.

c) In the Testing Method C, the specimen shall be the empty box, and on method A and B the specimen shall be the boxes containing the actual products or others of similar characteristics of those to be contained. The packaging of the specimen shall be carried out in the same condition as in shipping, and treated, as required, with air tight sealing, seal, typing bundling.

d) The specimen made by corrugated cardboards or fiberboards, having flaps, shall be assembled and sealed with the same materials as in actual shipping. The bending of flaps to outer side must be up to 90 degree angle.

e) Prior to the tests, the external dimensions and total mass of the specimen shall be measured.

5. Preparation Measures

Before the execution of the test, preliminary measures shall be taken according to MERCIS E 002. On this, the atmospheric temperature and humidity conditions are specified, depending on the purpose of the tests. If necessary, other tests shall be done, such as submersion tests, sprinkle test, etc.

6. Test Methods

6.1 Method A

Basically, it consists of a compression test of packaged specimen to study the damages that can be produced due to compression loads.

6.2 Method B

Basically, it consists of a compression test on side faces of packaged freights by using side clamp hooks, to study the damages that can be produced due to side compression loads.

6.3 Method C

This is a compression test carry out on a package or on an empty container, to study their resistance to compression.

6.4 Procedure

6.4.1 Vertical compression tests (Methods A and C)

The following procedure shall be applied on test methods of 6.1 and 6.3.

a) The compression load shall be applied to opposite faces.
b) The specimen shall be placed centrally on the lower platen of the test machine, in order to avoid unbalanced loads on the package to be tested.
c) In measuring compression, the initial reading (datum point) shall be taken at an initial load according to Table 1.

Table 1 – Initial Load Units

N {kgf}

Applied load range (N)	Datum point (N)
More than 100{10} Up to 200{ 20}	10{ 1.0}
More than 200{ 20} Up to 1 000{ 102}	25{ 2.6}
More than 1 000{ 102} Up to 2 000{ 204}	100{ 10.2}
More than 2 000{ 204} Up to 10 000{ 1020}	250{ 25.5}
More than 10 000{1 020} Up to 20 000{ 2041}	1 000{102 }
More than 20 000{2 041} Up to 100 000{10204}	2 500{255 }

d) In the Method C, in measuring the compression on corrugated cardboard made boxes, the datum point for double facer cardboard shall be 196N{20kgf}, and 392N {40kgf} for multiple liners. The datum point for other type of specimen or products, it will be established based on mutual agreements between parties.
e) By applying a defined compression speed, a compression load shall be added continuously up to reaching the conditions described below. The load and compression load shall be recorded by an automatic instrument or similar, and simultaneously, the damaged conditions of the specimen shall be observed and recorded.
   1) When the maximum load is applied.
   2) When the predetermined deformation is observed.

3) When the package or container structure starts to collapse and the content becomes visible.
4) When the predetermined collapse conditions are verified.
5) When the predetermined load is reached.

f) The predetermined load in Method A shall be calculated by the following formula:

$F = 9.8 \times K \times M \times (N - 1)$

Where:

F: Load (N)

K: Load coefficient (see Table 2)

n: Number of piled boxes

M: Gross mass of specimen (kg)

Table 2 - Load coefficient

Classification depending on the load	Classification by packaging characteristics, such as moisture absorption		
	When the external packaging has no possibility to absorb moisture, or it is not necessary to be considered	When the external packaging has possibility to absorb moisture	When the external packaging has high possibility to absorb moisture or the product is liquid
When the load is supported by external portion of the package (such as cardboard boxes)	4	5	7
When the load is supported by the content, the isolation materials, the container and external packaging as a whole	2	3	4
When the load is supported by the content and external packaging, but it is not necessary to consider the load on the last one	1	1	1

6.4.2 Horizontal compression test (Method B)

The test described in clause 6.2 shall be carried out by following method.

a) For containers of products provided with symbol markings for warning on handling, such as hook positions, hook use prohibitions, the compression-direction shall be applied on the indicated direction by placing the compressor platen on the upper side and lower side of the specimen. If the specimen does not shows handling markings, the compression-direction shall be applied vertically and on side direction.
b) The compression load shall be applied to opposite faces.
c) The specimen shall be placed centrally on the lower platen of the test machine, in order to avoid unbalanced loads on the package to be tested.

d) By applying a defined compression speed, a compression load shall be added continuously up to reaching the conditions described below. The load and compression load shall be recorded by an automatic instrument or similar, and simultaneously, the damages conditions of the specimen shall be observed and recorded.
   1) When the maximum load is applied.
   2) When the predetermined deformation is observed.
   3) When the package or container structure starts to collapse and the content becomes visible.
   4) When the predetermined collapse conditions are verified.
   5) When the predetermined load is reached.

7. Test Report

The test report shall include the following information.

a) Detail of the content, in case of packaged products (product name, type, and mass. In case of variety of products, their details, etc.)
b) Gross mass, dimensions, materials, structure of specimen, packaging method
c) Quantity (in units) of specimen
d) Model and capacity of used testing machine
e) Test method applied (method, load direction, shape of auxiliary plate inserted between compression platen and the specimen, specimen external view description at the test stage, differences respect the items specified on this Standard, necessity to adjust the internal flap, etc.)
f) Additional conditions incorporated to the specimen or product before the test
g) Records of the results of the test (Maximum load N{kgf}, datum point, elapsed time and their relation with compression variation, deformations (mm), occurrence of damages and their details)
h) Test date and ambient temperature and relative humidity conditions of that date
i) General comments about the results of the test
j) Name and signature of test executor
k) Other topics which are considered to be recorded

Example: In the case of containers made of wood or paper, it is necessary to record the moisture content of the product.

ANNNEX (Normative)

Piling Tests

1. Continuous range: This Annex specifies the compression test method for piled packed cargoes under static loads, during a defined period of time.

2. Test Apparatus

The equipment to be used for the tests must follow the following rules.

a) The compression test apparatus must be in accordance to the specification of the main part of this standard. Furthermore, they must be furnished with accesories suitable for covering the following conditions.
b) The apparatus must be capable to apply a defined load during defined period of time.
c) The variations of the load to be applied must be ± 4%.
d) The compression plates must be designed in such way that their relative displacement does not goes beyond the necessary value, in order to keep the predetermined compression load.
e) The recorder instruments must follow the specifications of the main part of this standard. Furthermore, they must be capable to recording the loads applied during the predetermined time and the compression plates displacements.

3. Test Method

The test method must be according to the following rules.

a) The test specimen must be placed accurately on the center portion of the compression plate, in order to avoid unbalanced loads.
b) Before starting the measurement of compression, an initial preload will be applied, according to the Table 1 of the main part of this standard. From this point, the predetermined load will be applied. The predetermined load will be applied gradually up to the predetermined time is elapsed, or up to the occurrence of damages on the packed cargo. The applied loads, the displacement of the compression plates and elapsed times will be recorded.
c) For special conditions of loading, additional auxiliary plates can be placed, having special shapes, between the compression plate and packed cargo, to make easier the monitoring of the effects of the compression. (1)

   Note (1) : The special condition of load means, for example the case of using one face pallet as an auxiliary device, and monitoring the effects on the lower face of this pallet.

4. Test Reports

The following items must be contained in the test reports.

a) In the case of packed cargoes, the content must be stated (description, type, mass, type of products, if multiple, their description)

b) Specimen: total mass, dimensions, materials, structure and packing method
c) Humidity content of the specimen (if necessary, i.e. wooden cases, carton pots, etc.)
d) Specimen quantity
e) Test equipment: model, specification
f) Test Method applied (method, compression direction, shape of auxiliary plate between compression plate and the specimen, specimen position at the time of the test, deviations against the specification of this standard, fixing or not of internal flaps, etc.)
g) Preconditioning applied to the specimen, before the tests
h) Records of the test results: Maximum reading of compression loads N (kgf), elapsed time T, displacement after elapsed time in mm, deformations, occurrence of damages
i) Test date, ambient temperature, and relative humidity
j) General comments about the test results
k) Name and signature of the test executor
l) Other topics which are considered to be recorded

ANNEX (Specification) PILING TEST

1. Scope

This Annex specifies the compression test method for packaged freights subject to static loads applied during long time periods.

2. Apparatus

The test equipment must accomplish the following.

a) The compression test equipment must accomplish the specifications of the main part of this Standard, and additionally, it must cover the following conditions.
b) It must have the capability of applying a fixed load during a determined period of time.
c) The variations of the fixed load must be ±4%.
d) In order to keep the fixed load, the compression platen shall not generate unnecessary movements.
e) The recorder must accomplish the specifications of the main part of this Standard, and additionally it must be capable to record the applied loads and platen displacement during the predetermined period of time.

3. Test Method

The test method shall be carried out according to the following items.

a) The specimen shall be placed centrally on the lower platen of the test machine, in order to avoid unbalanced loads on the package to be tested.
b) As indicated in the main part of this Standard, the starting point of the test is taken at the moment of applying the datum point, and then the predetermined loads are applied. The predetermined loads are applied during the fixed time, or up to until collapse occurs, whichever first, and the deformations, the load and elapsed time are recorded.
c) In order to make easy the observation of the effects of the compression due to predetermined load conditions (1), as required, it can be inserted an auxiliary plate with specified shape, between the compression platen and the specimen.

Note: (1)The predetermined load conditions are, for example, the use of one face pallet as auxiliary plate, and to verify the effects of the compression by the deck board.

4. Test Report

The test report shall include the following information.

a) Detail of the content, in case of packaged products (product name, type, and mass. In case of variety of products, their details, etc.).
b) Gross mass, dimensions, materials, structure of specimen, and packaging method

c) Moisture content of the specimen (for containers made of paper of wood, if necessary)
d) Quantity (in units) of specimen
e) Model and capacity of used testing machine
f) Test method applied (method, load direction, shape of auxiliary plate inserted between compression platen and the specimen, specimen external view description at the test stage, differences respect the items specified on this Standard, necessity to adjust the internal flap, etc.)
g) Additional conditions incorporated to the specimen or product before the test
h) Records of the results of the test (Maximum load N{kgf}, datum point, elapsed time and their relation with compression variation, deformations (mm), occurrence of damages and their details)
i) Test date and ambient temperature and relative humidity conditions of that date
j) General comments about the results of the test
k) Name and signature of test executor
l) Other topics which are considered to be recorded.

NARRATIVE "COMPRESSION TEST METHOD FOR PACKAGED FREIGHTS"(Draft)

1. Introduction

This Standard specifies the test method for evaluating the resistance level required for packaged freights transported within MERCOSUR region, related to compression loads due to piling during storage, or horizontal opposite compression loads due to forces applied by side clamp forks.

Furthermore, this Standards has been prepared taking as main reference to the JIS Z 0212 and the JIS Z 0200 [(3)] Standards.

2. About Compression Test Equipment

The structure of the compression test equipment is based on two high resistant plate positioned in parallel, up and down side, which can apply a load on the specimen through a mechanism by approaching each others under determined speed.

Furthermore, the upper side plate has two options of mechanical mounting: a) mounting having a possibility to turn around a center point supported by universal suspension; b) mounted with restrictions on the 4 corners, so that the displacement is always parallel to the lower plate.

In the case of center point suspension option, the test is reduced to the lower resistant corner of the box since the plate can be inclined. In the case of 4 corner displacement option, since the upper plate is displacing maintaining the parallelism against the lower plate, it will imply the measuring of the resistance of the portion of the box having higher height.

Due to this reason, the results can show slight differences depending on the application of one or other device utilized in the test.

This Standard allows the use of both types of devices. The only condition is that it must be clearly indicated the type of device used during the test, by the statements in the test report.

3. About measuring devices

The measuring-recording device must be capable to indicate all the range of displacement of the compression platen and the applied load. Also, the accuracy must be ±2% of maximum load and ±1mm of maximum displacement of the compression platen.

These grades of accuracy are within the ranges of normal measuring devices, under the condition that these devices are used correctly.

In the case of test apparatus having center suspension compression platen, it is very important to locate the measuring device exactly in the center of the platen. If the measuring point for displacements is positioned out of the center line, correct readings can not be measured.

4. About vertical compression test (Method A)

The vertical compression test (Method A) is carried out to verify the damages on the content of the packaged cargo, due compression loads, and it is made with packaging containing the product. Therefore, in this test, the specimen must include the bundle elements and the envelope, reproducing the packaging conditions applied in transportation. In case that the cargo is normally on pallets, it is recommended to place pallets above and under the specimen, considering the reproducibility of the test.

The crosshead speed is specified as 10±3mm per minute. If the resistance of the specimen is particularly high, the test must be carried out by reducing slightly the compression speed, taking due care so that the total time up to completion of the test are not too short.

5. About horizontal compression test (Method B)

Within the characteristics of the cargo handling process in MERCOSUR region, it can be mentioned that the side clamp forks is widely utilized. The cargo handling by using this kind of devices implies a high compression load on the side faces. Particularly for medium size cargoes, the boxes are moved in one operation by handling multiple boxes vertically piled, and multiples horizontally. At this stage, the box located in the lower center portion is subject to a particularly high compression, for avoiding their fall, so that sometimes collapses occur in the product.

The horizontal compression test is applied to verify the resistance of the packaged cargo against this type of horizontal loads. Consequently, in this test the specimen must contain the product and including all fastening elements and the envelope, reproducing all the conditions in transportation.

The compression test equipment can apply the load only on vertical direction, so that the specimen must be placed sideways.

Also, in the case of medium size packaged cargoes, it is possible to make test under more realistic conditions by placing multiple boxes between plates of similar size as side clamp panels, so that the handling conditions are reproduced as actual handling conditions.

6. Vertical compression test (Method C)

This test is carried out to verify the characteristics of the resistance of the containers against compression loads, so that the tests are done on individual containers. Particularly, this test is often made for the cases in which the secondary packaging is corrugated cardboard box.

In this case, it is recommended to carry out the test taking due care so that the testing equipment is under an environment equal to the conditioning environment conditions.

7. Piling test

This test is carried out to verify the compression resistance level of the packaged cargo when it is stored during a long period of time. For the execution of this test, it is recommended the use of deadweights for applying the loads, instead of the use of the compression test equipment.

For the measuring of the deformations of the specimen due to the compression, it is necessary to take 2 measuring minimum per each corner. If possible, it is desirable that the all the faces of the packaged container is measured.

6.3.3.4 Packaged Freights - Method of Drop Test (Draft)

1. Scope

This Standard specifies a method for drop test of packaged freights made by metals, wood, corrugated cardboard, laminated paper, plastics and the combination of these materials.

2. Normative References

The following Standards, through reference in this text, constitute provisions of this Standard. Regarding the standards having edition date, only the editions indicated are valid, and the further editions and/or revisions are not applicable. Regarding the standards without edition date, they are valid of applying the most recent editions (including the revisions).

Also, in case of reference standards others than MERCOSUR Common Standards, they will be applied under the same criteria as describe above.

The following are the incorporated standards:

(1) MERCIS E 001:”Method of Designating on Component Codes of Packaging”

(2) MERCIS E 002:”Packaged Freights – Preconditioning for Testing”

3. Glossary

The definitions of the terms used in this Standard are as follows:

(1) Drop height

In the case of testing by using the free drop test apparatus, the minimum distance between the lowest point of the specimen and the dropping surface. In the case of single support edge drop test, the minimum distance between the most distant edge from support platform and the dropping surface. In the case of free test using the impact test apparatus, the distance between the lower face of impact platform up to the impact generator device (refer to Annex 1 Fig.1, Fig. 2 and Fig. 3).

(2) Acceleration variations

The sum of absolute values of impact and reaction accelerations. It is equivalent to the area covered by the impact curve.

4. Preconditioning

The specimen shall be conditioned prior to the test, according to the method indicated in MERCIS E 002. The temperature and humidity conditions for the preconditioning will be fixed depending on the purpose of the test. Also, as required, water submersion or water sprinkling can be done. However, special conditions can be established under the agreement by the parties involved.

5. Specimen

The specimen shall cover the following conditions.

(a) The specimen must contain the actual product. However, a model product can be utilized as replacement, under the condition that they have same physical characteristics such as dimensions, mass and the location of the center of gravity. In each case, the air tight sealing, seal, typing bundling and othres must be the same as in actual shipping.

(b) The components designation of the specimen is in accordance with MERCIS E 001.

(c) More than 3 specimens to be tested are desirable.

6. Testing Apparatus

6.1 The free drop test apparatus shall be provided with the following conditions (see Annex Fig. 1).

(1) The specimen must be free to adopt any position, with the purpose of executing the drop and impact on correct way.

(2) The drop height must be adjustable for easy and exact control.

(3) The handling and hoisting of the specimen must be easy to carry out.

(4) It must be provided with hoisting devices so that it can not damage the specimen.

(5) The dropping surface must accomplish the following conditions:

(a) The mass of the material which comprises dropping surface must be 50 times larger than the specimen mass.

(b) For the entire flat surface, the leveling tolerance shall be less than 2 mm.

(c) For the entire flat surface, the deformations shall be less than 0.1mm with a static load of 98N{10kgf}/100mm^2.

(d) The dropping surface shall be large enough so that the dropping of the specimen is completed.

(e) The dropping surface shall be made by structural materials such as concrete, stones or steel plate.

6.2 The single support edge drop test apparatus shall be provided with the following conditions.

(1) The specimen must be free to adopt any position, with the purpose of executing the drop and impact on correct way.

(2) The drop height must be adjustable for easy and exact control.

(3) The handling and hoisting of the specimen must be doable easily.

(4) It must be provided with hoisting device so that it can not damage the specimen.

(5) The dropping surface must accomplish the following conditions:

(a) The mass of the material of dropping surface must be 50 times larger than the specimen mass.

(b) For the entire flat surface, the leveling tolerance shall be less than 2 mm.

(c) For the entire flat surface, the deformations shall be less than 0.1mm with a static load of 98N{10kgf}/100mm^2.

(d) The dropping surface shall be large enough so that the dropping of the specimen is completed.

(e) The dropping surface shall be made by a structural material such as cement, stones or steel plate.

6.3 The impact test apparatus shall be provided with the following conditions (see Annex Fig. 2).

(1) The main structure of the impact testing apparatus shall be in accordance with ISO 8568.

(2) The impact platform, where the specimen is placed, shall be resistant and suitable to maintain the flatness during the test and supported by a mechanical guide so that their displacement is going strictly on the falling down direction.

(3) The pulse generated on the impact platform, as result of the impact, should have an effective time less than 3 ms by a semi-sinusoidal wave.

(4) The setting of the drop height, for changes in the fixed speed variation, shall be precise, easy to adjust; and the repeatability for these changes shall be ±5%.

(5) The impact platform shall be provided with a breaking function to avoid the second impact after the first one, due to the rebounding.

(6) The impact platform shall be provided with a device to keep the specimen in position for testing.

(7) The apparatus shall be provided with measuring and recorder devices suitable for the accelerations, covering the following items.

(a) The frequency range shall be between a low limit of 1 Hz, and high limit higher than 500Hz.

(b) For the frequency full range, the measuring errors must be less than 4%.

(c) Further the acceleration wave generated in the impact platform, it is recommendable to take measuring by more than 4 channels, in order to determine the characteristics of weak points of the product.

(d) The maximum acceleration that can be measured shall be of 5880m/s^2 {600G}.

(e) The speed variation generated on the impact platform shall be measured.

7. Testing Method

7.1 Testing Environment

The environment where the test is carried out, shall be as close as possible to those of the preconditioning.

7.2 Selection of Test methods

Depending on the mass of specimen, a test method shall be selected among the followings.

(1) Drop test by using free drop test apparatus, to be applied on packaged freights less than 100kg in mass.

(2) The single support edge drop test to be applied on packaged freights more than 100kg in mass. However, in case that total mass of the packaged freight is more than 50kg, this test method is applicable.

(3) In case that the packaged freight is less than 100kg, and the impact test apparatus can be applied, it is recommended to carry out the test by using this equipment.

7.3 Test Method

The drop test shall be carried out by the following method described in clause 7.2.

7.3.1 The free drop test (Method A) by using the free drop test apparatus

This test shall be carried out as follows:

(1) Setting of drop position

(a) The setting of the specimen looking the face to drop shall be set up with horizontality within 2°. The horizontality of the face at the instant of the impact is recommended to be within 2° also.

(b) Single support edge drop and corner support drop: The dropping position of the specimen shall be arranged so that the vertical line passing through the center of gravity of the specimen is passing through the edge or corner to have the impact. Also, the horizontality of the dropping edge at the moment of the impact shall be within 2º.

(2) Drop height: It shall be determined depending on the purpose of the test. However, the height allowed range shall be ±2% or ±10mm, whichever higher value.

(3) Dropping portion and the number of times of dropping: They shall be determined depending on the purpose of the test.

(4) The packaged freight shall not be touched until the movements are completely stopped.

7.3.2 Single support edge drop test (Method B)

This test shall be carried out the following:

(1) The setting of the specimen for dropping is executed as shown in Annex Fig 3. The opposite edge to be impacted (edge 3-5 or 3-6) is positioned on a 15cm height stand, and it is dropped from the edge to be impacted (edge 3-6 or 3-5 respectively).

(2) Drop height: It shall be determined depending on the purpose of the test, limiting an allowed range of ±2% or ±10mm, whichever higher value.

(3) Number of times of dropping: It shall be determined depending on the purpose of the test.

7.3.3 Drop test by using the impact test apparatus (Method C)

This test shall be carried out as follows:

(1) Setting of dropping position

(a) The specimen is placed with the face to be impacted contacting the impact platform.

(b) The position of the specimen for dropping shall be fixed by using an accessory, so that the vertical line passing through the center of gravity of the specimen is passing through the edge or corner to have the impact.

(2) Fixing of the specimen: For the purpose to avoid a secondary impact on the specimen, due to a rebounding of the impact platform, the specimen must be slightly fixed by using a support plate or net.

(3) Effective time of the impact pulse: The desirable effective time of the pulse is shorter than 3 ms.

(4) Speed variations: It shall be determined depending on the purpose of the test.

(5) Dropping portion and the number of times of dropping: They shall be determined depending on the purpose of the test.

(6) The acceleration sensor, for measuring the wave of the accelerations generated on the impact table, must be installed in a nearest point to the specimen.

(7) All the acceleration waves generated at the moment of the impact must be recorded.

8. Test Report

The following items must be states in the test report:

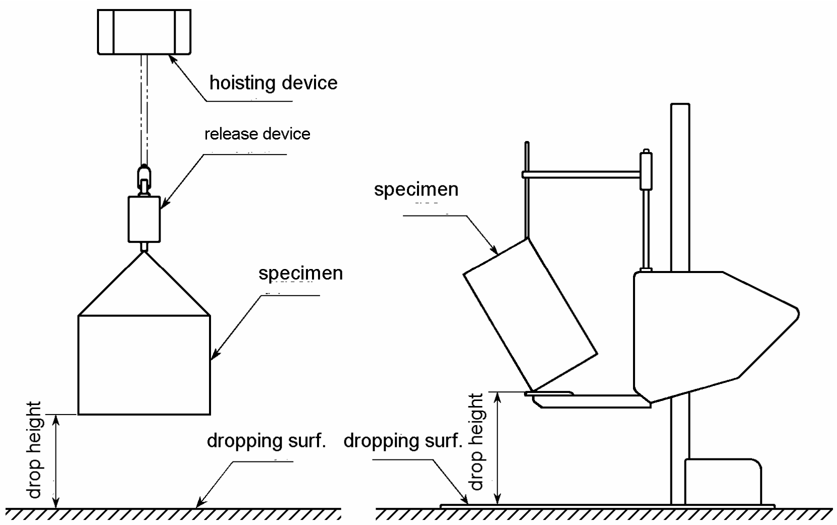
(1) Detail of the content (product name, type and mass)

(2) Gross mass, volumes, dimensions, materials, structure of specimen, packaging method

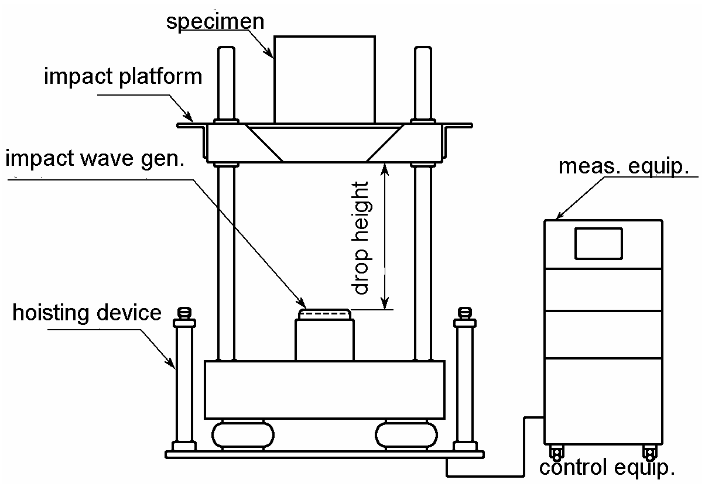
(3) Quantity (in units) of specimen

(4) Model and capacity of used testing machine

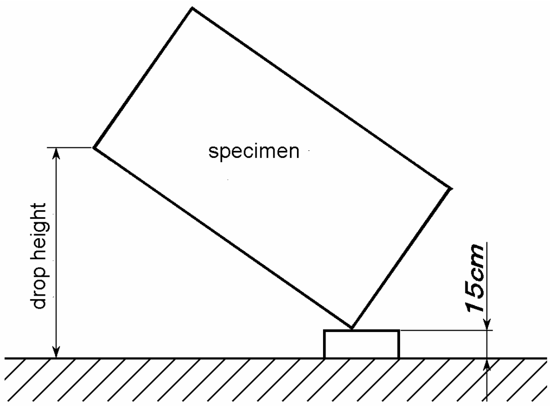
(5) Test method and applied conditions (method, portion to drop, drop height, speed variation, and number of dropping times)
(6) Additional conditions incorporated to the specimen prior to test
(7) Records of the results of the test (details of deformations and damages)
(8) Test date and test place ambient temperature and relative humidity conditions
(9) General comments about the results of the test
(10) Special note



Annex 1 Fig. 1 Example of free drop test apparatus



Annex1 Fig. 2 Example of impact test apparatus



Annex1 Fig. 3 Single support edge drop test

ANNEX 1 (reference) DROP TEST CONDITIONS

1. Introduction

This Annex is an additional text to the main part and it does not constitute provisions for this Standard. However, the users of this Standards, who does not have the actual data of transportation survey, can confirm the protection level of the packaging against possible impacts in actual handling in the transportation process, by the following provisions mentioning in this Annex.

2. Test Method

For the execution of the test, it will be carried out following the sequence indicated in Annex 1 Table 1, and dropping from a height indicated in Annex 1 Table 2.

2.1 The necessary conditions, such as the portion to drop, drop height, sequence of drop and number of times of dropping, shall be established depending on the purpose of the test. In case that there is no defined specifications, conditions must be established by using the following parameters as a reference:

2.1.1 Free Drop Test (Method A)

For the drop portion and drop sequence, the Annex 1 Figure 1 must be taken as a basis. The number of dropping shall be, in principle, 1 for each drop portion.

Annex 1 Table 1 Drop Sequence for Free Drop Test

Drop sequence	Drop portion	Remarks
1	Corner 2-3-6	In case of using multiple specimens, the drop portion for the even number specimen shall be 3-4-5.
2	Edge 2－3	In case of using multiple specimens, the drop portion for the even number specimen shall be 3-4
3	Edge 3－6	In case of using multiple specimens, the drop portion for the even number specimen shall be 3-5
4	Edge 2－3	In case of using multiple specimens, the drop portion for the even number specimen shall be 4-5
5	All the faces	Drop sequence not specified.

Note: The drop sequence can be modified or omitted a drop portion by means of mutual agreement between the parties involved.

Annex 1 Table 2 Free Drop Test - Drop Height

Packaged product mass（kg）	Drop height			
	Level I	Level II	Level III	Level IV
Up to 10				
From 10 up to 20				
From 20 up to 30				
From 30 up to 40				
More than 40				

Note: The drop height will be basically the same for all the directions.

2.1.2 Single Support Edge Drop Test

The drop height for single support edge drop test are as indicated in the Annex 1 Table 3.

Annex 1 Table 3: Single Support Edge Drop Test - Drop Height

Packaged product mass (kg)	Drop height (cm)			
	Level I	Level II	Level III	Level IV
More than 50 up to 200	50	40	30	20
More than 200 up to 500	40	30	20	15
More than 500	30	20	15	10

2.1.3 Drop Tests by Using Impact Test Apparatus

When the drop test is carried out by using the impact test apparatus, the additional speed applied to the specimen are as indicated in the Annex 1 Table 4.

Annex 1 Table 4 Speed Variations

Packaged product mass (kg)	Speed variations (m/s)			
	Level I	Level II	Level III	Level IV
Up to 10	3.96	3.43	2.80	2.42
from 10 up to 20	3.43	3.28	2.62	2.21
From 20 upt to 30	3.13	2.97	2.42	1.98
from 30 up to 40	2.80	2.62	2.21	1.71
from 40 up to 50	2.40	2.21	1.98	1.40
from 50 up to 100	2.21	1.98	1.71	1.40

NARRATIVE of "Drop Test Method of Packaged Freights" (Draft)

1. Introduction

This Standard specifies the method for testing the required resistance level against impacts occurred during the packaged cargoes handling which are transported in the MERCOSUR region.

This Standard has been referred to the guideline for vibration test given by the ISO and JIS standards. However, and apart from the aforementioned standards, the test conditions indicated in the Annex 1 have been developed based on the results of impacts measurements on handling cargoes, in cooperation of JICA between 2005 and 2006[(1)] and taking as reference the ISO 4180, JIS Z0200, NF H00-051 and packaging standards of Japanese companies for export packaging.

2. Drop Test

(1) The free drop test is to reproduce the estimated impact of individual freight during the cargo handling. Thus, this test is basically to be carried out on individual cargo, but in case of multiple products bundled or packed together in one packaging, the test can be executed on bundled packages as one unit.

(2) For the setting of the angle of face drop test, and the angle of the drop face at the moment of the impact, the specimen ought to be placed horizontality within 1 degree. However, since the settings under this condition are very difficult, it was established a horizontality of 2 degrees.

(3) For the edge drop and corner drop, they are applied two methods for setting the specimen: The first is to hold the specimen so that the center of gravity is located exactly on the vertical line of the edge or corner to be impacted on the dropping surface. The second is positioning the specimen so as to the opposite edge or corner to be impacted on the dropping surface is coming on the vertical line of those edge or corner (Normally named as "opposite edge" and "opposite corner" method).

In this Standard, it was adopted the method of positioning the center of gravity on the vertical line of the dropping edge or corner, which is harder condition for the package than another. By testing under this method, and in case that the setting of the dropping direction is perfect, the packaged specimen is likely to stop in upright position in the instant of the specimen collides with the surface, so that it can be clearly confirmed the accuracy of the setting.

(4) During the edge drop and corner drop tests, the test executor sometimes may hold the specimen just after the drop, to avoid falling down stemmed from any impacts other than the drop itself. However, in the case of the actual cargo handling during the

distribution of the goods, normally there is no margin for the prevention of falling before stopping the cargo. For this reason, it was incorporated the warning to avoid the touch of the specimen until the complete stop.

3. Single Support Edge Drop Test

(1) The single support edge drop test is to reproduce the impacts generated during the handling of large size packaged freights, such as industrial refrigerators and palletized cargoes, fastened by shrinkable elements.

(2) For the single support edge drop test, the hoisting device could be the hook for free drop test, in principle. But, fork lift can also be used.

4. Drop Test Using Impact Test Apparatus

(1) The test carried out by using the impact test apparatus is an alternative method replacing the free drop method. However, this method has the advantage over the positioning of the specimen to drop and the reproducibility of the test, so this method is recently spreading their application.

(2) The main difference between the free drop test and the drop test using the impact test apparatus is that, in the first method, a secondary impact occurs due to the fall after the drop against edge or corner. This, however, is not happened on the second method.

(3) In the case of drop test by using the impact test apparatus, the impact value and speed change must be recorded every time when the impact occurs. If the values are out of specified range, the test must be restarted from scratch.

(4) For measuring the acceleration, it is recommended to record the waves by not using the low pass filter. This device is recommended for the further analysis of the waves.

(5) The low pass filter must have a frequency of 200Hz minimum. The use of filters, having lower frequencies than above value, will distort the wave signal and it unable to measure the exact acceleration.

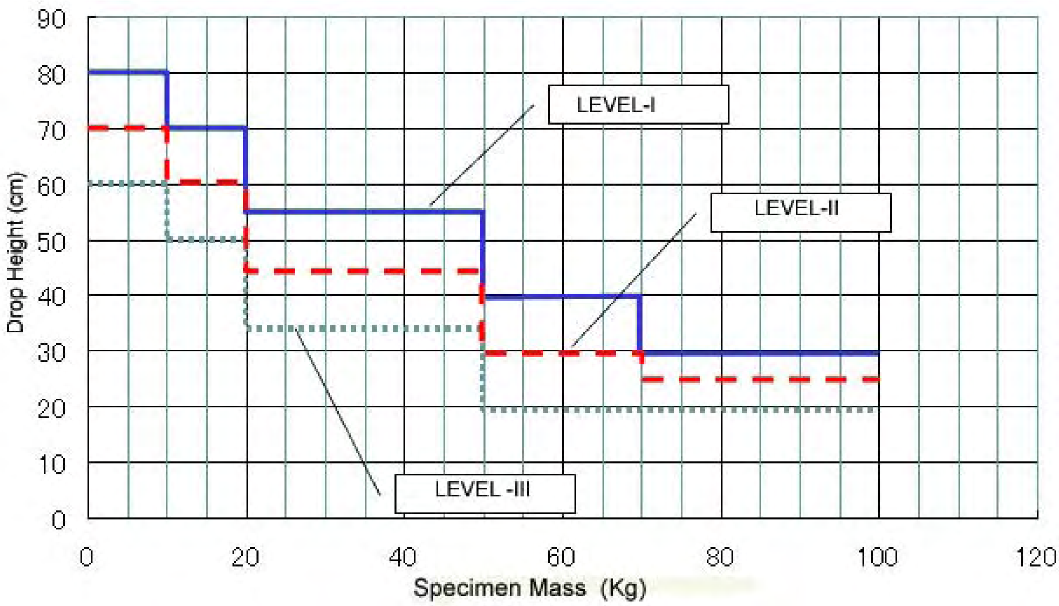
5. Basic Data for the Establishment of Test Conditions

The conditions for free drop tests are defined by the data obtained from Transportation surveys and the drop height obtained by calculation. Also, it was taken as reference the ISO 4180, JIS Z0200, NF H00-051 and packaging standards of Japanese companies for export packaging.

In the particular case of MERCOSUR, the reference values of this standards have been obtained from publicly known standards and the data obtained from drop heights data during cargo handling limited to following conditions: a) packaged freight of less than 10kg mass, b) packaged freight from 70kg and less than 100kg. Therefore, the drop heights stated in this standard must be considered as reference only, for the purpose of determining the test conditions.

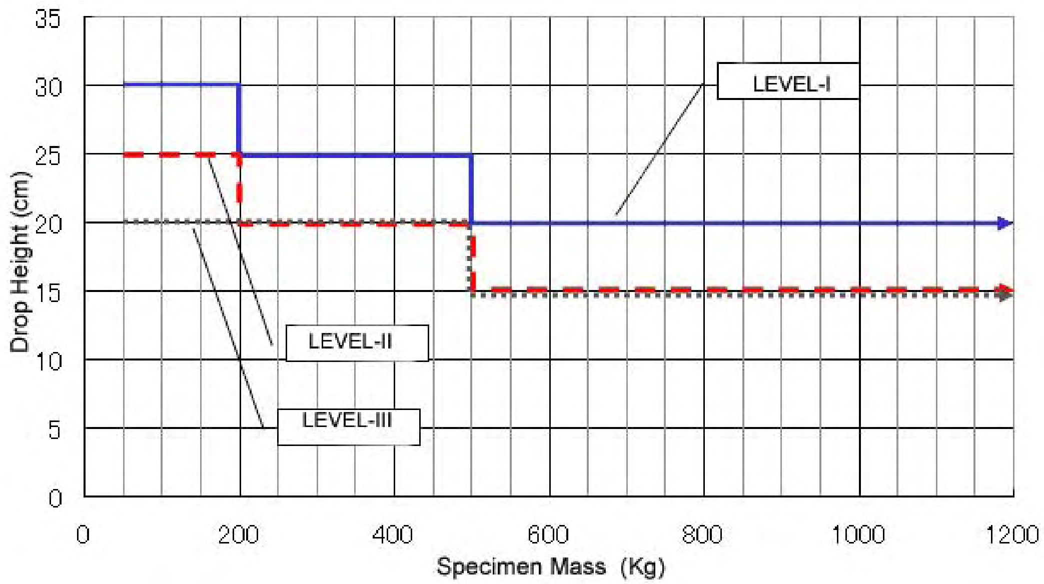
6. Graphics for drop conditions and mass of packaged cargoes

6.1 Free Drop test



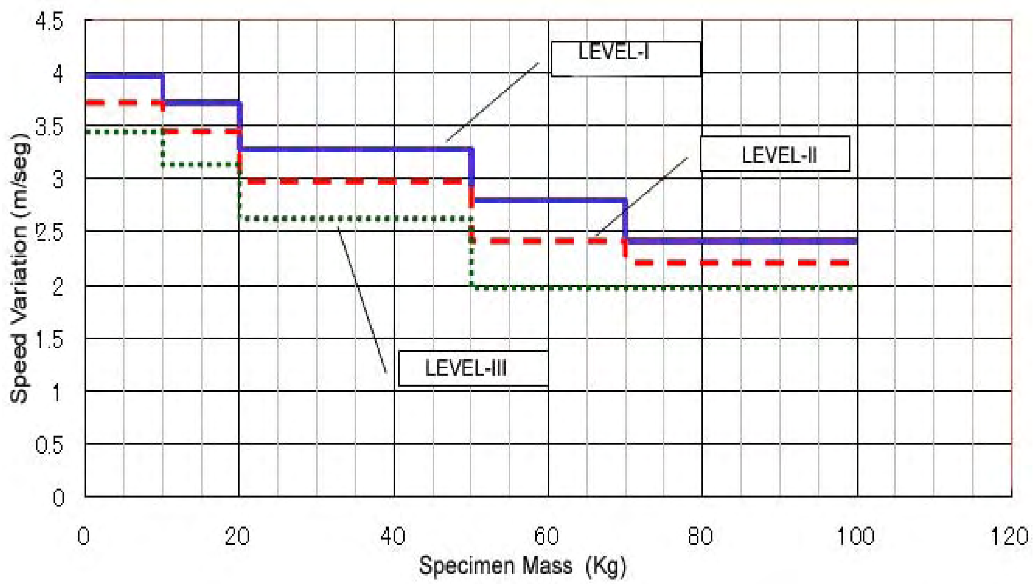
Narrative- Fig. 1: Relationship between Specimen Mass and Drop Height

6.2 Single edge support drop test



Narrative- Fig. 2: Relationship between specimen mass and drop height for single edge support drop test

6.3 Free drop test by using shock test machine



Narrative-Fig. 3: Relationship between Specimen Mass and Speed Variation for the Case of Tests by Using the Shock Test Machine

6.3.3.5 Packed Freights - Method of Vibration Test (Draft)

1. Scope

This standard specifies the test method to evaluate whether packed freights can withstand vertical vibrations suffered during the transportation.

2. Normative References

The reference standards listed below are part of this Standard. For those standards listed with issue date, issues to be considered are only those quoted herein. Later issues shall not be applicable. For those standards which issue date is not quoted, the latest edition is applicable (including revisions).

Additionally, for those reference standards which are not part of the MERCOSUR Technical Standards, above mentioned considerations shall be applied as well.
The standards taken as a reference are the following:

(1) MERCIS E 001 ”Method of Designating on Component Codes of Packaging”
(2) MERCIS E 002 ”Packaged Freights – Conditioning for Testing”

3. Glossary

The definitions of technical terms used herein are as follows:

(1) Power Spectrum Density (PSD)

The root mean square of the acceleration signal once passed through a narrow band filter with a central frequency. The limit value when averaging time tends to infinity and band width approaches to zero, expressed by the unit band width.

(2) Effective Value

The root mean square of the parameter indicating the acceleration, speed or displacement values during the Random Vibration Test.

4. Conditioning

The specimens to be tested shall be conditioned as per the MERCIS E 002 Standard prior to the test.

Special conditions can be agreed among the concerned parties.

5. Test Specimens

Test specimens shall comply with the following statements:

(a) Test specimens shall contain real products. However, a model product can be utilized as replacement, under the condition that they have same characteristics such as dimensions, mass and the location of the center of gravity. In each case, the air tight sealing, seal, typing bundling, etc must be the same as in actual shipping.

(b) Test specimen component designation shall be in accordance with MERCIS E 001 Standard.

6. Test Apparatus

The equipment to be used within the scope of the standards considered herein shall comply with the following conditions:

6.1 Direction of Vibrations: The equipment shall be able to apply vertical (up-and-down) vibrations to the specimen.

6.2 Accelerations: As a minimum requirement, the apparatus shall generate vibrations with an effective acceleration value calculated from the preestablished PSD for test specimens on loaded condition.

6.3 Vibration Frequency Range: Variable frequency range shall be greater than the frequency range corresponding to preestablished PSD.

6.4 Vibration Board: Vibration board shall be big and rigid enough to hold the test specimens and to maintain its surface leveled during the test. Minimum resonance frequency shall be higher than the preestablished test frequency range.

6.5 Accessories for the Vibration Board:

Optional accessories can be added to the vibration board:

a) An enclosure to avoid lateral or back-and-forth displacement of the specimens during the test

b) A kind of restriction device for model testing

6.6 Vibration Measurement and Control System: The following devices and functions shall be equipped for vibration measurement and vibration control system:

a) **Acceleration Sensor:** It measures the acceleration generated at the vibration board.

b) **Vibration Amplifier:** It amplifies the acceleration sensor signals and sends it to the control system.

c) **Vibration Control System:** It controls the vibrations at the vibration board by means of the feedback signal from the vibration control system.

d) **Data Output Equipment:** It indicates the vibration status at the vibration board.

e) **Data Recorder:** It record the PSD features of the vibration data generated at the vibration board and the vibration effective value.

f) **Frequency Features:** The values of frequencies gathered for measurement shall be within ±5% in vibration frequency range.

g) **Number of Measuring Channels:** It is recommended to have several sensors to measure test specimen reaction, besides the control sensor at the vibration board.

7. Functions of The Vibration Control System

The vibration control system shall accomplish the following functions and operations:

a) **Signal Output Function:** It shall emit the signal that generates the vibration with the pre-established PSD.

b) **Vibration Control Function:** It shall be able to control and maintain the pre-established features of the PSD at the vibration table (board). Besides, it shall be able to increase, gradually, to the pre-established level, and to stop without faults.
The PSD at the vibration board with the specimens placed therein shall be controllable at ±3db from the value set for all test frequencies. Furthermore, the allowable deviation for the effective acceleration is ±15% of the established value.

8. Test Methods

8.1 The testing area environment shall be, whenever possible, the same as the one at the conditioning area.

8.2 Test Specimen Setting: The test specimens shall be placed on the vibration table (board) in the way most resembling their actual loading conditions, including fixation methods and piling-up for transportation. In the case that the specimens shall be tied-up, the specimen's center of gravity must be as the nearest possible to the vibration board center. An offhand cage can be prepared to avoid displacement of untied specimens. A body can be piled-up on the specimen, provided its weight is the same as the one present in real transportation conditions.

8.3 Measurement of Imparted Acceleration: The acceleration imparted to the specimens shall be measured at the nearest possible point to the specimen.

8.4 Test Interruption: The test can be interrupted at any moment for visual inspection.

8.5 Vibration Signal Application: Vibration of the vibration board shall begin at low levels, such as 6db**,** and increase gradually to the pre-established level, in order to achieve the preestablished PSD. Once reached, the pre-established vibration level shall be maintained during the preestablished time.

8.6 Bouncing Vibration Test: The bouncing vibration test shall be performed after the Random vibration test as established herein.

8.7 Once the test is completed, the specimens shall be examined for damages.

9. Test Reports

The items for the Test Report shall be as follows:

a) Applied Standard
b) Company and test location, test requester name and location (address)
c) Test Report identification number
d) Specimens receipt date and test performance date
e) Name, position and signature of test responsible personnel
f) Statement about the fact that the test results are limited to present test specimens only
g) Declaration of full-text duplication forbiddance without laboratory authorization
h) Quantity of specimens used for the test
i) Details: specific gravity, dimensions, volume, specimen specification brochures, fixation method, cushioning method, packaging structure protection method, packaging closing and bundling method
j) Content details (product name, type and specific gravity:) In case of model specimens or dummy are used, all related information shall be detailed therein
k) Total mass of specimen
l) Temperature, relative humidity of the conditioning area and test area
m) Test Conditions (frequency range, PSD and test time); Effective acceleration and PSD test records
n) When piling-up stress has been tested, the product or weights used and the loading time have to be stated
o) Statement about restraints or cages (if any, detail applied method)
p) Deviations to the test methods described herein
q) Diagnosis related to the recorded PSD
r) Posture of specimen during the test
s) General information on test apparatus and its identification data (e.g. manufacturer number)
t) Test results record (description of deformation and/or collapse)
u) General view of test results

ANNEX A (reference)
PSD Diagrams and Conditions for Bouncing Test

1. Introduction

This Annex has the purpose to supplement the specifications indicated in the main part of this Standard and it is not a part of this Standard.

However, for the user of this Standard who does not have the transportation survey data, the development of tests following the indications of this Annex will allow to get test conditions very close to actual transportation conditions.

The tests are structured on two types of tests, the vibration tests and the bouncing vibration test, based on pre-established PSD. By carrying out these two tests, it can be considered that the vibration tests are complete.

2. Test Execution Sequence

When the test is carried out, the test pattern will be selected, Pattern A or Pattern B, according to Annex-A Table 1, depending on the characteristics of the target packaged product.

Furthermore, depending on the severity of the transportation conditions, one level (I to III) will be selected, as indicated in Annex-A Table 2. The tests will be carried out by applying the PSD characteristics indicated in Annex-A Table 3.

After the completion of the test described above, in turn, the bouncing vibration test will be carried out for each section. The bouncing vibration test shall be carried out without any mechanical fixation.

Furthermore, in case that the duration of bouncing test exceeds 5 minutes, the remaining period can be tested, as replacement, by impact test, where the number of impacts will be proportional to the number of minutes of the test. In case that results a fraction, it must be considered one if the duration is more than 0.5.

Annex-A Table-1 Divisions for Applying the Pattern A and Pattern B

Division	Applicable packaged cargo
Pattern A	(1) Case that the packaged product is an industrial product. (2) Case that the target product is a container of food product, in which packaging faults are gradually generated on lower cargoes due to upper cargoes weight, and the collapse is produced by exfoliation of container film.
Pattern B	(1) Case of packaging of food products, in which pin holes appear in the product bags due to causes such as friction, leading to packaging faults such as leaks.

In case that the selection criterion is difficult to be distinguished, Pattern A will be selected.

Annex-A Table-2. Divisions for Applying from Levels I to III.

Division	Applicable transportation conditions
Level I	Case of roads in bad conditions for major portion of the route, and they are expected frequent high accelerations.
Level II	Case of routes on normal roads.
Level III	Case of major portion of the route is going through good conditions roads, such as highways. They are expected a minimum points having high accelerations.

3. Test conditions

Annex-A Table 3-1(a) Pattern A, Level I

Point	Freq	PSD		Remarks
	Hz	m^2/s^3	$\{G^2/Hz\}$	
1	5	0.2964	0.003086	Distance: 4651 km Equivalent stretch: Aimogasta - Iguazu & Belem - Sao Paulo
2	11	0.0209	0.000218	
3	13	0.0209	0.000218	
4	18	0.5229	0.005445	
5	20	0.5229	0.005445	
6	30	0.2267	0.002360	
7	35	0.7670	0.007986	
8	50	0.2440	0.002541	
9	100	0.2440	0.002541	
Effect.Accel	$5.19 m/s^2$ {0.53G}			
Accel Time	1 hr			

Annex-A, Fig 1: PSD for testing, Level I

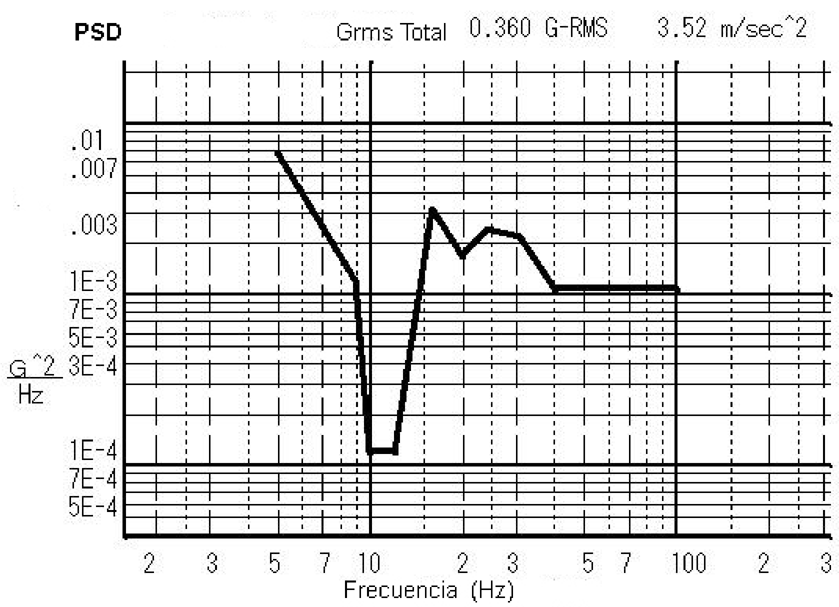
Annex-A Table 3-1(b) Conditions for Bouncing Test (10 Hz, 10,78 m/s (1.1G))

Testing Method	Duration (min)	Impact Test (1.4m/sec or 10cm drop)

Combined w/Impact Test	5	24 time

Annex-A Table 3-2(a) Pattern A, Level II

Point	Freq	PSD		Remarks
	Hz	m^2/s^3	{G^2/Hz}	
1	5	0.6508	0.006776	Distance: 1522 km Equivalent stretch: BsAs - Mendoza & Loma Plata – Asunción
2	9	0.1162	0.001210	
3	10	0.0116	0.000121	
4	12	0.0116	0.000121	
5	16	0.3021	0.003146	
6	20	0.1627	0.001694	
7	24	0.2324	0.002420	
8	31	0.2092	0.002178	
9	40	0.1046	0.001089	
10	100	0.1046	0.001089	
Effect.Accel	3.52m/s² {0.36G}			
Accel Time	1 hr			



Annex-A, Fig 2: PSD for Testing, Level II

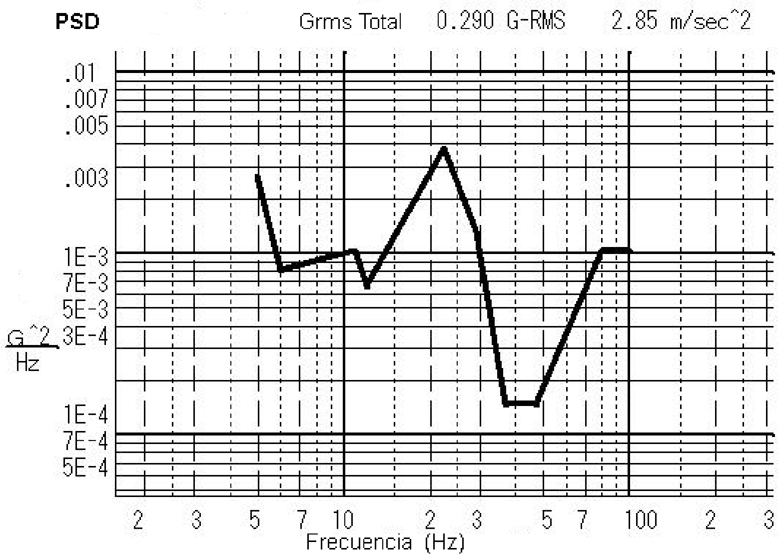
Annex-A Table 3-2(b) Conditions for Bouncing Test (10 Hz, 10.78 m/s {1.1G})

Testing Method	Duration (min)	Impact Test (1.4m/sec or 10cm drop)
Bouncing test (only)	17.1	——
Combined w/Impact Test	5	1 time

.

Annex-A Table 3-3(a): Pattern A, Level III)

Point	Freq	PSD		Remarks
	Hz	m^2/s^3	$\{G^2/Hz\}$	
1	5	0.2524	0.002628	Distance: 501km Equivalent stretch: Rosario - BsAs & Montevideo – Rivera
2	6	0.0771	0.000803	
3	11	0.0982	0.001022	
4	12	0.0631	0.000657	
5	22.5	0.3646	0.003796	
6	29	0.1262	0.001314	
7	37	0.0140	0.000146	
8	47	0.0140	0.000146	
9	80	0.0982	0.001022	
10	100	0.0982	0.001022	
Effect.Accel	$2.85m/s^2$ {0.29G}			
Accel. Time	1hr			



Anexo-A, Fig 3: PSD for testing, Level III

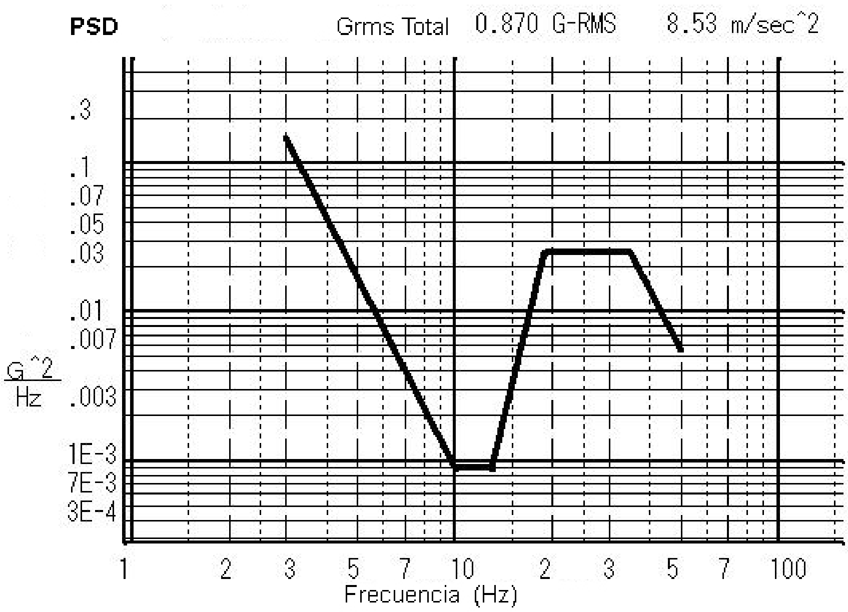
Annex-A Table 3-3(b) Conditions for Bouncing Test (10 Hz, 10.78 m/s {1,1G})

Testing Method	Duration (min)	Impact Test (1.4m/sec or 10cm drop)
Bouncing test (only)	15.6	——
Combined w/Impact Test	5	1 time

.

Annex-A Table 3-4(a) Pattern B, Level I

Point	Freq	PSD		Remarks
	Hz	m^2/s^3	$\{G^2/Hz\}$	
1	3	0.2964	0.14482	Distance: 4651 km Equivalent stretch: Aimogasta - Iguazu & Belem - Sao Paulo
2	10	0.0209	0.00089	
3	13	0.0209	0.00089	
4	19	0.5229	0.02451	
5	35	0.5229	0.02451	
6	50	0.2267	0.00557	
Effect.Accel	$8.53m/s^2$ {0.87G}			
Accel Time	2 hr			



Annex-A, Fig 4: PSD for testing, Level I

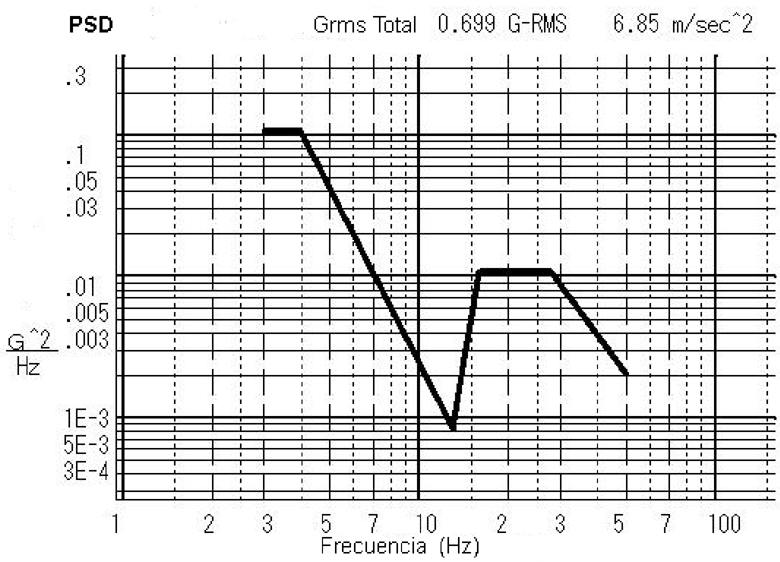
Annex-A Table 3-4(b) Conditions for Bouncing Test (10 Hz, 10.78 m/s {1.1G})

Testing Method	Duration (min)	Impact Test (1.4m/sec or 10cm drop)
Bouncing test (only)	243.6	——
Combined w/Impact Test	5	24 time

.

Annex-A Table 3-5(a) Pattern B, Level II)

Points	Freq	PSD		Remarks
	Hz	m^2/s^3	$\{G^2/Hz\}$	
1	3	0.2964	0.106432	Distance: 1522 km Equivalent stretch: Bs As-Mendoza Loma Plata - Asuncion
2	4	0.0209	0.106432	
3	13	0.0209	0.000832	
4	16	0.5229	0.010810	
5	28	0.5229	0.010810	
6	50	0.2267	0.002079	
Effect.Accel	$6.85 m/s^2$ {0.7G}			
Accel Time	1 hr			



Anexo-A, Fig 5: PSD for testing, Level II

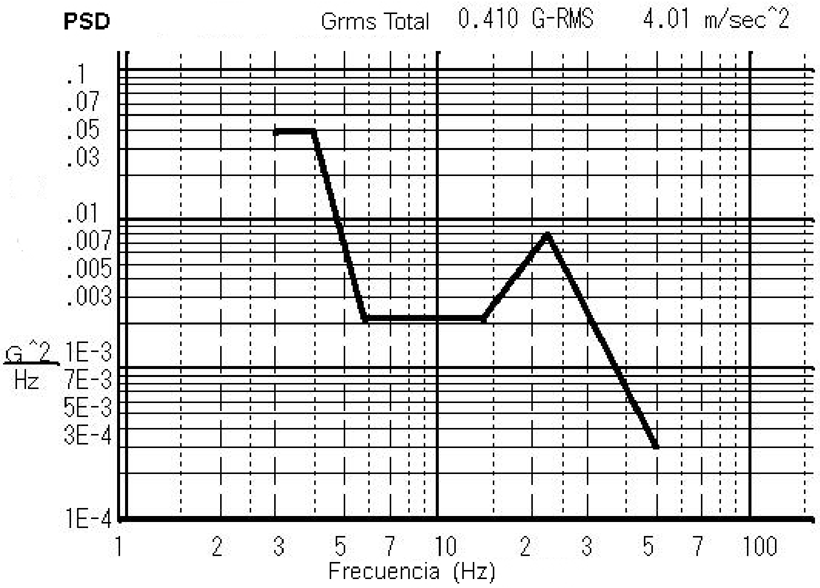
Annex-A Table 3-5(b) Conditions for Bouncing Test (10 Hz, 10.78 m/s {1.1G})

Testing Method	Duration (min)	Impact Test (1.4m/sec or 10cm drop)
Bouncing test (only)	17.1	——
Combined w/Impact Test	5	1 time

.

Annex-A Table 3-6(a) Pattern B, Level III

Point	Freq	PSD		Remarks
	Hz	m^2/s^3	{G^2/Hz}	
1	3	0.2964	0.03835	Distance: 501 km Equivalent stretch: Rosario-Buenos Aires & Montevideo-Rivera
2	4	0.0209	0.03835	
3	5.8	0.0209	0.00211	
4	14	0.5229	0.00211	
5	22.5	0.5229	0.00785	
6	50	0.2267	0.00030	
Effect.Accel	4.01m/s^2 {0.41G}			
Accel Time	1 hr			



Anexo-A, Fig 6: PSD for testing, Level III

Annex-A Table 3-6(b) Conditions for Bouncing Test (10 Hz, 10.78 m/s {1.1G})

Testing Method	Duration (min)	Impact Test (1.4m/sec or 10cm drop)
Bouncing test (only)	15.6	——
Combined w/Impact Test	5	1 time

.

ANNEX-B (Reference)
Characteristics of Random Vibration Tests

This Annex has the purpose to supplement the specifications indicated in the main part of this Standard, and it is not part of the Standard.

1. General

The loading platform of the transportation vehicles, during the movement, receives the oscillations coming from the irregularities of the road surface through the tires and the suspension.

Since the irregularities of the roads have no defined patterns, the vibrations of the loading platform are Random type. However, considering that on the way of transmission of these vibrations up to the loading platform they are placed mechanical parts in the middle, having their own natural frequencies, as a result, vibrations are not totally Random but pseudo-Random.

Furthermore, since on the roads some steps or damaged portions are present, on some point of the route impact waves must be added. For this reason, it can be said – strictly speaking – that the vibrations on loading platform are Random oscillations plus impact waves added, which can be named as “Shock on Random Vibrations”

However, in order to input these “Shock on Random Vibrations” on the vibration test apparatus the conditions become very complex, and additionally, the phenomena analysis are difficult and moreover, the mechanical load on the test equipment is becoming too high.

For these reasons, for general vibration tests they are applied the Random test for one side and the impact test by other side, in separate way.

This Standard applies the same concept, so that both tests have been specified separately. On the Annex B Fig.1 a) it is indicated a typical Random wave. As it can be observed on the diagram, the general type of Random waves has a totally irregular shape, where it cannot be seen any periodical signals, as observed in sinusoidal waves. The Random waves have some statistical characteristics, so that when the data are processed by using statistics tools, it can be determined the actual characteristics of the wave.

Using a common expression, the aspects related to frequencies are measured by the PSD, and the vibration amplitude by means of the amplitude occurrence density.

2. Power Spectrum Density (PSD) of acceleration

This is parameter used for indicating the distribution of accelerations against frequencies. The explanation below is based on the wave form indicated as example on Annex B Fig.1.

When the acceleration signal is passing through a narrow band filter, having an center frequency of 5Hz, only a portion of the signal pass through the filter on a band around 5Hz, as indicated in the curve b). This filtered signal apparently has a sinusoidal shape but it contains not only a pure 5Hz signal but also other components waves close to 5Hz, depending on the filter, and their intensity on the band width.

Furthermore, the signal level is not fixed, as it is in sinusoidal waves, but variable by Random way.

The signal indicated in b), can not be used for statistical calculations since it includes values below zero. Consequently, this signal is transformed to a square parameter.

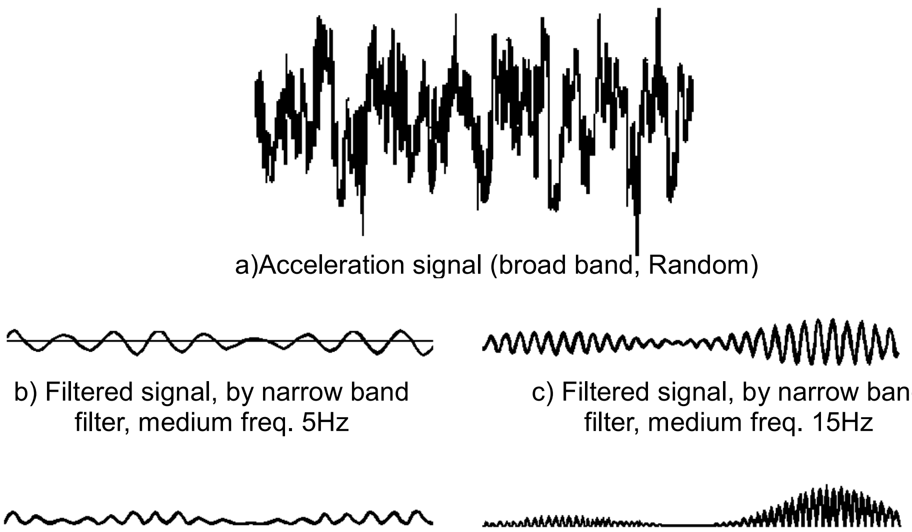
The signals of d) are the square of the b) signals and all the values now are positive.

The signal of c) is a filtered signal, previously set with a center frequency of 15Hz, and the signal e) is the square signal of the last one.

The band width of the filtered signal will depend on the filter resolution, so that it is necessary to determine that resolution to a value near to 1Hz.

The term of “density” used on the naming of the PSD of acceleration is referred to the process, indicating that the signal has been passed all these calculations. Furthermore, since this signal also is varying on the time, it is necessary to process them by calculating the averages in the time axis.

As result of passing through all this process within the measuring frequency range, finally the PSD curve of acceleration (broken line) is obtained.



a)Acceleration signal (broad band, Random)

b) Filtered signal, by narrow band filter, medium freq. 5Hz

c) Filtered signal, by narrow band filter, medium freq. 15Hz

d) Square signal of b wave

e) Square signal of c wave

ANNEX B Fig. 1 – Steps for obtaining the PSD curve of acculeration

3. Acceleration Occurrence Density

The distribution of the instantaneous signal used in the Random vibration test if following a standard distribution curve. However, the tests are performed by using a limited signal, so that they can not be generated peaks higher than 3 times of effective value.

The control systems of the standard test apparatus are provided with functions to perform all this process automatically. Therefore, this parameter is an item to be taken into account on the stage of equipment selection and it has no influence in the execution of the tests.

4. Effective Acceleration (Arms)

The effective acceleration is calculated from the variation of acceleration through time, as per following formula(1).

$$Arms=\sqrt{\frac{1}{T}\int_{t_2}^{t_1} A^2(t)dt} \qquad \text{........................(1)}$$

Where:

$Arms$: Effective acceleration

$A(t)$: Acceleration through time

t_1 : Initial time of the calculation

t_2: End time of the calculation

T : Time period between t_1 and t_2

The effective acceleration can be calculated from the PSD of acceleration, according to the formula (2).

$$Arms=\sqrt{\int_{f_2}^{f_1} \phi(f)df} \qquad \text{........................(2)}$$

Where:

$\phi(f)$: PSD function of frequency f

f_1 : Frequency low limit

f_2: Frequency upper limit

Since the PSD is input data to the Random vibration tests, it is possible to calculate the effective accelerations required, by the formula (2). Normally, on the test apparatus they are provided the function for doing these calculations automatically.

Also, this value is indicating by the area covered by the PSD curve (broken line).

5. Effective Speed

From the power spectrum acceleration, it can be determined the speed spectrum, so that by replacing $\varphi(f)$ in formula (2), the calculation is very simple.

However, this value is applied only for the selection of the test apparatus, which are using them, but it is not required for the execution of the test itself.

6. Effective Displacement

The effective displacement is calculated on a simple way, starting from the spectrum acceleration, so, it is determined the spectrum displacement and this is replaced in the formula (2). In general, this value is used only for the selection of test equipment, and it is not required for the execution of the vibration tests.

However, it is quite significant since it is the origin of the faults on the products due to displacements caused by vibrations, analyzed in the tests of “Pattern B” of this Standard.

Narrative for "Vibration Test Method for Packaged Freights"
(Draft)

1. Introduction

This Standard specifies the testing methods for evaluating the degree of resistance of packaged freights to vibrations during the transportation within the MERCOSUR region.

This Standard has been prepared based on JIS and ISO standards as a reference. However, regarding to the ANNEX A of this Standard, the test conditions indicated have been configured based on the results of vibrations measured during the transportation route surveys, taken on loading platforms of loaded vehicles, as a part of studies carried out in cooperation with the JICA on year 2005 and 2006, independently from the standards mentioned above. (1)

Therefore, in the case of routes which are not surveyed at that time, or routes constructed or repaired after the survey, it is possible to find some vibration conditions other than those specified in this Standard. Also, there are some cases of routes remarkably out of the normal conditions, due to the degradation of the surface at the moment of the survey.

In order to cope with all these cases, it is recommended to continue the measuring of vibrations on the routes which are not surveyed yet, and determine the test conditions by comparing with already analyzed routes.

Also, in the case of Argentina, the National Traffic Office (Direccion Nacional de Vialidad) is publishing every year the Road Index of the national routes (a factor indicating the road surface irregularities) of almost all the country, indicating a factor value per each segment.(2)

If a comparison study is made between this information and the data of the JICA Study, it would be possible an objective evaluation of routes.

Similar information can be found in the others 3 countries of the region.

On the other hand, this Standard has been prepared mainly based on JIS Z0232 standard as a reference.(3)

2. Axis of the Test

The loading platform of the transport vehicles is vibrating normally on 3 axes, vertical, longitudinal and transversal directions. Therefore, the ideal condition is to carry out a test driving vibrations on these 3 directions. But, on the actual tests, the vibrations applied are reduced to vertical direction only, due to the following reasons:

a) The test apparatus which are suitable for accelerations on the 3 directions are very expensive. Also, almost all the institutes of the counterparts of MERCOSUR are not furnished with this type of equipment.

b) The vibrations on the loading platform of transportation vehicles show remarkably high values on vertical direction compared to the others directions.(4) On the other hand, in the field, it was proved that almost all packaged freights passing the vertical vibration tests have the necessary characteristics to resist the actual transportation conditions.

3. Test Apparatus

The specifications of the test apparatus, indicated in the related clauses, can be covered by standard apparatus, such as inductive electric type or hydraulic-electric controlled equipment. However, the moving parts of the equipment are deteriorated due to the repetition of tests, and the aging of non-movable parts along the time.

Furthermore, the measuring instruments and control systems are suffering aging phenomena also. For these reasons, it is necessary to take measures in order to ensure a proper functionality and accuracy, by carrying out a calibration at least once a year.

The vibration test apparatus have their own limits, according to the frequency range, accelerations and speeds.

Regarding the displacements, the apparatus are provided with a device for limiting the oscillations (limiter). Based on these restrictions, the test conditions limits are determined.

The limits of the test conditions are indicated through a broken line in chart of acceleration, speeds and displacement. The figure of Narrative-Fig. 1 shows an example of the chart indicating the limitations of a test.

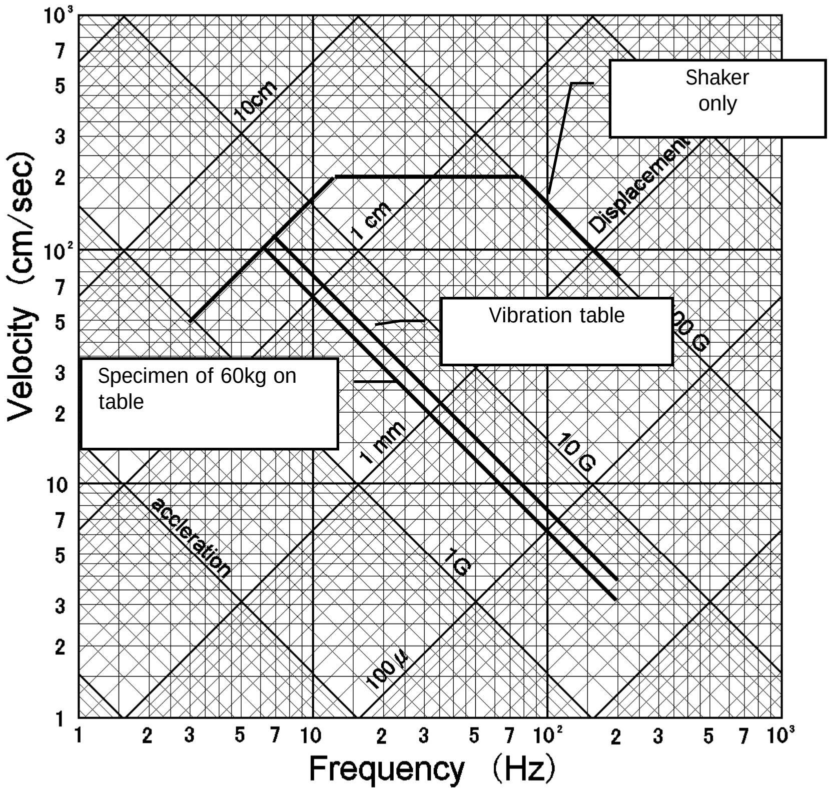
In this example, the allowable frequency range is 3Hz to 200Hz, the maximum speed of 200cm/s, and maximum displacement of 50.8 mm (2 inches), and maximum acceleration without load of 980 m/s^2 {100G}.

It must be noted that maximum accelerations can varies, depending on the mass of the specimen placed on the test apparatus.

Note 1): The maximum allowable acceleration is the result of dividing the electrical output of vibration equipment by gross mass of the movable parts. The gross mass of movable parts is the sum of mass of the shaker, vibration table, the specimen, and fittings.

For example, if the output of the vibration equipment is 2500 kg-G, the mass of movable part 25 kg, the vibration table with accessories 500kg, the mass of the specimen 75 kg, the total of fittings 8 kg, then the gross mass of all movable parts is 608 kg. So, the maximum allowable acceleration will be 40.3 m/s^2 {4,11G}.

Also, if protection devices are placed on the vibration table, to avoid fallings, the mass of these devices must be added to the total mass of movable parts, and then the maximum allowable acceleration will consequently decrease. For this reason, necessary care must be taken.



Narrative Fig-1 Parameter Limits on a Vibration Test Apparatus

4. Test Method

4.1 Vibration driving methods

According to actually applied methods of vibration tests on packaged freights, there are 3 types of tests: with fixed frequency, variable frequency by sweeping, and random frequency. The method by fixed frequency includes the case of oscillations produced by a determined frequency (i.e. 10 Hz) and the others where the impulse is given by the natural frequency of the specimen.

The vibration tests by fixed frequency are normally carried out for investigate the sliding of palletized cargoes. Also, considering the transportation and packaging conditions in MERCOSUR region, it is not necessary of an immediate action to implement a Standard for this matter. However, since it is very difficult for the full reproduction of the transportation conditions on the MERCOSUR routes by using Random tests, the “Shim Test” has been introduced as replacing method in this Standard in order to cover this gap, as indicated on next pages (See details in Clause 4.3).

The vibration test by natural frequency is applied normally to replace the Random tests.

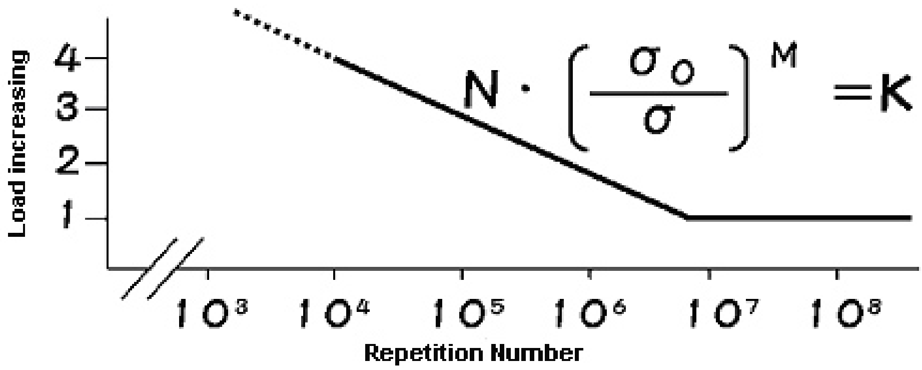
It is often used to supplement other tests to investigate the resistance of industrial products. Since this Standard is basically to specify the Random tests, it is not stated any specification for methods for replacing them. Also, since the standards related to the verification of resistance of products are specified by others standards, they are not included in this Standard.

4.2 Classification of test conditions according to target products

The PSD characteristics applied on the tests have been classified into two types, Pattern A and Pattern B. These patterns, in turn, are divided by levels I, II and III, according to the severity of the transportation conditions.

Pattern A

The Pattern A is the case for reproducing the process which leads to a fault of components, particularly the weak ones, due to fatigue through a repetitive force. It is based on the concept of S-N curves applied for metallic pieces. (see Narrative Fig. 2)
This pattern is applied to the packages covering the following conditions.



Narrative Fig.2 S-N Characteristic Curve for Metallic Pieces

1) In case that the content of the package is an industrial product: Considering that the fault is reached due to the application of repetitive forces on the weak portion, the use of Pattern A is the most adequate.
2) For the case of the target is a container for food product: This is the case when the fault is reached by the exfoliation of the films of containers placed in the lower part of a cargo, and produced due to the weight of upper portion.

Also, in the case of packaged freights with contents other than industrial products, and if the origin of the faults are assumed due to weights or repetitive loads, it is recommended to define the test conditions analyzing the collapse characteristics as Pattern A.

Pattern B

The Pattern B is the case to reproduce the fault conditions such as product leaks due to pin holes in the container bags, originated by the friction caused by vibrations. It is applied particularly for packages influenced by some frequency band and number of oscillations. The applicable packaging conditions are indicated below, and it is not applied to industrial products.

1) Packaging of food products, where the fault appears as product leak due to generation of pin holes on a portion of the container bags, originated by friction.

Regarding the divisions of each condition, they are described in the items 1 to 4 of the main part of this Standard.

4.3 Frequency range of vibrations

The frequency range have been defined for each Pattern case by case. For Pattern A, it is from 5Hz to 100Hz; for Pattern B, it is from 3Hz to 50Hz. The reasons are described below.

4.3.1 Lower Frequency limit

1) The total mass of the foundation required for installing a vibration test apparatus, normally it is considered to be 100 times higher than the mass of movable parts. Moreover, for obtaining a stable vibration, it is required a 200 times foundation mass. Since there is no any merit in reproducing low frequencies, lower than those required the lower frequency limit has been fixed considering only the net low limit required.

2) Since the Pattern A has an objective the products in which the fault is produced due to repetitive loads, as indicated in Clause 4.2, where big accelerations or low frequencies are not present, it will be enough reproducing frequencies around 5Hz.

3) Regarding to the Pattern B, since the purpose is to reproduce frictions stemmed from displacements, the necessary condition is the reproduction at low frequencies. Therefore, it was fixed as test range the frequency of 3Hz, which are present in the load platforms of transportation vehicles.

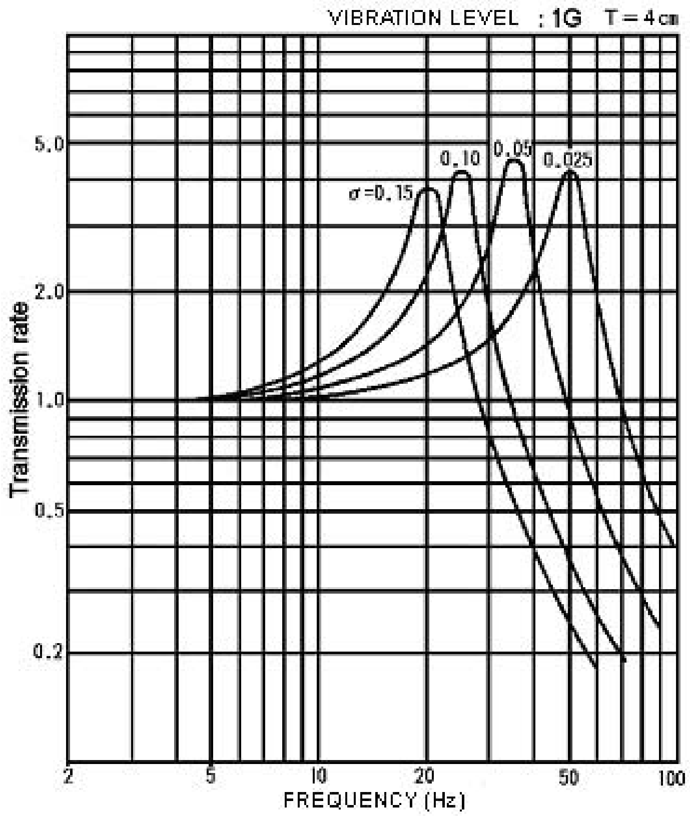
4.3.2 Upper frequency limit

1) Regarding to the Pattern A, the upper frequency limit has been fixed considering the vibration transmissibility to the product. When a vibration oscillation is transmitted to a packaged cargo, the low band frequencies are transmitted directly to the product as it is.

But the high frequencies are not totally transmitted, depending on the packaging materials. This phenomenon is especially remarkable in the case of packaging using expanded plastics as cushioning material. The reason is because the expanded plastics have the characteristics of decrease suddenly the vibration response once exceed their own natural frequency (see Narrative Fig. 3).

Up to now, a frequency of 50Hz as upper frequency limit was considered enough, but according to the last tendencies of packaging, originated on environmental aspects, there is an increasing utilization of cushioning materials made by paper cellulose, so that it can be said that the adequate upper frequency limits are slightly higher than those applied up to now.

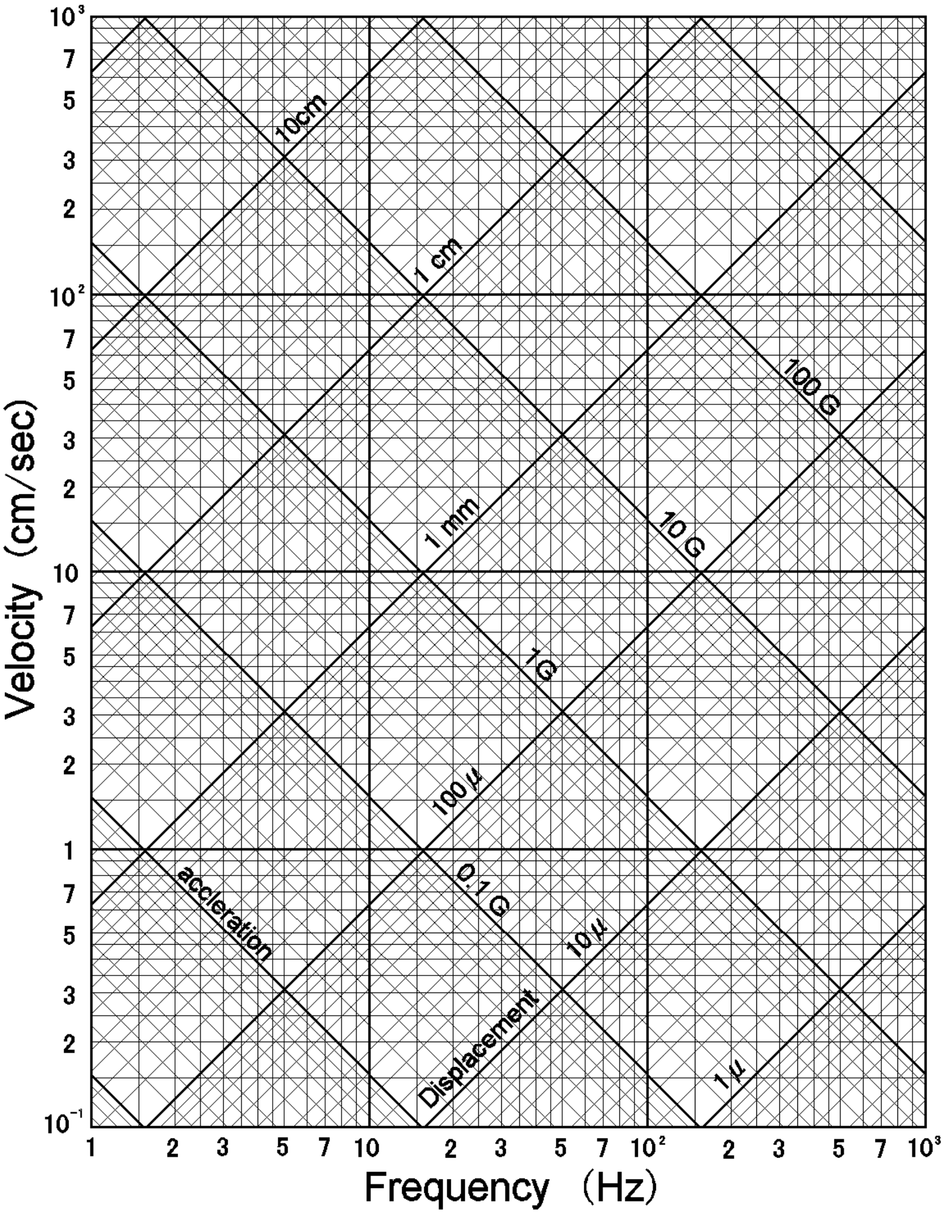
Taking into consideration all these aspects, the upper frequency limit has been fixed as 100 Hz.



Narrative Fig.3 Examples of Response Curves of Expanded Plastic Cushioning Materials

2) The Pattern B is the test case where the main parameter is the vibration amplitude. For oscillations of 50Hz and 1G, the half wave is no more than 100μm (see Narrative Fig. 4). So, for a vibration of higher frequencies, there is no influence to producing a friction, since

the vibrations will be absorbed for almost all the usual packaging materials. Taking into consideration this fact, the upper frequency limit has been fixed to 50Hz.



$A = (2\pi f)^2 d$、 $V = (2\pi f)\ d$

Where A: Oscillation acceleration (cm／sec^2)、

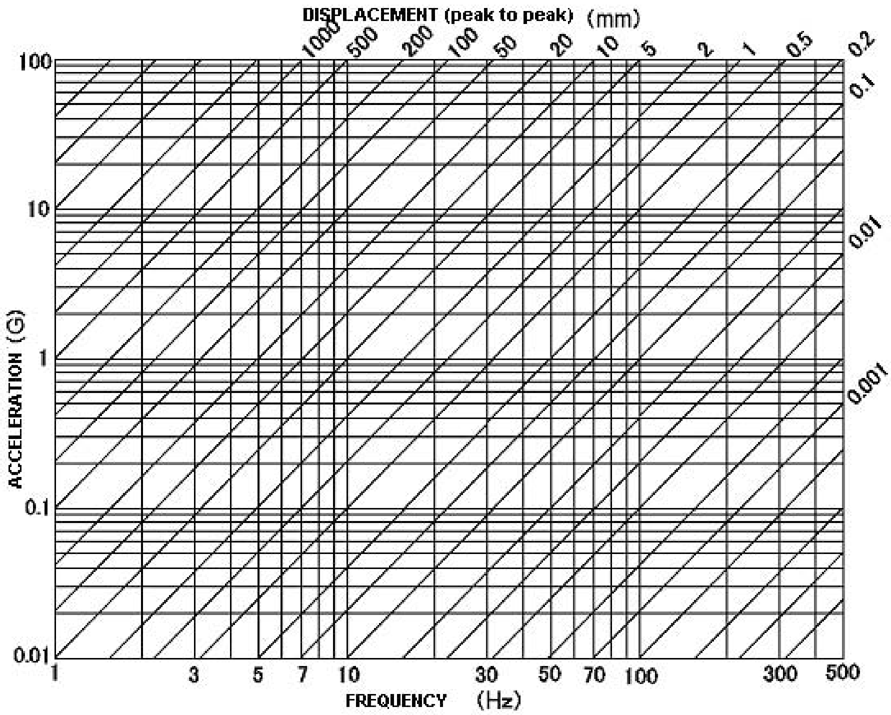
V : Oscillation speed (cm／sec)

f : frequency (Hz) d: displacement (half wave) (cm)

Narrative Fig. 4 Vibration Chart of Multiple Parameters

The multiple parameter chart of Narrative Fig. 4 is the element linking the 4 parameters of a sinusoidal wave, this means, frequency, acceleration, speed and displacements. The relationship can be seen directly on the chart; for this reason this chart is useful and appreciated.

Regarding to the chart mentioned above, the other chart including frequency, acceleration and displacements is also widely used. The displacement data are abbreviated since this is no so much used. The charts for 3 parameters are shown in Narrative Fig. 5.



Narrative Fig. 5 Vibration Chart for 3 Parameters

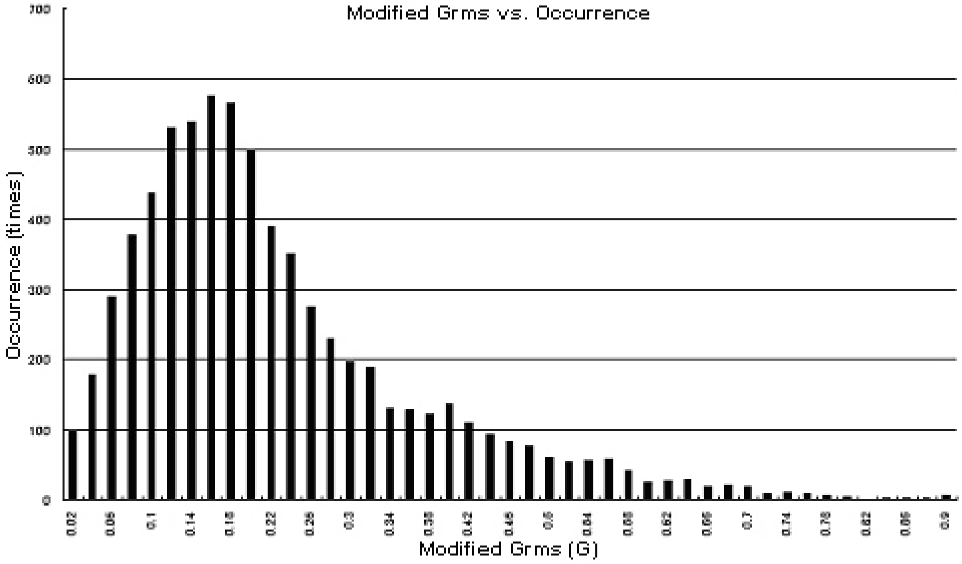
4.4 "Shim" tests

The "Shim" test is specified in standards such as ISTA (5). On this test, a metal plate named "shim" is used (2" x 10" x 1" size) which is placed between the vibration table and the specimen. This plate can be moved horizontally by short displacements, left and right, when vertical vibration test is carried out.

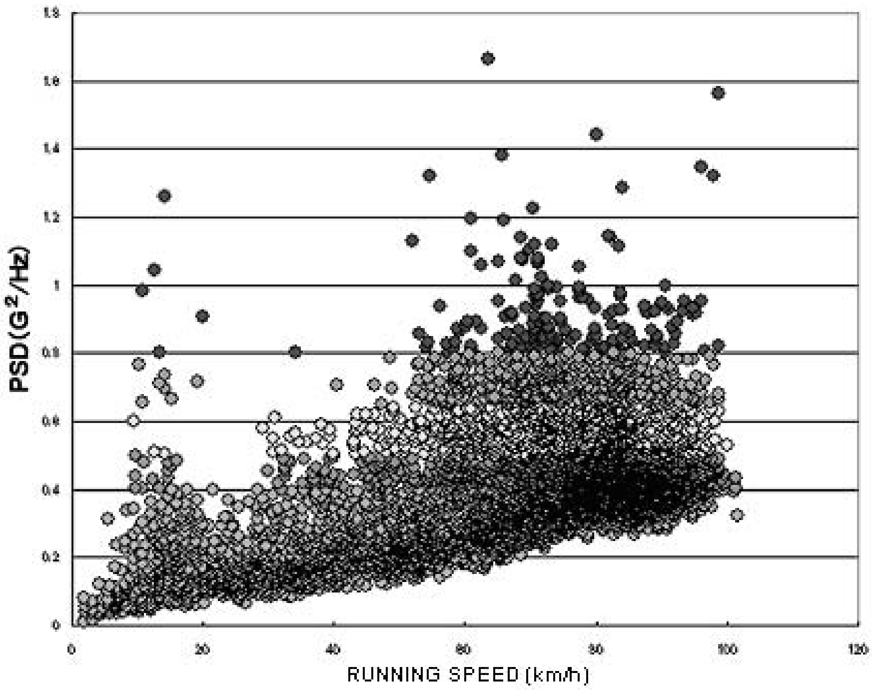
Through this method, high accelerations are generated since in some instants the specimen is jumping falling apart from the vibration table, and then impacting on them repeatedly.

This test has the purpose to reproduce the phenomenon of high accelerations, over the range of random vibrations on the roads (Very frequent on bad conditions routes).

(see Narrative Fig. 6 and 7).



Narrative Fig. 6 Effective Acceleration and Occurrence Times



Narrative Fig. 7 PSD and Vehicle Speed Relationship

Therefore, this test is not carried out independently but it must be combined with Random tests. Depending on the test levels, there are some cases where this test is not carried out.

Furthermore, since this test implies the application of oscillating loads on the equipment table by bouncing of the sample, it is highly probably that vibration overloads are generated on the machine. Consequently, in case that the number of bounce is very high, it can be decided to replace the tests by impact tests.

The impact tests are carried out according to the MERCIS E 202 Standard. The test conditions will be in accordance to Table 3.1 (b) to 3.6 (b) of Annex A of this Standard.

4.5 Reference bibliography

Normally, the standards do not include reference bibliography. But, considering that the route information is very important for this Standard, and the necessity to clarify the basis of all the discussions developed, the reference documents have been incorporated as a part of the narrative section.

Bibliography:

1) JICA cooperation Study – Final Report- (March 2007)
2) Argentina Traffic Office (Dirección Nacional de Vialidad) – Road Status Report
3) JIS Z 0232- Packaged freights - Method of Vibration Test (2004)
4) K. Hasegawa -“Determination of Packaging Test Standards, based on Transportation Environment Survey data–Japan Packaging Association MagazineVol.13 Nro.2.(April 2004）
5) ISTA – “Package Testing” Test Procedure 1-A.

6.4 Reference Guideline for Packaging Tests, for Evaluation: Data Input into the Database (DB)

Based on the data classification for the DB discussed and mutually agreed on February 16, 2006, at the time of the Joint Meeting of 4 member countries for the presentation of the Progress Report of this Study done on May 2006 (Campinas, Brazil), - starting point of the 3rd year of activities, the whole data have been transferred to each counterpart institute through a hard disk (HDD).

This DB is prepared by all the gathered information up today, and based on the data classification system indicated above.

On the other hand, the following documents and supplementary information will be added to the DB: a) document of "Reference Guideline for Packaging Tests, for Evaluation", b) background information of route classification based on “grades”, c) others support information.

The details of criteria and validation related to this topic are all described in the Chapter 5 of this report.

Chapter 7 Packaging Design and Testing

Chapter 7 Packaging Design and Testing

7.1 Packaging Design Procedures

The following paragraphs describe the steps required to maintain the quality of products and packaging, in respect of the household appliances selected as target products for this Study.

The five steps for packaging design are: (1) transportation conditions, (2) product resistance control, (3) the study of the packaging material, (4) the packaging design techniques and (5) the packaging evaluation tests. In this case, it is mainly referred to refrigerators.

In this chapter, item (2) will be considered in respect of household appliances.

7.1.1 Product concept for household appliances and packaging design

The main issue to be taken into account in order to develop a product is its outstanding quality and functions; lately, the sum of the product plus its packaging is being considered. Therefore, factors beyond the external aspect of the packaging should be taken into account, considering the life cycle of the product and the distribution process.

In case of industrial products, packaging is determined by the specific life cycle of the product (product characteristics, production, distribution and consumption), and taking into account how consumers accept the packaging and the transportation conditions of the product. Based on that, processes should be reorganized by analyzing feasibility in order to minimize costs, including the product. In this respect, the items to be taken into account when designing packaging, in furtherance of an effective development of the product, packaging and distribution, are described in Table 7.1.1-1.

Table 7.1.1-1 Packaging Design Requirements

1. Characteristics of the product	2. Production line
Size, mass	Conveyor belts structure
External aspect, photograph	Packaging equipment
Price, number of units to be manufactured	Palletizers
Vibration, impact properties	Loading/unloading equipment
3. Transportation environment stress test (see 7.1.2)	4. Packaging tests standards (see 6.3.3)
Transportation	Applicable standards and their effects
Storage	Vibration, compression, drop tests
Handling of the cargo	Cargo handling tests
5. Applicable packaging standards	6. Integral packaging
Labels, caution indications	Standards and regulations
Specifications required by the customer	Specifications required by the customer

Source: JICA Study Team

The following is an example of common household refrigerators, the target product of the Study. In this design, the color was selected to combine with the walls of the house.

Right side Front side Rear side

Source: JICA Study Team

Fig. 7.1.1-1 Product External View (refrigerator)

Design:

As seen in the photograph, the door can be bilaterally opened, to the left or to the right, as required. The design has taken into account drainage details. Since this model opens to both sides, the design is restricted and has specific characteristics since it does not have a handle.

Structure:

The back side of the refrigerator, painted white, is a very thick wall. The appliance is basically a metal box with isolating material adhered to it. However, since the radiator serpentines are exposed, the packaging should protect them.

Compressor:

The compressor is fixed with a clinch, which has a rubber cap to reduce vibrations and ends in a plate stamped protuberance on the tray that supports the compressor.

Door:

The door is placed on hinges. One of the parts of the door is mechanically weak.

The number of refrigerators sold is relatively high and their price is low, so the impact of transportation costs is low as well. In case of long distance transportation, trucks have to carry as many refrigerators as possible, so usually a line of refrigerators is loaded in vertical position plus two lines of refrigerators in horizontal position, or alternatively, 6 horizontal lines.

However, when placed horizontally, the compressor could be subject to additional mechanical efforts. To avoid this, the trucks should be loaded very carefully.

In serious cases, the base or the clinches that hold the compressor could be damaged.

Five years ago, these refrigerators were packed in cardboard boxes. Then, cardboard was replaced for EPS due to price increases. At present, EPS is used under the current specifications.

The different aspects of packaging improvement were analyzed taking into account the latest packaging trends and transportation conditions.

a. Packaging design improvements, taking into account the fragility of the product
b. Packaging design improvements taking into account the "3R"
c. Packaging design improvements to comply with the Reference Guidelines for the Transportation Environment Surveys

7.1.2 Stress test of the distribution environment for household appliances

To perform the stress test of the conditions of distribution of the products, the distribution process itself should be analyzed first. This analysis should include the organizational structure of distribution, storage, transportation and distribution centers, stage by stage. Detailed records of the working methods and the equipment used are maintained. Based on this analysis, the number of times the product has been handled can be determined, as well as the conditions of the loading/unloading equipment, the impacts due to dropping, static compression on the boxes, dynamic compression, vibrations during transportation, etc., obtaining a general overview that can be used to plan the packaging design.

In case of new products, the results of the actual transportation /distribution routes test should be analyzed.

Table 7.1.2-1 shows the results of surveys performed in Japan on household refrigerators. Besides, to supplement this information, Table 7.1.2-2 shows the results of surveys performed on refrigerators in Brazil.

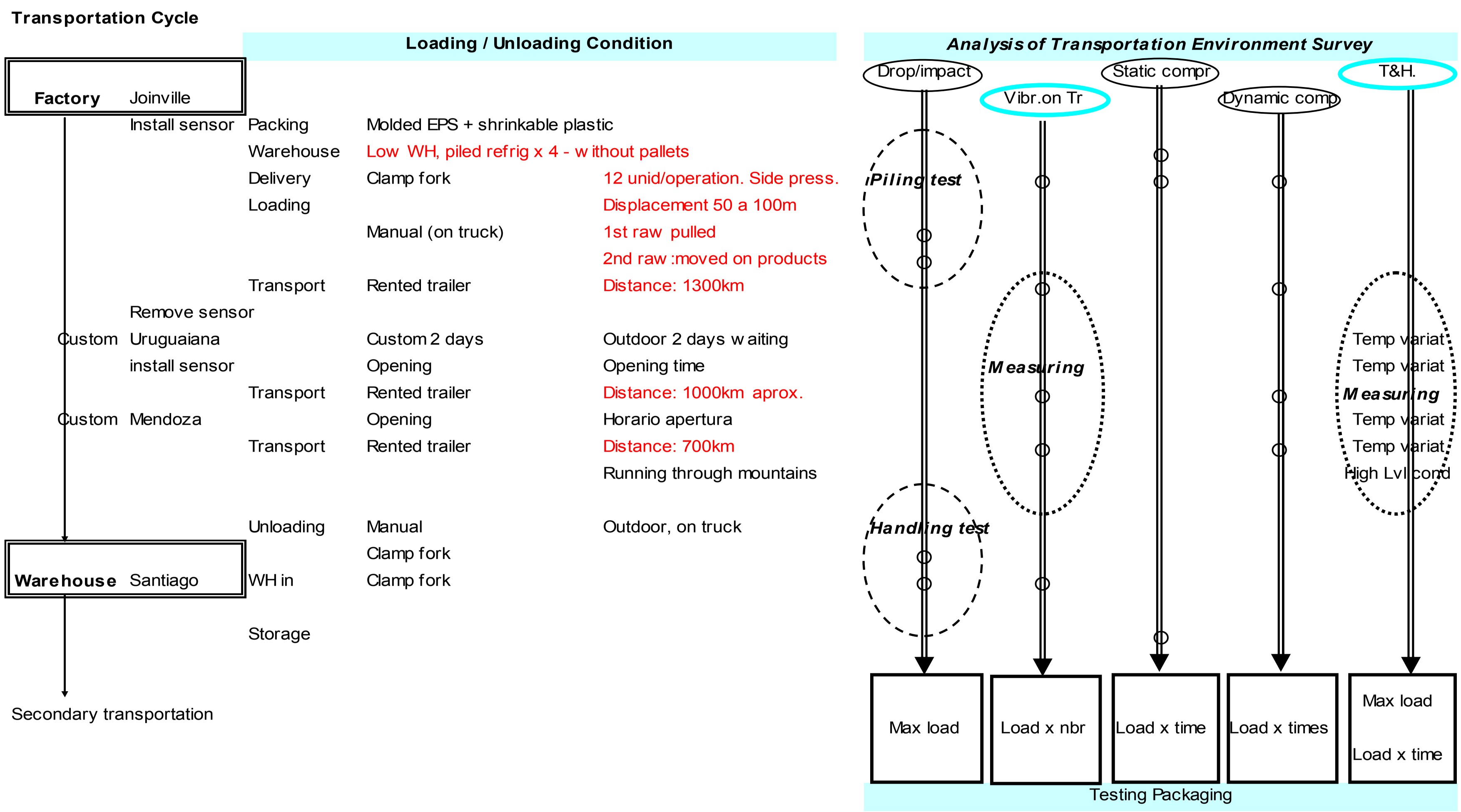
Table 7.1.2-1 Distribution Environment Stress to Refrigerators (example)

	Transportation, storage, loadn/unloading, others			Stress Analysis						
Product flow	Action on distribution	Equipment	Comments about stress	Manual	Mechanics	Fall impact	Other impacts	Static compression	Dynamic compression	Vibration
1) producton line	Palletization	Palletizator palette	1350x2200		□		□			□
2) Factory storage	Handling	Pile with Fork lift	4 units/level/PL/420L distance to around 40m cargo 2 pallets		□		■		□	□
Comm.WH	Warehouse	Palletizer	Cargo 2 pallets - -Storage 2 months max. T 40C 90% RH 1W					■		
	- .- Tr. by truck	12 Ton truck	- Travel around 4 km							□
	Warehouse	Palletized	Cargo 2 pallets					□		
	Transportation by truck	12 Ton truck	Travel around 4 km							□
3) delivery	Handling	Fork Lift	Travel around 15m, cargo 2 palletes		□		□		□	□
	Tr. by truck Tr by train	Handling	1 or 2 persons: Handling. Pull and turn	□	□		□		□	□
4) transportation	Tr by truck	Fork Lift	Travel around 15m, pull and turn							□
	Tr by train	12 Ton truck	Travell around 1300Km.				□		□	□
	Warehouse	Pallete Wagon	1 level, upload turned upside					□		
	Handling	12 Ton truck	Travell around 1300Km. 15Km from the station						□	□
	Truck loanding	Handling	Palletized, pulled and turn	□		■	■			
	Transportation by truck	Fork Lift	Travell around 15m, upload 2 palletes		□		□		□	□
5) WH entry	Download	Palletized Direct Upload	Upload 2 palletes, 2 levels. Warehouse around 1 month. 30-40ºC, 90-95%RH	□						
	Handling	Fork Lift	Travell around 15m, upload 2 palletes		□	■	□ ■		□	□
6) Dist center	Warehouse	Handling	1 person: hanging. Pull and turn	□				□		
	Transportation by truck	4 Ton truck	Delivery truck. Mixed payload with major appliances. Run around 420Km with payload turned above			■	■		□	□
	Download	Handling	Palletized, pulled and turn	□						
7) Delivery	Handling	Handcart	Travell around 15m with high ground				□			□
	Warehouse	Palletized Direct Upload	2 levels upload with 2 palletes 30-40ºC, 90-95%RH					□		
	Truck loanding	Handling	1 person: hanging. Pull and turn	□		■	■			
8) Transportaton	Transportation by truck	4 Ton truck	Route wagon with mixt cargo. Travell allong 260 km. Pull and turn						□	□
9) WH entry	Download	Handling	Pull and turn	□		■	■			
	Handling	Handling	Hang at the back, pulling, turn	□		■	■			
10) WH supplier	Warehouse	Direct upload	1 level, few days					□		
11) Delivery	Truck loanding	Handling	Pull and turn	□		■	■			
12) Transportation	Transportation by truck	Small truck	Cable placing							□
13) WH entry	Handling	Handling	Hang at the back, pulling, turn	□		■	■			
14) shop	Handling	Handling	Dragging ahead packaging stock	□		■	■			
15) delivery	Handling	Handling	Product handling, download and upload stairs. Return of packaging stock	□		■	■			

Handling: aproximately 11 manoeuver	Other impacts: It is required the cargo study respect on the manual maneuver
Mechanic manoeuver: 5 with fork lift and 1 with palletizer in factory	Stactic compression: In storage 2 levels and 3 months
Fall impact: 50 times around during 11 manoeuver. It's considerer the testing manoeuver of falls of JIS to respective step	Dynamic compression: Upload turning above + vibration on travel
	Vibration on travel: on 11 ton truck. And 1800Km more in a small truck 300Km, and run on forklift with 2 levels of full palletes

Source: JICA Study Team

Table 7.1.2-2 Actual Case of Brazil (example)



Source: JICA Study Team

7.1.3 Household appliances production line and packaging

Packaging of large products, such as refrigerators, is limited from the point of view of the production line.

(1) *Assembly line:* The packaging material may not be adequately transported on the conveyor belt (especially soft materials or those easy to bend). They should be considered in the product assembly stage.

(2) *Problems related to the packaging equipment:* The production line platforms should have a hole at the bottom to allow the passing of air during the shrinking process when using shrink type material.

(3) *Packaging of accessories:* this allows for the reduction of steps (the method used to pack the accessories should be defined).

7.1.4 Design of packaging for dairy products

The following is a summary of the tasks required for the design of packaging for dairy products as well as the specific details corresponding to milk pouches, aluminum foil lids for yogurt pots and milk jam pots.

(1) Design and evaluation of packaging for dairy products

To design (re-design) packages, the specifications of the currently used packaging should be determined and then establish the objectives of the new design. These factors should be taken into account throughout the whole design process.

1) Packaging design and objectives

[1] Level of security and hygiene of the product

[2] Level of protection (mechanical, thermal, moisture resistance, gas or water barrier properties)

[3] Workability (handling of the packaging, mechanical and filling properties)

[4] Cost effectiveness (production-materials-transportation, final price of the product)

[5] Functionality (easy to transport, easy to open)

[6] Marketability (display effects, easy to display)

[7] Environmental adjustment capacity (waste treatment and recycling properties)

2) Packaging design and pilot sample evaluation procedure

The evaluation procedure is carried out step by step making the pertinent adjustments.

[1] Step 1: Evaluation of the pilot sample (manual)
After completing the design of the improved packaging, a sample is manually prepared and evaluated. Tests are performed using sensors and other devices. Sensor tests are very important as well as those to verify whether the packaging is easy to open.

[2] Step 2: Evaluation of the sample using mechanical equipment
Mechanical tests are performed as well as tests using sensors and devices. The mechanical properties of the packaging are also tested. In case of difficulties, the design shall be modified.

[3] Step 3: Market evaluation tests
A small batch is prepared using the redesigned packaging and launched to the market for evaluation in a selected area. Comments not considered during the design stage could be made by consumers such as: consumer friendly product, handling difficulties or failures, etc.
All the comments both from consumers as well as from the carriers should be taken into account, analyzed and considered when redesigning the packaging.

[4] Step 4: Launching of the improved packaging to the market
The improved packaging is gradually marketed. If problems arise, new modifications should be made.

3) Mechanical evaluation of the pilot sample

The redesigned packaging is tested using sensors, opening tests and mechanical tests are also performed to analyze resistance.

[1] Drop tests
[2] Compression tests
[3] Hot seal tests
[4] Sealing tests
[5] Vibration tests

(2) Pouches for dairy products

Pouches for dairy products are prone to leak both through the body of the pouch as well as through the upper and lower seals. Leaks through the body occur due to a deficient central sealing line, which is a “pillow type joint”, sealed by heating only one side. This kind of sealing should be replaced by a method whereby the 2 sides are heated.

The upper and lower seals are of the “melting and cut” type. This method uses a heated piano string that cuts the pouch simultaneously melting and sealing it. Therefore, the width is very small so security is compromised.

In conventional pouches the sealing is of approximately 5 mm wide, so the level of security is also high. To solve the leaking problem of pouches, the existing filling machines should be modified, which is very difficult. Therefore, this alternative should not be considered when determining the improvement of sealing methods. However, even if the existing machines are used, this problem may be solved by carefully monitoring the heat sealing operations and increasing quality control. This is so because different results were obtained among the different companies and in samples from the same company (see 7.3.3.1 and 7.3.4.1).

To improve packaging design using the existing equipment, the LDPE film material specifications should be modified.

L-LDPE linear low density polyethylene has excellent sealing properties, higher sealing strength, better sealability with impurities and better hot-tack properties. Therefore, the percentage of this L-LDPE should be increased.

(3) Aluminum foil lid for yogurt pots

Aluminum foil lids are prone to occur pin holes during transportation, causing leaks. Besides, the material may tear when opening the pot. The opening properties can be improved reducing the adherence of the adhesive band. However, a pot that has both function of good sealing properties and easiness to open is very difficult to obtain.

If aluminum vapor deposition film is used, pin holes during transportation and tearing problems would be reduced, but this material cannot be used in the existing equipment because the film curls.

To solve the tearing problem, the material should be changed, i.e. aluminum foil laminated with plastic should be used.

(4) Milk jam pots

During the vibration tests performed on milk jam pots, it was seen that pin holes are caused by friction between the external plastic cap and the internal aluminum foil lid, causing leaks.

Besides, it was found that, in addition to friction, the fatigue of the aluminum material also generates leaks.

Consequently, the plastic cap was modified to avoid contact with the aluminum foil. Besides, the aluminum foil material should be replaced by plastic laminated foil.

7.2 Packaging Materials

7.2.1 Flexible packaging film[1]

Within the range of flexible packaging, the most major one is pouch packaging.

7.2.1.1 Base material of the flexible film

There are two types of flexible packaging films: a) monolayer (not laminated) and b) multilayer (laminated). The following is an easy way to identify them: when the front of the packaging is printed, the material is monolayer, such as the packaging for bread and cookies. Packaging with high quality printing use multilayer film. From the point of view of materials, the latter is the most important one.

The external layer of the multilayer film is called base film. To manufacture a bag, a sealing process is needed. In case of flexible films, hot sealing is used because the material can only be sealed by heat and cold. It has excellent properties as regards speed, low cost and stability.

The internal layer of the multilayer film (adhered to the other ones) allows for hot sealing and is called "sealing material". In addition to these two layers, multilayer films sometimes have a third layer with gas barrier properties called "middle material".

The base film is mainly made of oriented polypropylene (OPP), polyethylene terephthalate (PET), Nylon and vinylidene (PVDC). Table 7.2.1-1 shows the properties of the three kinds of materials.

Table 7.2.1-1 Properties of the Films per Type

Property	Unit	O-Nylon	PET	OPP
Thickness	μm	15	12	20
Tensile strength	kg/cm²	2500	2200	1900
Elongation	%	100	150	100
Tensile resilience	Kg/mm²	100	430	200
Bursting resistance	kg/cm²・mm	250	150	130
Impact resistance	kg/cm/mm	350	250	300
Pin hole resistance puncture diameter 0.49Φ	kg/mm	80	75	60
Pin Holes due to bending film 60μ, GELBO	unit	2 (5000times)	1 ~ 5 (300times)	2 (3000times)
Pin Holes due to friction	times	200	60	20
Vapor permeability ratio	g/m²・24hs	250	50	10
Oxygen permeability ratio	cc /m²・24hs	45	120	2200

[1] Source: Ohsuga, Hiroshi. "New Food Packaging Film – Flexible Package / Theory and Application". Nippo Co., Ltd.

Property	Unit	O-Nylon	PET	OPP
Moisture absorb 20℃×60%RH	%	3 ~ 4	0.4	< 0.1
Melting point	ºC	215	264	165

OPP is pretreated oriented polypropylene, that is expanded in two directions. It has moisture barrier properties and within the olefin films it has excellent transparency, resilience, low temperature and impact resistance properties.

CPP (cast polypropylene) not pre-expanded has better heat resistance properties than LDPE (low density polyethylene) so it is used to seal retort type packing.

PET film is made by a polymer similar to that used in PET bottles and is obtained from the polymerization of ethylene glycol y terephthalic acid obtaining the polyethylene terephthalate.

When used as base material, PET film is pre-expanded in two directions.

PET has excellent mechanical properties due to this bi-directional pre-expanding, and partly due to the crystallization of molecular chains.

Besides, it has good stability properties in case of high temperatures and chemicals as well as transparency, smells and gas barrier properties. However, it has no properties in respect of pin holes due to bending.

Nylon used to be the name of a product manufactured by DUPONT, but in time, the material itself was called like that. In chemistry, this material is known as polyamide fiber. The amide radical is formed by an amine radical and an acid, releasing water. It is called "polyamide" because its molecules have numerous amide radicals. Therefore, it is the generic name of several substances.

The Nylon used in flexible packaging is Nylon-6. The Nylon used as base material is usually pre-expanded in 2 directions, and is known as O-Nylon.

The Nylon used for packaging food, in special, is very well known due to its good resistance to pin holes due to punctures, bending and friction as well as for its drop resistant bags. It has good gas barrier properties but since its molecular composition has NH2 radical, if the relative moisture increases, it may absorb water, so its barrier properties decrease. Besides, the MXD-6 (Metaxylene diamine 6 – Nylon) is used only in certain applications due to its low oxygen permeability.

7.2.1.2 Characteristics of sealant films

Since base film cannot be subject to hot sealing, the internal side of the base film is adhered to this kind of film. It is manufactured in the following manners: a) lamination by extrusion (film adhered during the extrusion of the polymer), b) dry lamination (the film is adhered to an already existing film), c) wet lamination, and d) simultaneous multilayer extrusion. The characteristics of sealing film are the following.

(1) Sealing strength

In case of flexible plastic pouches, sealing strength is essential. This type of film sealing strength is a key factor, i.e.

(2) Quality of the "sealability with impurities"

The package is sealed once it is filled. In this stage, the sealing surface is usually covered with the product. In case of TETRA cardboard packaging, for example, the sealing is wet. This type of sealing, that provides good sealability even in case of external substances, is called "sealability with impurities".

(3) "Hot Tack" properties

When the "vertical pillow" pouch is filled, from the sealing of the upper part (using horizontal sealing bars) to the final cutting by the end of the process, the pouch usually opens due to its own weight (with the product) since the sealing is not adequately cold. Sealing materials that do not open at this stage are said to have "good Hot Tack" properties. In general, this property is measured by the unfolding distance. As regards resins, a material with high viscosity when melting is required.

(4) Low temperature sealing properties

In general, this term applies to materials with quick sealing properties as well as in respect of: a) materials with very thick lamination, b) structures with a third film layer, and c) materials with low resistance to heat.

Table 7.2.1-2 shows the characteristics of the above mentioned sealing polymers with these properties and their sealability properties.

Table 7.2.1-2 Comparison Table of Sealant Films

		LDPE		L-LDPE		Iono -mer	EVA VA5%	CPP
		MI Low	MI High	Met. infated	Met. T die			
Seal ability	Hot seal resistan.	○	○	◎	◎	◎	○	◎
	Seal. Low Temp	○	○	×	×	◎	◎	×
	Seal. Impurities	△	△	○	○	◎	○	△
	Hot Tack prop.	△	△	◎	◎	◎	○	◎
Heat resist	Water 80C aprox.	◎	◎	◎	◎	○	◎	◎
	Water 90C aprox.	◎	△～○	◎	◎	×	×	◎
	Water 100C approx.	△～○	×	◎	◎	×	×	◎
	Retort 120℃	×	×	×	×	×	×	◎

		LDPE		L-LDPE		Iono -mer	EVA VA5%	CPP
		MI Low	MI High	Met. infated	Met. T die			
Cold Resist	Approx. 0ºC	◎	◎	◎	◎	◎	◎	△
	Approx. -20ºC	○	○	◎	◎	○	◎	×
Drop resist as sack		○	○	◎	○	○	◎	△
Pressure Resist		○	○	◎	○	○	○	×
Pin hole resist due puncture		△	△	○	○	△	○	×
Friction Resistance		△	△	△	△	△	×	△
Grease Resistance		△	×～△	○	○	○	○	◎
Flexibility		△	△	△	△	△	○	×
Transparency		△	△	△	◎	△	△	◎
Low odor		○	○	×～△	×	○	△	○

◎ : Excelent ○:Good △ : Satisfactory ×:Bad MI : Melting Index
LDPE: Low Density Polyestyrene L-LDPE: Linear Low Density Polyestyrene
EVA: Ethil Vynil Acetate copolymer VA: Vynil Acetate CPP: Cast Polypropylene

7.2.1.3 Sealant Film Types

Sealant films are mainly polyolefinic materials, classified as polyethylenes and polypropylenes.

High density polystyrene (HDPE) is easily crystallizable due to its linear ethylene chains (not branched). It has a high mechanical strength, and therefore widely applied in packaging. It is not used as sealant.

Low density polyethylene (LDPE) has randomly branched chains. It has been applied as sealant since its introduction.

Linear low density polyethylene (L-LDPE) has short chains, like LDPE. It is a linear low density polyethylene.

Fig. 7.2.1-1 shows the structure of branched and linear polyethylene.

Linear low density polyethylene (L-LDPE) comes from the polymerization of low quantities of certain hydrocarbons (co-monomers). Depending on the L-LDPE type they can be C4 (butane), C6 (hexane) or C8 (octane). The structure design is such that short chains are linked to a main chain

C4 type L-LDPE is the most widely applied one. On the other hand, C6 and C8 ones have better mechanical strength properties.

L-LDPE properties are better when compared to LDPE's, regarding hot sealing strength, sealability through product and Hot-Tack properties, as shown in Table 7.2.1-2. Furthermore, it has good resistance qualities to oil and to puncturing pinholes.

Fig. 7.2.1-2 shows the relationship between hot sealing temperature and seal strength. Lately, some L-LDPE-like materials, polymerized with metallocene catalysts have been introduced.

Molecular distribution is very tight, and co-monomers are uniformly distributed, when compared to traditional Ziegler-Natta catalyzed product. Consequently, its mechanical properties are outstanding.

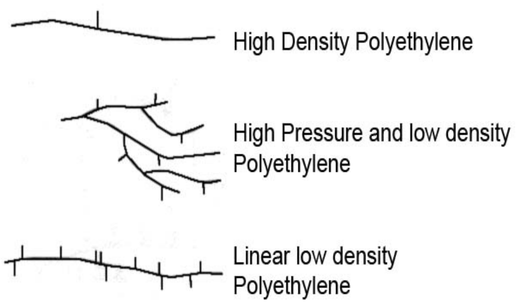


Fig. 7.2.1-1 Polytehylene Structure

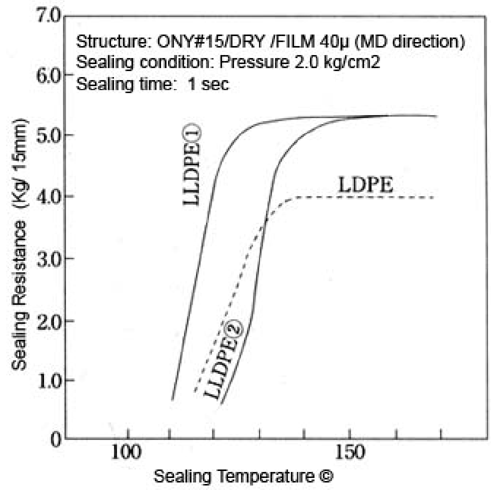


Fig. 7.2.1-2 Seal Resistance vs Sealing Temperature

Cast polypropylene (CPP) is the polypropylene (PP) sealant. It is a not pre-stretched material. Mainly, it is available the ethylene 2 to 5% polymerized material and the propylene-ethylene-butene-1 material.

L-LDPE is used for containers that are to be boiled and CPP for retort containers to be heated above 120ºC

As stated above, L-LDPE has a better sealability than LDPE, and it is 1 to 2 per cent cheaper, also. The melting point changes with the density: the melting point for LDPE (density=0.92) is 119ºC, while for L-LDPE is 10 to 15ºC higher. Moreover, hot sealing temperature for LDPE is 130ºC, while for L-LDPE is above 150ºC.

Regarding L-LDPE film manufacturing, probably it cannot be handled with quite old machinery, due to its high melting point, and sealing devices in packing machines may not be suitable due to the low thermal capacity of the sealing clamps.

7.2.1.4 Film and intermediate sheet structure

The following three variants have to be considered:

(1) Single layered film (base film)

The base film acts as sealant film as well. Example: the single layered LDPE film used to pack sugar, salt, cookies, kidney beans, etc.

(2) Double layered film with base film and sealant layer

Example: PET/LDPE vacuum containers, ONY/LDPE food containers for cooling, OPP/LDPE containers for dry food, ONY/LDPE containers for fluid food and PET/CPP retort food containers.

(3) Triple layered film with base film, intermediate sheet and sealant layer.

When the film required qualities cannot be achieved with only a base film and a sealant layer, there are some options for quality improvement. Example: a film made of OPP/gas vaporized Al/PET/CPP can be used for light blocking improvement, as in potato chips containers. Films made of OPP/EVOH/CPP are used for oxygen gas barrier containers.

7.2.2 Aluminum Foil[1]

(1) General Features

The most known aluminum foil is the 99.3% purity one, identified by JIS standard as 1N30. In recent years 8021 Al-Fe alloy is being used. It has the same properties as JIS 1N30, plus high moldability and good gas barrier quality.

Aluminum foil use in flexible packaging is spreading and growing due to its excellent features as gas and light barrier, the decorative properties of the metal shine and the easy-to-cut quality. The usual aluminum foil thickness used for packaging is 7 μm, and 9 μm in a less extent. There are special cases: 12 to 15 μm thickness aluminum foil is used in cheese packaging, 15 to 20 μm in PTP containers and 20 to 40 μm aluminum sheets for sealable covers.

There are two kinds of aluminum foil: soft and hard. Soft aluminum foil is used in most flexible packaging items. It is manufactured from the hard one by means of annealing at 400ºC. Moreover, one of the aluminum foil faces is bright while the other is opaque. For the 50 μm foil manufacturing 2 foils are rolled together, and the brilliant face will result the one facing the rolls. Aluminum foil features are shown in Fig. 7.2.2-1.

[1] Source: Ohsuga, Hiroshi. "New Food Packaging Film – Flexible Package / Theory and Application. Nippo Co., Ltd.

Table 7.2.2-1 Physical and Mechanical Features of Aluminum Foil

Foil thickness（μm）			7	9	12
Sample thickness （μm）			6.4～7.6	8.3～9.7	11.1～12.9
Unit weight（g/m^2）			17.3～20.6	22.5～26.3	30.1～35.0
Specific area (m^2/kg)			57.7～48.6	44.5～38.0	33.2～28.6
Tensile strength（kg/15mm）	Hard	Vert	1.7	2.0	2.8
		Horiz	1.8	2.1	2.9
	Soft	Vert	0.7	0.9	1.2
		Horiz	0.6	0.8	1.2
Elongation（%） reference distance 100mm	Hard	Vert	0.8	1.2	1.3
		Horiz	1.4	1.9	2.4
	Soft	Vert	3.6	4.4	5.4
		Horiz	4.3	4.7	6.0
Burst strength（kg/cm^2）	Hard		0.35	0.50	0.8
	Soft		0.33	0.45	0.6

Aluminum foil below 20～25μm is well known to have pinholes. Single foils are oxygen permeable, therefore plastic laminating or lacquer coating shall be used.

(2) Pin Holes

Aluminum foil is a good gas barrier; nevertheless it is an easy-to-tear material. Furthermore, it is well known to have pinholes due to material heterogeneity. Here below, we describe the methods designed for plastic film investigation of pinholes.

There are three kinds of pinholes: a) puncturing/punch pinholes, b) edge friction pinholes, and c) bending fatigue pinholes. For example, the following formula shows the puncture strength of a laminated film evaluated with a 0.5mm diameter pin:

Breaking strength x 2 π x 0.5mm

Calculated and actual values match with a narrow closeness.

The breaking strength for soft aluminum foil 9μm thick is 1.9 kg/15 mm while the elongation rate is only 5%.

Calculated puncture strength is 120g and actual measurement gives 30g. There is a wide difference between calculated and actual values; nevertheless pinholes appear notwithstanding the application of small forces.

In some real cases (potato chips' edges) the product stabs through plastic film generating pinholes. As per bibliography, an effective preventive measure is to use plastic laminated films with a 5.7 kg breaking strength for 10 mm width.

Friction pinholes are directly correlated to material wear. It is defined as the accumulated pressure value due friction displacement in a unit area. In practice, friction pinholes appear because of the sharp edges of the container's folds. Taking a sheet of laminated film, folding it twice, and placing a fingertip just in the pointed corner obtained anybody can prove that the level of pain varies with the film material and its thickness. For a given load: the lesser the supporting area for the load the higher the pressure value per unit area. Consequently, the sharper the contacts end the higher the pressure as well as the wear, leading to the outcome of pinholes.

For the bending or flexing fatigue pinholes the breakage is similar to that of repetitively bending a piece of wire. The same happens in plastic films. Fatigue is provoked by the application of repetitive loads, and when it leads to a breakage it is called fatigue breakage. Material bending fatigue pinholes are an example of fatigue breakage.

The most reliable method to test flexing fatigue is the GELBO Tester under ASTMF 392 standard that evaluates the number of repeated folds and the resulting quantity of pinholes for each type of plastic film.

There are no significant expectations regarding the aluminum foil strength. Therefore, it has to be bond to either a paper or a plastic film for packaging manufacturing. Notwithstanding that, even a PAPER/Al/ LDPE film shows clear pinholes after being repetitively folded (10 times) in the GELBO test. On the other hand, there is no pinhole generation after repetitive load testing (250 times) performed on simple materials as aluminum deposition PET, and it is scarce after bending tests.

7.2.3 Plastic film with vacuum metal deposition[1]

Metal vapor deposition (metallizing) is a vacuum metal vaporizing process that lays a very thin metal layer on plastic film or paper surfaces. Aluminum is the most frequently vaporized metal, among others like gold, silver, copper, chromium, nickel, cobalt and their alloys.

Deposition is a metal vaporizing technique that takes advantage of the fact that vaporizing temperature falls when vacuum increases. For example: aluminum vaporizing point is 2,060ºC; when submitted to 10^{-2} or 10^{-4} torr vacuum it lowers to 1,148ºC and 927ºC respectively.

Vacuum deposition equipment is usually furnished with two vacuum chambers. The upper chamber bears the feeding reel and the final reel, at a vacuum level of 1.3 Pa (10^{-2} torr). The lower chamber has the vaporizing and heating devices, with a vacuum level set at 0.013 Pa (10^{-4} torr). The vaporized metal reaches the base paper or plastic material and it is cooled by the refrigerating rod, and the film is rolled on reels.

[1] Source: Ohsuga, Hiroshi. "New Food Packaging Film – Flexible Package / Theory and Application. Nippo Co., Ltd.

Aluminum deposition film is the most popular one for containers manufacturing.

(1) Aluminum deposition film

Aluminum deposition film of 40 to 60 nm thickness is the most widely applied in containers manufacturing due to the following properties

1) Excellent gas and moisture barrier properties
2) Excellent UV/IR barrier properties
3) Excellent odor protection properties
4) Better flexibility and higher pinhole resistance than aluminum foil
5) Excellent decorative material
6) This material promotes natural resources saving, because its weight is 100 to 200 times less than aluminum foil's.

Plain aluminum foil is mostly used in 7 to 8μm thickness. Deposition aluminum film is dramatically thinner: from 40 to 80 nm (0.04 ~ 0.08μm). This fact clearly points out how thin these kinds of layers are.

The most common base films for deposition are: PET, CPP (Cast propylene), OPP (Oriented Propylene), ONy (Nylon).

(2) Transparent deposition film

The following are disadvantages of the deposition aluminum film: lack of transparency to see the contents, not microwave safe, difficult to apply in retort containers. Considering that silicon oxide shows opacity properties under X rays, it is named "vaporized glass".

Silicon oxide film, symbolized as SiOx, has two variants: brown silicon oxide (SiO) and colorless silicon dioxide (SiO_2) or silica.

Silicon oxide's gas barrier properties decrease with oxygen content. Therefore the SiO oxygen content is controlled during the vaporization process in a range of 1.5 to 1.8.

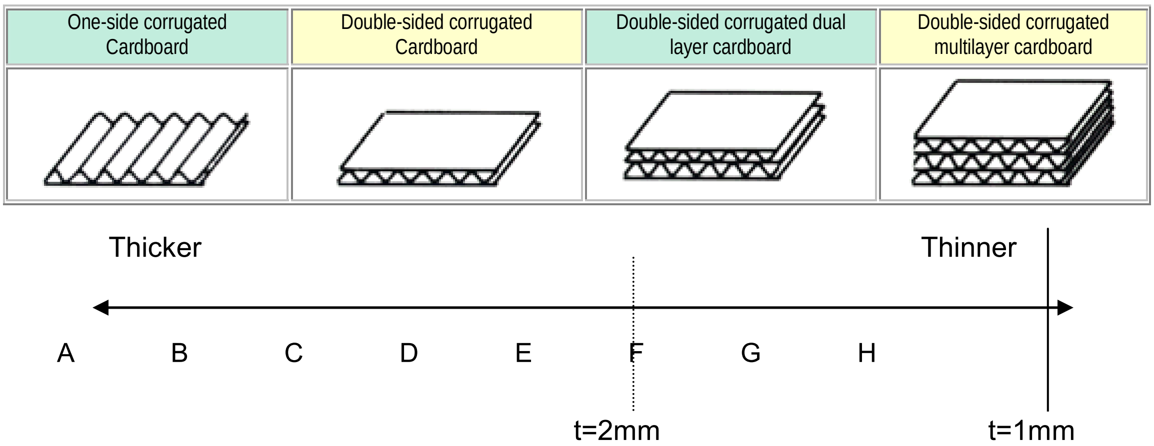
The barrier quality of this deposition film is proportional to the deposition thickness. Anyway the gas barrier quality stability is greater than the one of the films laminated with other materials. Oxygen gas transmission of laminated plastic films is between 0.5 and 1.5 cc/m^2 · 24hs, and for water steam it is approximately between 1 to 3 g/m^2 ·24 hs.

Aluminum oxides deposition films are obtained by alumina (Al_2O_3) deposition on a base film. These are colorless materials.

7.2.4 Corrugated cardboard

The case indicated in this clause is the material of corrugated cardboard manufactured in Brazil. KLABIN *Embalagens* is one of the biggest paper companies in Brazil. The company possesses 9 factories is Brazil, and the mission focused the visit on the Jundai factory, which works since 1992. A number of different classes of cardboard are produced at this factory (see grades E to A as described below).

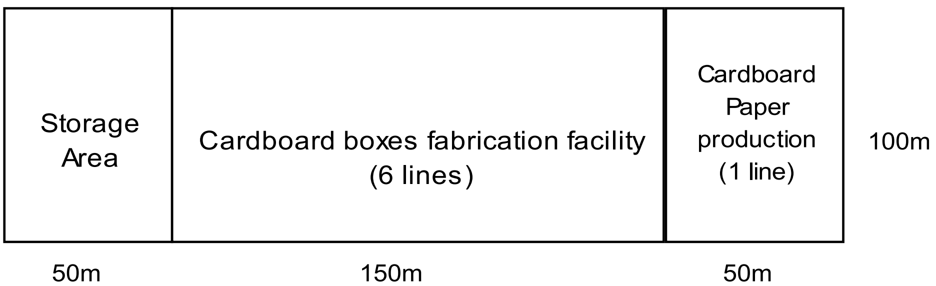
Light: 350 g. per m^2 , liner 110 g. per m^2 core 95 g. per m^2
Heavy: 2100g per m^2 double-sided corrugated multilayer cardboard, Liner 110 g. per m^2 , core 95 g. per m^2
(Used for cigarette packing. Compression strength up to 15 tons)



Source: JICA Study Team

Fig. 7.2.4-1 Range of Manufacturing of Corrugated Cardboard

Corrugated Grade H thickness is less than 1 mm, and it is not manufactured by this company yet. In Japan, the material of this grade was considered as "common carton" (due to external appearance). In recent years, due to the influence of the application of "Packaging Recycle Law"[1] the actual tendency is that, even for so thin materials, to be considered as "corrugated cardboard".[2] This material of small thickness is known as "microflute" in Japan.



Source: JICA Study Team

Fig. 7.2.4-2 Cardboard Factory General Layout

[1] NT: According this Law, the manufacturers which are using "recyclable common materials" must pay a tax per ton, for subsidize the recycling program. But the corrugated cardboard is exempted to pay this tax.

[2] NT: The recycling of corrugated cardboard is widely implemented in the recent years in Japan, showing high recycling index rates.

In the stage of packaging design by using corrugated cardboard, the most important point for verification of their resistance is the compression resistance. The cans or glass containers do not have major problems on this sense, since the container itself can withstand the external loads. On the contrary, in the cases of carton pots or plastic pots, part of the loads must be withstood by the product itself. Also, in the case of pouch or fresh fruits, the total of the loads must be withstood by the carton box. From this point, the necessity shall be paid attention in the design.

The corrugated carton boxes circulating in the region apparently are relatively of low quality compared with those in Japan, particularly under the material resistance point of view. Consequently, in order to ensure the prevention against damages on the products, resistance calculations must be carefully developed during the design process of corrugated carton boxes, particularly for packaging destined for food products or household appliances.

As a reference, examples of "Calculations of resistance of corrugated cardboard boxes against compression forces" are shown, and the "Selection of materials for corrugated carton boxes", based on available specifications of Japanese material suppliers of liner paper and wave papers.

It can be mentioned here that recently, the JIS standards related to corrugated cardboard papers have been revised dated September 2005.

On the following tables, they are shown the resistance values of papers for liner (Table 7.2.4-1) and waves (Table 7.2.4-2).

Table 7.2.4-1 Resistance Values of Papers for Liner (JIS P 3902)

Type		Properties	
Categ	Rated Density g/m^2	Compress Resist ISO (horiz) kN/m	Bursting Resist. kPa
LA	180	1.77 or more	522 or more
	220	2.31 or more	616 or more
	280	3.31 or more	756 or more
LB	170	1.51 or more	459 or more
	180	1.59 or more	486 or more
	210	2.07 or more	546 or more
	220	2.17 or more	572 or more
	280	2.94 or more	700 or more
LC	160	1.21 or more	288 or more
	170	1.29 or more	306 or more
	210	1.59 or more	378 or more

Note1 : The allowable error on the figures is of ±3%.

Note2 : The compression test according to ISO standard is made by using a sample of 6 x ½ inch (152.4 x 12.7 mm) cylinder shaped.
Thus, for the calculation it is applied the following: C Tot (kN)＝ISO(kN/m) x 0.1524m

Note3 : The moisture content when extracting the material coil is:
Moisture content = 7.5±1.5%

Table 7.2.4-2 Resistance Values of Papers for Wave (JIS P 3904)

Type		Properties	
Categ	Rated Density g/m^2	Compress Resist ISO (horiz) kN/m	Bursting Resist. kPa
MA	160	1.63 or more	8.0 or more
	180	2.01 or more	9.0 or more
	200	2.43 or more	10.0 or more
MB	120	0.91 or more	4.8 or more
	125	1.59 or more	5.0 or more
	160	1.42 or more	6.4 or more
	180	1.59 or more	7.2 or more
MC	115	0.72 or more	3.5 or more
	120	0.75 or more	3.6 or more
	160	1.21 or more	4.8 or more

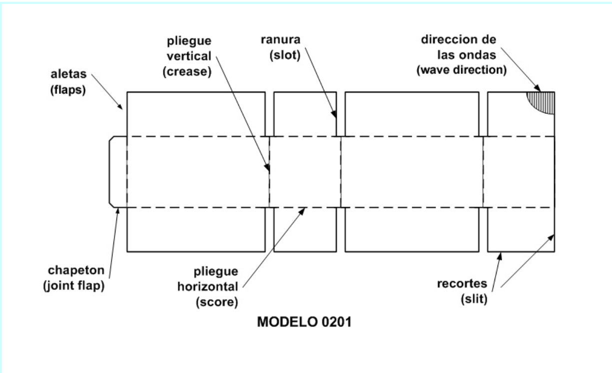
Note1 : The allowable error on the figures is of ±3%.
Note2 : The compression test according to ISO standard is made by using a sample of 6 x ½ inch (152.4 x 12.7 mm) cylinder shaped.
Thus, for the calculation it is applied the following: C Tot (kN)＝ISO(kN/m) x 0.1524m
Note3 : The moisture content when extracting the material coil is:
Moisture content = 8.0±1.5%

As next step, it is indicated an example of packaging design for food products verifying their resistance, as a part of design procedure by using corrugated cardboard.

(1) Compression resistance calculation for corrugated cardboard box. (example):

For the calculation of the compression resistance of JIS Model 0201 corrugated cardboard box (model having slots), the Kellicut formula is to be applied.

This type of box is made by a unique piece of cardboard, and it has a joint flap.



The Kellicut formula is expressed as:

* Wave A: $P = 0.748 \times Rx \times Z^{1/3}$

* Wave B: $P = 0.612 \times Rx \times Z^{1/3}$

where:

P: Compression resistance of the box (N) or (kgf)

Rx: Compression resistance of paper, total (N) or (kgf)

* Double sided corrugated board : $R_1 + Rm \times C + R_2$

* Multiple layer corrugated board: $R_1 + Rm_1 \times C_1 + R_2 + Rm_2 \times C_2 + R_3$

C is wave factor for : Wave A=1.6; Wave B=1.4

$Z^{1/3}$: cubic root of perimeter of box (cm)

Furthermore, the conditions varies depending if the corrugated cardboard are of one layer or multilayer, as indicated above in clause 7.2.1. Regarding to the types of corrugated cardboard, they are indicated on Table 7.2.4-3.

Table 7.2.4-3 Corrugated cardboard: Types and structures

Type	Cod	Waves/30cm	Corrug. Height mm	Wave factor	Remarks
Wave A	AF	34±2	4.5 to 4.8	1.5 to 1.6	External
Wave B	BF	50±2	2.5 to 2.8	1.3 to 1.4	External
Wave C	CF	40±2	3.5 to 3.8	1.4 to 1.5	External
Wave E	EF	Approx.94	1.1 to 1.2	1.2 to 1.3	Internal, indiv. package

Source: Textbook of the 31st Cardboard Package Design Course (Kanto Branch of Japan Packaging Institute), p8.

On the following example, it is shown the compression resistance calculation for a corrugated cardboard box model 0201 (JIS) by applying Kellicut formula.

<u>Example No.1:</u>

Calculate the compression for a box having following internal dimensions:

360L×300W×250H (mm), and the materials to be utilized is LB220×MB125×LB220 with Wave A type.

<u>Response 1:</u>

First, it is calculated Rx.

The compression resistance of Liner LB220 will be:

P_L = 2.17kN/m× 1,000/k ×0.1524m＝331 N

Compression resistance of the wave MB125 is:

P_O = 0.94 kN/m ×1000/k ×0.1524m＝143 N

Thus, the value of Rx is:

Rx＝{331N＋143N×1.6＋331N}＝891 N

Next, the cubic root of perimeter z is calculated:

Z＝(36＋30)×2＝132(cm)

Z1/3＝5.09

Finally, the compression value calculated will be as follows:

P=0.748× 891N ×5.09＝3,392 N

(2) Selection of the materials for the corrugated cardboard box (example)

The procedure of the selection of materials for the box is as follows:

[1] Calculate the load applied on the bottom end box of a pilling on storage.

[2] Calculate the compression resistance required for the box, considering a safety factor due to others aspects such as material aging.

[3] It is selected the wave type, and based on reverse calculation from Kellicut formula, it is calculated the required resistance of the paper.

[4] Finally it is selected the material which covers the compression requirements, both for the liner and for wave.

Example No 2

Select the required material for a box Model 0201 (JIS) under the following conditions.

‣Box internal dimensions : 450L×350W×250H(mm)

‣Total weight of the box: 12kg

‣Number of boxes pilled vertically: 10 boxes

‣Safety Factor: 3 Response 2:

(1) The required resistance is calculated.

P=12×(10-1)×3×9.81＝3,178 N

(2) The reverse calculation by Kellicut is made:

$Rx=P/(0.748\times Z^{1/3})$

(3) The value of cubic root is calculated $(Z)^{1/3}$

The perimeter of the box is: (45＋35)×2＝160(cm)

$(Z)^{1/3}=5.43$

(4) The value of Rx is calculated

Rx =3178N/(0.748×5.43)＝782N

(5) The material is selected:

Considering to use the material LB180 for the external and internal liner, the compression is calculated.

(1.59kN/m×1000/k×0.1524m) = 242 N

Thus, the compression resistance will be the double: 484 N.

The compression resistance of the wave will be:

(782N-484N)/1.6 ≒ 185N

Compression resistance as per ISO is:

(185N÷1000/k÷0.1524m)＝1.21kN/m

From material various, the one which covers this condition is: MC100.

Consequently, the materials for the box, covering the mentioned conditions are:

LB180×MC160×LB180 and with Wave-A.

The specifications of materials indicated above, have been taken as reference from the training program texts of the XXXI Training Course for Packaging Design with Corrugated Cardboard, of the Japan Packaging Association Inc. (JPI).

7.2.5 Shrink type film[1]

7.2.5.1 Kinds of shrink type film

The definition of "shrink type film" for packaging defined in the JIS Z1709 standard, says that it is a pre-expanded film that, when used for packaging, shrinks upon the application of heat, preventing the goods from moving. Based on this definition, there are several kinds of shrink type film: for box packaging, for packaging in general, for big packages (such as pallets). In addition, there are other kinds of film, such as shrinkable labels, "poli-ball", and insulating sleeves etc.

At present, the different kinds of commercially used shrink type film are very well known. The materials used to manufacture these films are: vinylidene polychloride, vinyl polychloride, polyethylene (including "bridging" PE, low density L-LDPE, expanded PE). Besides, bubble-wrapped PE products are also being marketed.

In addition, polypropylene, polystyrene, polyester and Nylon are used and multi-material laminated films are well known too.

7.2.5.2 Main features of shrink type film

Shrink type films should have the following features.

[1] Good shrinking speed, shrinking ratio, stress and yield point, and shrinking temperature range.

[2] High strength and impact resistance

[3] Good sealing properties

[1] Source: Ohsuga, Hiroshi. "New Food Packaging Film – Flexible Package / Theory and Application". Nippo Co., Ltd.

[4] Good mechanical properties
[5] Good external aspect and easy to print

Fig. 7.2.5-1 shows the curves that relate the heating temperature of the shrink type film to the pertinent shrinking ratio. Table 7.2.5-1 shows the types of films and their characteristics.

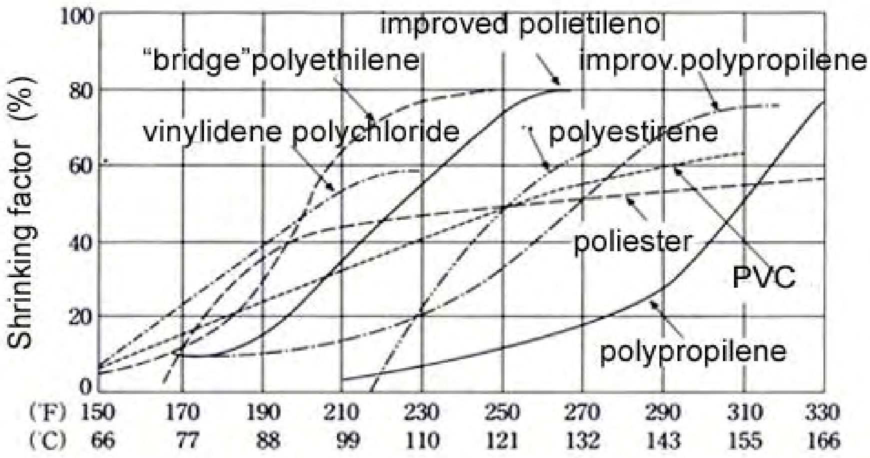


Fig. 7.2.5-1 Shrink Factor vs Heating Temperature of Films

Table 7.2.5-1 Types and Features of Shrink Type Film

	Polypropylene	PVC	Polyethylene
Main applications	Individual packaging Ramen Noodles, liquid dairy products, aerosols, packaged pastries	Individual packaging, primary packaging Pastries, batteries, jars, cosmetics, stationery	Joint packaging medium and big External packaging Heavy items, electrical equipment, pallets, bottles, cans
Thickness	12～13µ	13～35µ	30～200µ
Advantages	Transparent, shiny, strong, high endurance	Transparent, shiny, strong. Ample range of shrinking temperature, easy to handle	Highly resistant to impact at low temperature, good sealing properties
Disadvantages	Low hot seal temperature range	Easy to become unsealed spots when sealed	Low shrinking and adhesive properties
Opening	Good separation from slot casting expands when heated	Relatively stable casting in different directions	Difficult to open, casting expands and tears
Directionality	Simultaneous shrinking in 2 axis (vert,hor)	Up to biaxial, based on one of them	Up to biaxial, based on one of them
Cost	Medium	High	Low

7.2.6 "Stretching" and "Wrapping" films[1]

"Stretching" packaging is obtained by stretching the film. "Wrapping" film is also stretched – mainly for commercial applications – so it is frequently used as internal layer of a "stretching" film.

Table 7.2.6-1 describes the classification of these films.

"Stretching" films for packaging should have the following features.

‣High resistance to pin-holes under stress traction conditions

‣Good elastic recovery properties to remain stretched

‣No yield point

‣High traction resistance

‣Sufficient self adherence properties

‣Good transparency properties

In addition to the mentioned features "Wrapping" films require barrier, anti-moisture protection properties and it should be easy to cut. Besides, in case of microwave oven applications, resistance to high temperatures is required.

"Stretching" films, have different adherence properties: a) based on the adherence properties of the material, b) based on the application of heat, and c) those based on a combination of both. The adherence of the material is obtained by adding substances such as resins derived from oil or "rosin" and their subsequent kneading.

However, new adhesive substances are being used lately such as liquid polybutene.

In the case of pallet packaging using stretch film, the materials used up to date have a stretching ratio of 100 to 130%. But recently, new pre-stretched materials have been developed that allow the subdivision of the process in two stages: pre-stretching and packaging application. In this way, the stretching ratio of the film increases to 250 - 300%, reducing consumption.

Table 7.2.6-1 Applications of "Stretch" Film

Application	Description	Material	Structure
Pallet Stretching	Avoids collapsing For transportation	EVA L-LDPE	Multi-layer
"Wrapping" film	Home use Industrial use	PVDC, PVC Polyolefins	Single layer

[1] Source: Ohsuga, Hiroshi. "New Food Packaging Film – Flexible Package / Theory and Application". Nippo Co., Ltd.

7.2.7 Expanded Polystyrene (EPS)

The EPS has a variety of functions and properties such as: cushioning support, suitability for primary packaging and for external packaging. Some examples are as follows:

(1) Pots and trays for food products, manufactured by continuous extrusion process and molded in vacuum condition

(2) Packs, pots, cushioning material (i.e. for fish), trays manufactured from expanded material from chips raw material

However, this material is not fully the ideal material, since it is made by a fragile styrene resin. But thanks to their expansion during the fabrication, the material is light and relatively low cost, so that it is widely applied as packaging material, specially for household appliances.

In the case of refrigerators produced in Latin America, they are used an average of 1 kg of material per unit, as cushioning material and external protection element as well. This is due to the good use of their advantages to allow the protection of the product for long distances transportation and their low weight, and the ausence of compression creep phenomena. This means, this material allows a design covering two aspects: a) to have an enough area so that the product can be piled 3 units vertically, and 4 units in horizontal position for transportation (the surface is enough for not creating creep due to compression), b) to allow a cushioning design to resist the impact requirements for the product.

The information of properties of the materials for the design can be obtained from the EPS material manufacturers, through Internet etc so that the only point required it to make an appropriate selection of the materials, according to the design needs.

Table 7.2.7-1 EPS Volume Used for Refrigerators in Latin America (example)

	Brazil → 872gr				Argentina → 782gr			
Component	Bottom	Top	Col*B	Col *F	Bottom	Top	Col*B	Col *F
Nbr pieces	1	1	2	2	1	1	2	2
Mass gr	366	242	108	156	255	231	181	115
Lenght mm	692	691	1425	1425	622	622	1525	1505
Wide mm	642	642	140	160	620	620	205	150
Thick. mm	105	127	70	80	120	120	85	65

Source: JICA Study Team

7.3 Packaging Design Covering the Requirements of Reference Guideline

The "Reference Guideline for Packaging Tests, for Evaluation" is described in the Chapter 6 of this report. In this section, it will be explained the procedures for the design control to accomplish the requirements of that reference guideline.

(1) The general check of the packaging design is prepared, considering the steps of the design of the product, during engineering process. In Table 7.3-1, it is shown an example of the determination of the reference values, taking into account the (allowable) errors during the manufacturing of the product.

Table 7.3-1 Development Steps and Reference Values for the Evaluation and Design of the Product (guideline)

Validation Step	General Criteria		
	Ref. Value for Vibration Tests	Ref. Value for Compression Test	Ref. Value for Drop Tests
Prototype tests	100%	105%	105%
Trial tests for mass production	100%	100%	100%
Mass production tests	90%	90%	90%

Source: JICA Study Team

This table is showing the reference values only, with the purpose to explain the works criteria. For defined products, it is possible to determine the values case by case, according to particular needs.

(2) The reference guideline for packaging are applied, based on the existence of the control of distribution process. In other words, the companies which do not have those controls, the reliability factor will be zero. In order to make feasible the validation of the packaging design for a defined product, it is strictly necessary to establish a strict control system. Depending on the type of problems to be solved, this matter is of a high level, so that it can be treated as top management issue, including as company to company issue.

Next, it is showed the process in order to cover the design quality requirements, based on the reference guideline and according to the type of product. The external view of the improved packaging (pilot cargo) is shown in Fig. 7.3-1

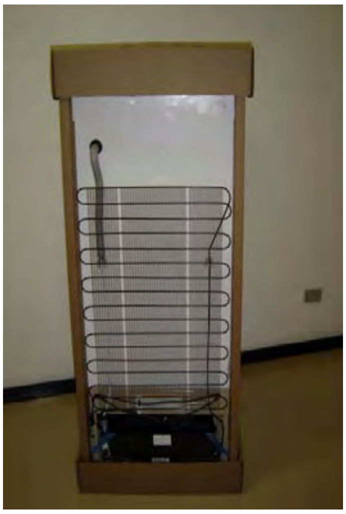
Table 7.3-2 Packaging Design Process for Target Product

	Brazil	Argentina
STEP 1 Product characteristic		
External Dimens. (mm)	615×610×1470	615×610×1470
Product mass (kg)	49.5	55
Product Volume (m ^{3})	0.55	0.62
Product Fragility (G)	30	25～30
Compression Resis (Kg)	300	224
STEP 2 Distribution Condit.		
Transport vehicle	Semi trailer 3000km Vertical x 1 + horizont. 2	Semi trailer 1500km * Vertical x 1 + horizont. 1
Storage	4 months	4 months
Cargo handling	Side clamp F.lift + Manual	Side clamp F.lift + Manual
STEP 3 Eval.Pack quality		
Vibration test (reference)	ASTM: Truck transported 3 ~ 200Hz 0.52Grms 6hr	ASTM: Truck transported [1] 3～150Hz, 0.2Grms, 5min Various Tests [2] Between Bs.As./Mendoza 0.3108Grms, 3hr
Reference value (estim)	Stretching level 3000km	Stretching level 1500km *
Compression test	Piled cargo x 4 units	Piled cargo x 4 units
Drop test	20cm	20cm
STEP 4 Materials charact.		
E P S	Manufacturer Study Cushion.Charac./Creep Char.	Manufacturer Study Cushion.Charac./Creep Char.
STEP 5 Re-Design		
Opcion: Corrugated board	Board Mfr proposals	Not applied
Opcion: E P S	Using Dens 30kg/m^3 f/tests	To review existing model
Internal accessories of pack.	Not applied	To prep. Pack. specifications Accessories by 3rd party

Source: JICA Study Team

*: The sum of 300km between Bs.As./Rosario and 1,200km between Bs.As./Mendoza are considered.

Design proposal by using local material (Brazil)



Design proposal by using local material (bottom EPS pieces added)

Proposal of improvement: packaging of accessories (AR.)

Improvement in EPS dimensions

Product before wrapping by shrinkable film

Source: JICA Study Team

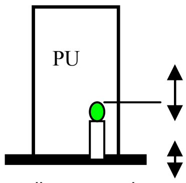
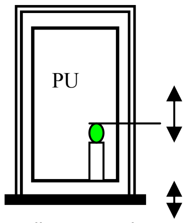
Fig. 7.3-1 Improved Packaging for Tests (Brazil and Argentina)

7.3.1 Evaluation of packaged cargoes

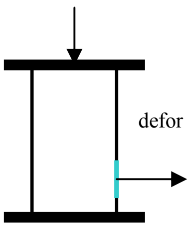
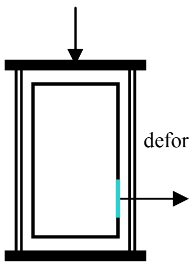
(1) Working plan for improvement of refrigerators: Packaging design quality evaluation tests

The test contents of packaging design quality evaluation, developed in Brazil are shown below.

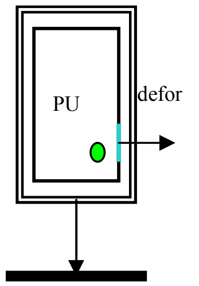
Vibration Test

Product	Prod+Packaging	Sample	Necessary Equip.
 Vibrac. Random (Vert./Horizontal) - Vibration Sensor	 Vibrac. Random (Vert./Horizontal) - Vibration Sensor	1 packed unit (to use for others tests also)	Vibration Apparatus PU

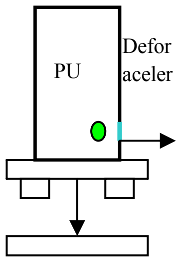
Compression Test

Product	Prod+Packaging	Sample	Necessary Equip.
 Static Load (Vertic./Horiz.) ◎Load－deformac. ◎Load-distorsion ◎Plastic Defor.zone	 Static Load (Vertic./Horiz.) ◎Load－deformac. ◎Load-distorsion ◎Plastic Defor.zone	Packed unit：1 Frame pack: 2	Compres Test Eq. Caliper Dial gage

Drop Test

Product	Prod.+Packaging	Sample	Necessary Equip.
（not applicable）	 Free drop ： bottom edge ◎acceleration ◎deformation ◎damages	Packed units:2	Drop Test Equip.

Impact Test

Product	Prod.+Packaging	Sample	Necessary Equip.
 Drop impact ◎acceleration ◎deformation ◎damages	（to verify as per requirements）	Products: 2	Vibration Test Eq. PU Caliper Dial gage

Sample quantity indicated are minimum required →products 2, packed units 5, frames 2. If possible, the availability of one additional packed unit as spare would be convenient.

(1) Packaging study on refrigerators manufactured by company B

1) Target product external dimensions

	Product	Packaging
wide mm	615	692
deep mm	610	642
height mm	1,470	1,562
vol m^3	0.55	0.69
mass kg	49.5	50.5
dens kg/m^3	89.8	72.8

Source: JICA Study Team

Fig. 7.3.1-1 Product external view

2) EPS

	Bottom	Top	Pillar*B	Pillar*F
quantity	1	1	2	2
Mass g	366	242	108	156
Long side mm	692	692	1,425	1,425
short side mm	642	642	140	160
thickness mm	105	124	70	80

3) Shrinkable film

Thickness μ

Film opened surface

total used m^2

4) Adhesive tapes

Adhesive tape is used for fixing the internal components to the refrigerator.

Source: JICA Study Team

Fig. 7.3.1-2 Component Fixing View

5) Packaging design remarks

1. EPS density

   Size 50 x 50 x 50 mm

   Mass : 2.637 gr

   Density: 21 Kg/ m^3

2. Cushing properties

   EPS support face and thickness have been measured.

   Support face: 1129cm^2

   Avg thickness: 6.3cm

   Cushining properties have been calculated and it was detemined the Fig. 7.3.1-3.

   Drop height: 8 cm→Generated acceleration 30g's but EPS was deformed for approx. 6%.

3. EPS creep limit

By observing the characteristics curves for a density of 23.5 kg/m^3 of the limit force of creep of 50Kp (0.5097 kg/cm^2), the consumption amount of EPS can be reduced. For the increased amount of the generated acceleration shall be adjusted by changing shapes on drop tests.

4. Packaging improvement points

EPS re-design

Based on Fig 7.3.1-3, it is considered quality fault.

Verifications to be made by changing the EPS density to 32.5 kg/m^3

Depending on product, probably high Gmax are generated and starting from below, some improvement are expected.

→Revision of drop tests from transportation data.

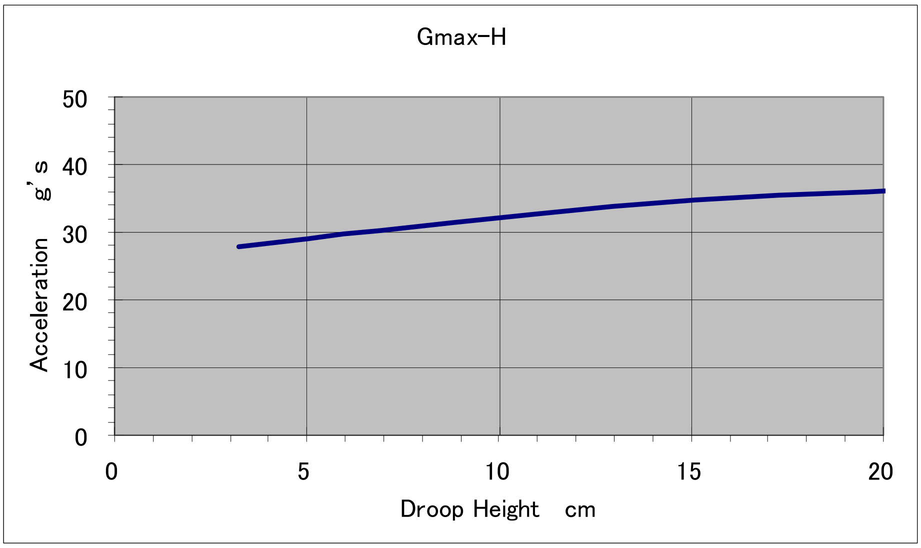
→Test Results of fragility evaluation test

Incorporating of EPS + CPB made trays

Study alternatives as topics for the future.

Study of fixing methods for internal components

Replacement by low elasticity tapes and analyze the tape fixing method



Source: JICA Study Team

Fig. 7.3.1-3 Cushioning Effect - Calculated Values

(2) EPS support surface and thickness, measured values

Lower face holder

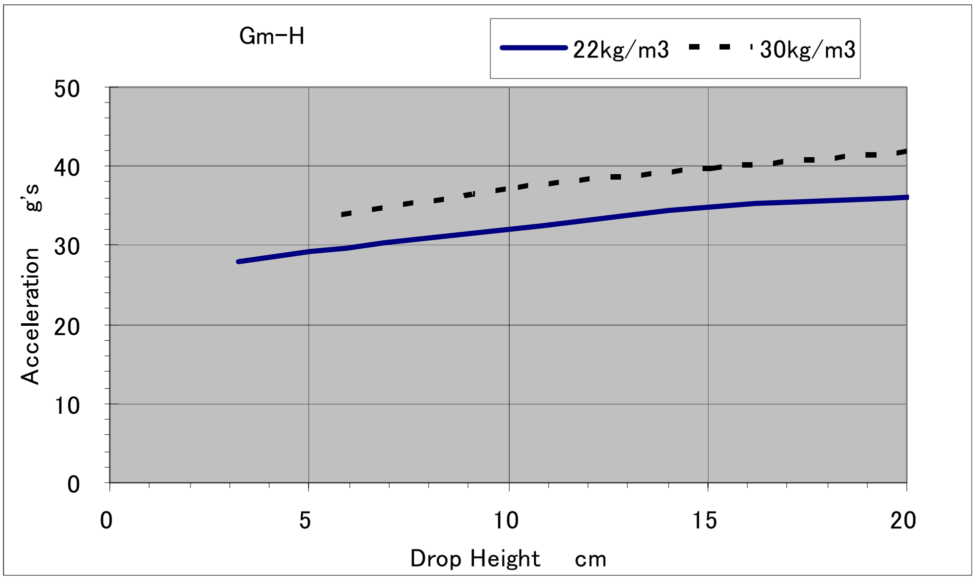
	thick	size	size	qty	surf	part vol
	cm	cm	cm		cm2	cm3
MAX	6.5	10	7	2	140	910
	6.5	7	20	1	140	910
	6.4	41.2	4	2	330	2109
	6.3	10.2	9	2	184	1157
	6.3	15.5	7	2	217	1367
MIN	5.1	9	3	4	108	551
	5.1	1.5	7.5	1	11	57
Ave=	6.3				1,129	7061

Upper side holder

	thick	size	size	qty	surf	part vol
	cm	cm	cm		cm2	cm3
	3.3	18.8	5	1	94	310
	3.3				111	368
	3.3				553	1825
PROM=	3.3				758	2502

Source: JICA Study Team

Reference: in Fig. 7.3.1-4, it is shown the cushioning calculated value based on Fig 7.3.1-3, by applying a density of 30 kg/m^3.



Source: JICA Study Team

Fig. 7.3.1-4 Cushioning Value by Applying Density = 30 kg/m^3

The resistance tests are executed based on the conditions of item (1) indicated above, and doing calculations based on the criteria table which depends on the type of the product.

In the case where the information of the product and the distribution route are available, they can be used as reference the information of the Transportation Environment Surveys of this Study.

Next, it is detailed as an example, the case of the refrigerators.

The works related to the improvement of the packaging of refrigerators could be developed thanks to the availability of reliable data of the commercial network system.

The steps for the evaluation of the resistance of packed products have been carry out based on that information.

For determining the reference values for the Random Vibration tests, they were taken the steps indicated in Clause 6.1.(4), Chapter 6.

In here, it is indicated the tests by PSD curves which reflects the oscillations of the actual distribution route, based on the evaluation PSD of each route type, gathered from recorded data.

Based on this method, it is possible to calculate the PSD for 4 routes in Brazil, and 1 route of Argentina. At this step, it can be observed a difference on the reference values, between results of actual routes and the conventional method as per ASTM standard.

The main points are detailed below.

(1) Method of integration of PSD data from 4 transportation routes

Since the 4 routes to be analyzed were completely different each others, even due to distances or due transportation durations, it was decided reordering the PSD information by taking the most representative curves per each route.

- The data measured per each day / each route have been integrated.
- The four days data have been integrated. The PSD representative of each route has been calculated.
- The PSD Curve for Test is calculated, by converting to a reference distance of 500km, and a duration of test of 1 hour.

(2) Differences with conventional method

As observed in the PSD for 500 km of 4 routes of Brazil, the PSD Curve for Test in the zone below 5 Hz has no their equivalent in ASTM curve. In the band of 5 to 20 Hz, the situation is inverted. In the zone above 40 Hz the curve shows very high values which probably reflect a bad condition routes. From this, it is possible to inferring that the evaluation on the zone below 5 Hz and above 40 Hz, it was not possible to be done by applying the conventional method.

Furthermore, regarding to the refrigerator of Argentina, tests have been developed (3 hours tests) by using integrated data of stretches of Rosario-Buenos Aires and Buenos Aires- Mendoza totalizing 1300km.

7.3.2 Tightness test equipment and vacuum dryer

As a part of the activities performed during the second year of this study, the tightness test equipment was purchased, given that there was no equipment of this kind in any of the four counterparts' laboratories of the four participating countries. Additionally, a vacuum dryer[1] was supplied during the first part of the third year of this study. Here follows the detailed information about above mentioned equipment.

(1) Tightness Test equipment

It is also called Seal Tester. A self-adhesive septum is bound on the test surface or on the center part of the air-tight container to be tested (to insure that there is a perfect seal selected for the injection of air). After that, the septum is punctured with a needle connected to the equipment through a needle-head assembly. No air leakage shall be verified.

Source: JICA Study Team

Fig. 7.3.2-1 Tightness Test Equipment

When the equipment compressor starts, the pressure builds up in the package until it reaches 100 mm Hg. It is then held at a constant level for 10 seconds. Package leakage is then verified and measured.

Additionally, the same equipment can be applied to bursting test performance, when using pressures above 100 mm Hg. Burst resistance for yogurt pots was determined to be between 0.4 and 0.6 kg/cm^2.

No leakage was detected during the seal tests performed on yogurt pots.

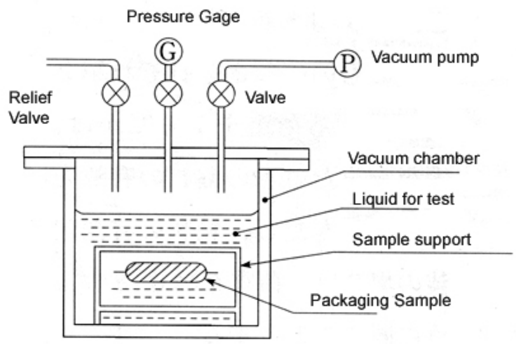
There was no leakage detection in milk pouches when using pressure values up to 100 mmHg. Above this pressure value containers expand and leakages cannot be accurately detected.

[1] NdT: Vacuum dryer equipment to be used for tightness tests.

(2) Vacuum dryer equipment

Source: JICA Study Team

Fig. 7.3.2-2 Vacuum Dryer Equipment



Source: JIS Z 0238

Fig. 7.3.2-3 Hermeticity Test

This test is also called Leak Test. Vacuum dryer equipment is used (vacuum chamber). The package to be tested is placed into the vacuum chamber, which is filled with water. Vacuum is applied, and air bubbles coming out from the submerged package into the water are measured as air leakage indicators. Vacuum increases during a 30 seconds to 1 minute period and has to be maintained still during at least 30 seconds.

This is an adequate method to be applied on relatively high air content samples, and several samples can be tested at a time. Vacuum levels are set according to the sample features, and by parties' mutual agreement. It can also be applied to leak detection on samples that have undergone drop testing or compression testing.

7.3.3 Endurance tests evaluation in Paraguay

Here follows detailed information on the study performed on milk pouches and yogurt containers.

7.3.3.1 Milk pouch containers

(1) Milk pouch container types

Polyethylene sachets are used as milk containers, as well as in Uruguay and Argentina. This kind of container is not in use in Japan. (Fig. 7.3.3-1 and Fig. 7.3.3.-2). A resin manufacturing company informed that they are also used in China.

There are two kinds of containers: with one polyethylene layer and with three polyethylene layers as light barrier (white LDPE, black LDPE, and translucent LDPE). There is a third kind of container in Uruguay and Argentina: the five-layer one, with EVOH (ethylene-vinyl alcohol copolymer) as a gas barrier, competing with the Tetra pack (carton/aluminum foil) for long life milk packaging.

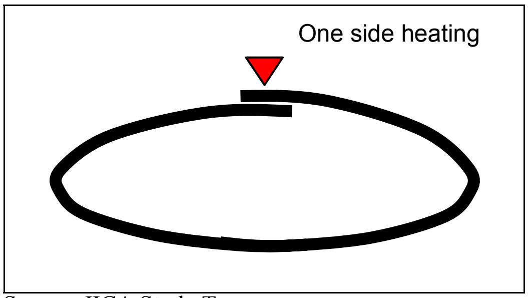
Source: JICA Study Team

Fig. 7.3.3-1 Milk Pouch Container

Source: JICA Study Team

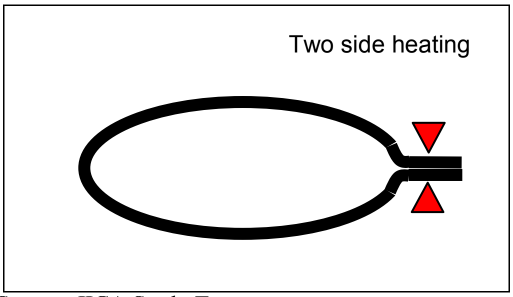
Fig. 7.3.3-2 Pouches in Shops

There are two sealing designs for pouch manufacturing: a) pillow type sealing[2] and b) three side type[3] sealing. Most market products use pillow type sealing, while only one brand uses the three side type one.



Source: JICA Study Team

Fig. 7.3.3-3 Overlap Seal (pillow)



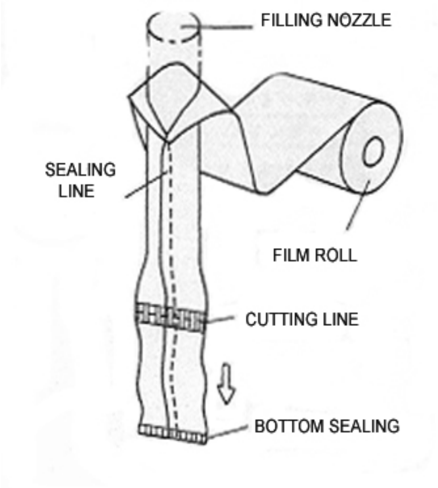
Source: JICA Study Team

Fig. 7.3.3-4 Jointed Seal (3 side)

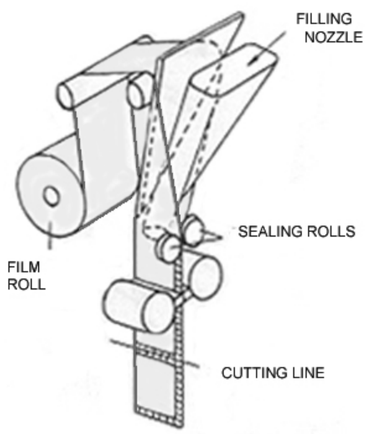
Pouches manufacturing process produces vertical pillow type containers that are sealed closed once they have been filled with product. The first sealing process involves one side heating (Fig. 7.3.3-3 and Fig. 7.3.3-5) while the second one requires two side heating (Fig. 7.3.3-4 and Fig. 7.3.3-6).

[2] NdT: In Japanese "envelope type";

[3] NdT: In Japanese "praying hands"



Source: Packaging Technology Handbook
Fig. 7.3.3-5 Pillow Type Pouch (overlap)



Source: Packaging Technology Handbook
Fig. 7.3.3-6 Three Side Pouch (joint)

Upper and lower end sealing of the pouch are performed by material fusion, using a simultaneous heating and cutting procedure, with a piano chord from heater. Therefore, the sealed band with is very narrow, leading to a low sealing strength. On the other hand, commercial pouches used for other purposes have a 5 mm seal width, with high seal strength.

Most milk pouches are pillow type sealed, and leakage can be detected on its main body and on both upper and lower end seals. Therefore, we can see clients placing milk pouches into plastic polyethylene bags to carry them home safely.

(2) One side heating for pillow type sealing

Multilayer bags are usually sealed using one side heating process. This method brings high seal strength, and it is called pillow type sealing.

Pillow type sealing equipment is furnished with a cold sealing bar (passive bar, cold element) and a heated sealing bar. The passive bar's temperature increases by means of the heat transference from the heated bar. Adherence is achieved by packing material fusion. Process control parameters are: the hot bar initial temperature and the cold bar heat gain. That is to say that if the process stops for a moment, 10 operating cycles will be needed to reach fusion regime again.

Temperature, pressing and time is the fundamental parameters for hot sealing processes. Whenever a defective sealing occurs, temperature should be raised. However, when the raise is excessive, material changes can lead to low seal strength.

For two-side heating sealing processes, sealing time ranges between 1 and 2 seconds. Temperature shall be above 130ºC for LDPE and 150ºC for LDPE to achieve nominal strength. Adequate sealing pressures are between 1 and 2 kg/cm^2.

When both temperature and pressure are increased, melted material flows along the sealing area leading to bead formation. These are ripping and pinhole generating points, despite high seal strength.

(3) Drop testing on milk pouches

Drop tests were performed on milk pouch containers. Drop height for 1kg masses is 30 cm, according to JIS Z0238. All samples passed the test under said conditions. A new test series was performed with 1.0 m drop height above a concrete surface, in order to investigate seal leakage and its causes

Test sequence was as follows: a second drop test was performed whenever no leakages were found after the first drop test; a third drop test (drop height= 1.4 m) was performed whenever no leakages were detected after the second drop test.

Five containers were tested for each sample. Test results are shown Table 7.3.3-1.

Table 7.3.3-1 Drop Tests on Milk Pouch Containers

The container's face with the seal impacted on the drop surface (n=5)

Film Structure	Sealing Method	Manuf	Drop Height 1.0 m		Drop Height 1.4 m		Leak location and origin			
							Body		Upper	Lower
			1st	2nd	1st	2nd	T def	T exc	T exc	T exc
3 layer	3-side	A	0	0	0	0	0	0	0	0
1 layer	Pillow	A	0	1	0	1	1	0	0	1
1 layer	Pillow	B	1	1	0	1	2	0	1	0
1 layer	Pillow	B	-	-	1	4	3	2	0	0
1 layer	Pillow	C	0	2	1	0	0	2	1	0
1 layer	Pillow	D	0	0	1	1	0	0	1	1
1 layer	Pillow	E	2	1	1	1	1	2	2	0
1 layer	Pillow	F	1	0	0	1	0	1	0	1

Source: JICA Study Team

Above Table shows that:

Company A's containers are: a) three layer– three sides type sealed, and b) one layer- pillow type sealed. The five samples of the first kind of containers showed no leaks after drop testing, even from 1.4 m height. On the other hand, two leakage cases were detected on one layer- pillow type sealed containers of this company. Additionally, leaks were detected in one layer- pillow type sealed containers from remaining companies, after drop testing from 1.0 and 1.4 m height, with slight variations among companies.

Container's body flaws were detected, due to excessive temperature and to defective temperature as well. Leaks were originated by seal thickness reduction due to a slight temperature excess, in upper and lower ends' seals as well.

(4) Compression and seal strength tests on milk pouch containers

Two methods were used for compression testing on milk pouches. Compression load for 1 kg samples is 60 kg, as per JIS Z023 standard. Twenty kilograms weights were applied as loads on the compression board during 1 minute time. Additional weights were placed provided no leaks were detected. The pouches were placed with the seal line on one side. That is to say: three sides type sealed pouches laid flat while pillow type sealed pouches laid sagittally. Compression seal strength for three side type sealed pouches was 60kgf, and for pillow type sealed ones it was above 100kgf. No further details on results will be given.

When pillow type pouches are placed sagittally, the contact area increases with pressure, relieving the pouch internal pressure and increasing overall compression strength.

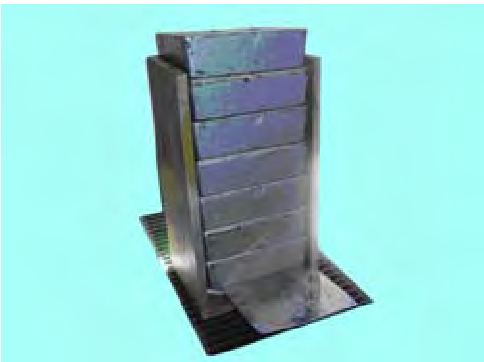
Those samples showing leaks during the drop test showed low compression strength values as well.

Three types of pinhole resistance tests were applied.

Upper and lower seals' pinhole resistance was above 1.5 kgf (15mm probe), while the body's one was lower, showing a problem therein.

No significant difference was found when correlating pinhole resistance, drop tests results and compression tests results. More data have to be gathered in the future with this aim.

The flexible PE films used by each manufacturer have been characterized by means of their elongation values.



Source: JICA Study Team

Fig. 7.3.3-7 Compression Test Device for Milk

Source: JICA Study Team

Fig. 7.3.3-8 Seal Resistance Tester

(5) Seal test of improved film for wet sealing (Fig. 7.3.3-8)

The low density polyethylene (LDPE) are structured by branched molecules located at Random, and it is used as sealant film from long time ago.

The linear type L-LDPE has linear chains; same as the LDPE as indicated above in clause 7.2.1.3, but in this case the chains are short and linear type. Compared with the LDPE, this material has excellent properties of seal resistance, good seal ability under impurities, and a good property for Hot Tack.

For example, it can be described the case of liquid milk pouches. This product has a surface tension of 50 to 60 dyn/cm for a 20℃ temperature, lower than of the water which is 72.75 dyn/cm, and it has a little tendency to generate an interface.

Furthermore, the viscosity is 1.5 to 2.0 cP which is relatively higher than the water (1.0 cP 0.01 g/cm-sec) due to the content of oily component, molecules and proteins under colloidal condition, all soluble in water. This means, this substance has viscosity and physical activity for generating an interface, so physically tends to create foam.

Consequently, when the product is filled in the pouch, the liquid tends to be adhered in the surface to be sealed, so that the seal ability is decreased.

As result of this analysis, it was decided to modify the design by using another material having a higher content of L-LDPE, in order to improve the stability of the sealing, since the surface always is impregnated with milk during the filling process.

Regarding to he cost aspects, the L-LDPE material is 1 to 2 % cheaper than conventional LDPE. The melting point varies depending on the density of the material. As reference, for LDPE of density 0.92 the value is 100℃ approximately, but for the L-LDPE this value is increasing 10 to 15℃. On the same way, the sealing temperatures are: 130℃ for LDPE, and more than 150℃ for L-LDPE.

Regarding to the manufacturing equipment of L-LDPE film, there are some difficulties in the case of using existing machines of models of few years ago, since the melting temperature of this material is higher than LDPE temperature. On the other hand, regarding to the packing machine by using L-LDPE also has difficulties in the case that the seal bars have not enough capacity to cover the requirements.

The improved material used for the study was a LDPE film having a 15% increased content of L-LDPE.

This film showed a better elongation property than the conventional material, during the tensile strength test, so that it can be observed the effect of the change of chemical composition (more L-LDPE) of the improved material.

After that, the seal test has been carried out, with milk impregnated surface. Small band shaped samples of 20 mm wide have been cut, locating the seal line in the center portion.

The seal test method consisted on sealing samples per each temperature, varying 1℃ each, and the exfoliation has been checked manually.

The temperature of those samples not showing exfoliation but showing breaks have been recorded, for the total of 5 samples, as shown in following table.

Table 7.3.3-2 Hot Seal Test for Improved Film under Wet Condition (milk)

(seal: $2kg/cm^2$, 2 sec)

Film type	(Wetted with milk) Exfoliation		Remarks
	YES	NO	
Conventional Film	180°C	183°C	Vapor and foam generation. Film shrinks when temperature rises.
Improved Film	203°C	208 to 217°C	No foam generation, even when soaked. Wider operating temperature range.

Improved film material: 15% L-LDPE enriched
Source: JICA Study Team

As shown in above table, neither vapor nor foam generation or film shrinkage occurred with the improved material, even when it was soaked with milk. Additionally, the work temperature range proved to be wider.

During the fifth stage of this study, it is planned to manufacture this material on line production, and to check its performance as well.

7.3.3.2 Yogurt containers

(1) Endurance Tests （sample number n＝5）

Endurance Tests were performed on 140g yoghourt pots. Results are summarized as follows:

1. Container's seal test: Yoghourt pots were placed in the Tightness Test equipment, under 100 mmHg pressure during 10 seconds. No leakage was detected.
2. Bursting Test: It was performed in the Tightness Test equipment. Flaws were detected at a pressure of 0.4-0.5 kg/cm^2.
3. Compression Test: a method like the one applied for milk pouches was used herein. For 100 to 400g samples, the applied load shall be 40 kg as per JIS Z0238 standard. This product passed the test for 30 kgf loads but it didn't resist 40 kgf ones.
4. Drop Tests: For 100 to 400g samples, drop height shall be 50 cm. Leakage was recorded at 50 to 70 cm drop heights

(2) Sensory evaluation of containers' opening

Figures 7.3.3-9 and 7.3.3-10 show the samples used for this evaluation.

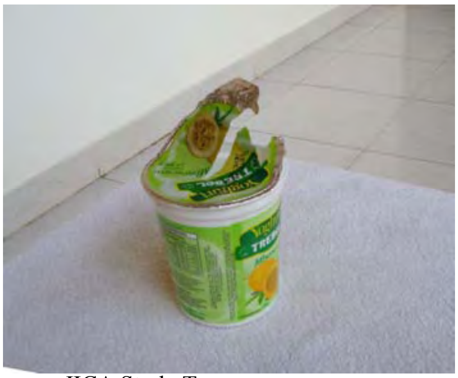
Source: JICA Study Team

Fig. 7.3.3-9 Yogurt Pot with Aluminum Lid

Source: JICA Study Team

Fig. 7.3.3-10 Yogurt Pot with Laminated Aluminum Lid

The sample in Fig. 7.3.3-9 is a cylindrical plastic pot with an aluminum foil lid. The sample on the right (Fig. 7.3.3-10) has a square lid (in line type) made of PET/aluminum film. Sensory evaluation was performed on these samples by 25 people of the INTN staff. Evaluators shacked the pots at first, opened them and drank the product directly from the pot. Results were as follows:



Source: JICA Study Team

Fig. 7.3.3-11 Aluminum Lid Tearing

Source: JICA Study Team

Fig. 7.3.3-12 PET/Al Lid Curling

Half the evaluators recalled that the opening was difficult for the first product, and it has to be improved. Three evaluators detected lid tearing defects. When considering previous experiences on this problem, the percentage of detection increases to 40% of the evaluators.

Ninety per cent of the evaluators recalled an easy opening for the second product. No further problems were found. Nevertheless, 10% of the evaluators said that the easy opening feature gave them an uncertainty feeling. On the other hand, almost 40% of the evaluators recalled that the square-shaped container was not easy to drink from, and the aluminum lid curled touching one's nose while drinking.

One relevant aspect to be considered is the aluminum foil lid tearing, as children could accidentally swallow aluminum debris. Therefore, the lid tearing issue has to be worked out as a priority. One option could be to lower the lid sealability in order to improve the opening process and avoid the lid tearing. Even though, it would be very difficult to improve both aspects. Using laminated aluminum film would solve the tearing problem, but there are technical problems (curling) to be solved to use this film on present production line equipment. Actually, multilayer aluminum/plastic film should be used in order to work out the tearing problem.

7.3.4 Endurance tests evaluation in Uruguay

7.3.4.1 Milk pouch containers

General conditions were much like the Paraguay case. Here follow the specific issues differing from that country.

Mostly 3 layered polyethylene film（white LDPE /black LDPE /translucent LDPE ）is used as light barrier. The main sealing method is the three sides type sealing, while the pillow type sealing is randomly used. Nevertheless, many test samples were of the pillow type seal ones.

(1) Drop testing on milk pouches

Manual drop testing was performed, like in Paraguay. Some pinhole flaws were detected when studying leakage defects (Fig. 7.3.4-1). In some cases, complete seal failure (upper or lower) was observed, leading to an impact milk jet (Fig. 7.3.4-2). Exceptionally, both upper and lower seals failed at once.

Source: JICA Study Team

Fig. 7.3.4-1 Partial Loss of the Lower Seal

Source: JICA Study Team

Fig. 7.3.4-2 Milk Jet from Lower Seal Failure

The following conclusions were driven from the drop tests (see Table 7.3.4-1) :

Table 7.3.4-1 Drop Tests on Milk Pouch Containers

The container's face with the seal impacted on the drop surface (n=5)

Company: product type	Sealing Method	Seal position at impact	Drop Height 1,0 m		Drop Height 1,4 m		Leak location and origin	
			1st	2nd	1st	2nd	T exc Body	T Exc Lower seal
A: Ultra	3- side	Side	1	2	1	1	5	
A: Ultra	3- side	Down	1	0	2	1	4	
B: Ultra	3- side	Side	0	1	1	0	2	
B: Ultra	3- side	Down	1	1	0	0	2	
B: Fresh	Pillow	Down	0	0	0	0		* 1)
B: Drinkable milk	Pillow	Down	0	1	1	0		2 *2)
C: Yogurt	Pillow	Down	4	0	0	0	3	1
D: Yogurt	Pillow	Down	1	1	2	0	1	3

*1): 1 sample with leaks from 10 purchased
*2): with pinholes
Source: JICA Study Team

1. Pillow type sealed samples from the Company A showed 4 to 5 leak points whenever dropped with the seal laterally or downwards. Leaks were located in the container's body, and they were provoked by excessive sealing temperature. On the other hand, in Paraguay, three-side type sealed products from the Company A showed no flaws in the drop test. This means that the seal defects observed in Uruguay, even in three-side type sealed products,

appeared because there had been no accurate control of the hot sealing process. Therefore, the implementation of a severe quality control program was recommended.

2. Three-side type sealed samples from the Company B showed leak flaws whenever dropped with the seal laterally or downwards. For pillow type sealed products of the same company, there were no flaws in fresh milk pouches and 2 flaws in the upper seal plus zero defects in the container's body for liquid yogurt pouches.

   Body flaws appeared due to an excessive sealing temperature, even in three-side type sealed containers, while there were no body flaws in pillow-type sealed ones. Therefore, we can say that body flaws can be reduced by means of a thorough quality control.
3. Four out of five samples of pillow-type sealed containers from the Company C failed the drop test (drop height= 1m) due to body leakages, and one body flaw was detected in the the Company D samples. Hot sealing control improvement was recommended for the body seals, as well as for upper and lower seals (cut seals).

(2) Compression tests on milk pouch containers

Source: JICA Study Team

Fig. 7.3.4-3 Compression Test Method

Compression tests on milk pouch containers were performed (see Fig. 7.3.4-3). A holding device was applied in order to prevent weights from falling off the compression board. Results are shown in Table 7.3.4-2, and conclusions can be driven as follows:

1. Compression strength for three-side type sealed containers from the Company A placed either transversely or flat was above 100 kg.
2. Compression strength for pillow-type sealed containers from the Company A was above 60 to 100 kg.
3. The Company C's containers were tested flat and transversely as well, and a comparative study was carried out. The first ones resisted over 40 kg compression load, while the second ones' resistance was below that value. This can be explained because when the pouches are placed transversely, the contact area for pressure load application is reduced, and pressure increases, when compared to the flat position.

Table 7.3.4-2 Compression Tests on Milk Pouch Containers (Uruguay)

Company and product type	Testing position	Load kg (1 min)				Leak point and origin
		40	60	80	100	
A Ultra Three-side type	Flat	○	○	○	○	
		○	○	○	○	
		○	○	○	○	
B Fresh Pillow type	Transversely	○	○	○	○	
		○	○	○	○	
		○	○	××		Exc. Temp body
C Yogurt Pillow type	Flat	○	○	○	×	Exc.Temp upper seal
		○	×			Exc. Temp body
		○	×			Exc.Temp lower seal
	Transversely	○	×			Exc.Temp upper seal
		××				Exc.Temp upper+lower seals
		××				Exc.Temp lower seal

○ : no leaks ×× : leak in less than 5 sec × : leak in less than 1 minute
Source: JICA Study Team

(3) Tightness test and container's film thickness

Dairy products containers' film thickness changes for each company and product. The ultra milk container from the Company A (95.4μ) is the thickest one, while the fresh milk container from the Company B (73.2μ) is the thinnest one. Standard deviations of material thickness are low, and it has proved to be uniform for each of the companies.

Tensile tests were performed in order to determine hot seal strength. Recorded seal strengths were above 2.2 kgf/ 15mm, notwithstanding some differences among companies and products. Provided these values, there is no correlation between drop resistance and compression resistance vs leak flaws. The reason for such defects is pinhole generation, despite a high seal strength in average.

On the other hand, body seal strengths for the containers of the Companies A and B (three-side type sealed) were 1.7 kgf / 15 mm and 1.9 kgf / 15 mm respectively (i.e. above 1.5 kg/15mm[1]). Compared with the four remaining samples, these values were quite low. Pillow type sealed containers from the Company C showed a seal strength of 2.1 kg/15mm, which is quite low too. Body leak flaws during drop tests could be related to the low body seal strength values. In order to determine whether a seal strength value is or not a proper one, the seal strength index calculated as per below equation shall be high:

[1] NdT See Paraguay case, pinhole resistance (7.3.3.1 (4)).

$$\text{Seal strength index} = \frac{\text{Body seal strength}}{\text{Tensile strength}}$$

We came to know that the material for fresh milk containers from the Company B has been improved by means of a slight increase in its L-LDPE content and a decrease in film thickness. As a consequence, sealing time shortened, and the work line productivity changed. L-LDPE is stronger than LDPE, and its elongation is higher, too.

Table 7.3.4-3 shows that for fresh milk containers from the Company B, an extremely low thickness value (73.2μ) corresponds to a considerably high body elongation value (959 %).

Table 7.3.4-3 Seal Strength in Dairy Product's Pouches

Company and product type	Thickness µm (n=5)		Part	Seal Strength (kgf/15mm)		% Elongation (n=3)	
	Average	σn-1		Average	σn-1	Average	σn-1
A Ultra Three-side type	95.4	0.9	Upper seal	3.0	0.13	437	39
			Lower seal	2.7	0.09	330	56
			Body	1.7	0.11	464	38
B Ultra Three-side type	89.0	1.4	Upper seal	2.8	0.04	296	40
			Lower seal	2.6	0.13	191	64
			Body	1.9	0.02	550	4
B Fresh Pillow type	73.2	0.8	Upper seal	2.6	0.29	227	132
			Lower seal	2.5	0.07	265	60
			Body	2.4	0.80	959	272
B Liquid yogurt Pillow type	81.8	0.8	Upper seal	2.4	0.15	355	104
			Lower seal	2.3	0.06	327	19
			Body	2.5	0.71	819	220
C Yogurt Pillow type	88.8	1.5	Upper seal	2.5	0.34	82	33
			Lower seal	2.7	0.14	101	32
			Body	2.1	0.03	706	24
D(Ar) Yogurt Pillow type	91.0	0.7	Upper seal	2.4	0.11	410	47
			Lower seal	2.2	0.02	342	10
			Body	2.6	0.12	877	93

Source: JICA Study Team

(4) Vibration Tests

Most yogurt pouches from the Company C failed the drop test (drop height =1m) in the first try. They also failed the compression test when placed transversely under a static load of 40 to 60 kg. They were considered as "faulty sample" C due to its low seal strength.

On the other hand, fresh milk containers from the Company C were considered as "good sample" B, due to their low failure rate in the drop and in the compression tests.

Source: JICA Study Team

Fig. 7.3.4-4 Vibration Tests for Pouches

Ten samples from the Companies B and C, respectively, were placed in a basket and then submitted to a vibration test at 5 Hz, with 25mm displacement during 15 minutes. As there was no failure record, the test continued for 15 minutes more, and no failures were detected even then. Additional tests were carried out during 60 minutes more, but there was no failure detection either.

For pouches, we can infer that even low seal strength materials show almost no vibration damage. It may be due to the fact that pouches behave as flexible elements, and vibration loads distribute throughout the container.

7.3.4.2 Yogurt containers

(1) Bursting test

Bursting tests as described in in the Clause 7.3.2 were performed on yogurt pots, using the equipment depicted in Figure 7.3.2-1. The samples were 145g yogurt pots (lid diameter = 65mm) and 185g yogurt bottles (lid diameter = 25 mm). Bursting resistance value for pots ranged from 0.4 to 0.6kg/cm^2, and it was 0.7kg/cm^2 for bottles, without bursting.

These results were compared to the ones obtained with the test equipment manufactured by the LATU. As the bursting levels obtained were almost equal to the above ones, this equipment proved to be reliable.

A bursting resistance value of 1.3 kg/ cm^2 was obtained for bottle-type pots. Seal failure points were found peripheral, but not in the seal itself. We can say that bursting resistance is higher in low-diameter lid containers.

Source: JICA Study Team

Fig. 7.3.4-5 Bursting Test Arrangement in LATU

Source: JICA Study Team

Fig. 7.3.4-6 Bubbles during Tightness Test

(2) Tightness tests on pots

Tightness tests as described in the Clause 7.3.2 were performed on yogurt pots, using the vacuum dryer equipment (see Fig. 7.3.2-2). The samples were 145g yogurt pots (lid diameter = 65mm) with aluminum foil lid and with aluminum deposition film lid.

No failures were detected with relatively low vacuum values (0.3 ～ 0.5kg/cm^2). Nevertheless, leakage began at slightly higher vacuum values, and lids burst at even higher vacuum values.

7.3.5 Milk caramel transportation packaging evaluation in Argentina

(1) Production information

Mastellone Company is one of the leader dairy companies in Argentina. The company collects a daily volume of 4,500 kl of milk, twofold the Japanese milk production in year 2005. Some of its manufactured dairy products are: milk, yoghourts and cheese, besides milk caramel which is not popular in Japan.

(Note: Milk Caramel is a milk and sugar mixture (1:10 V/V) cooked and stirred until it becomes a brown creamy product, like a milk jam).

This dairy product is consumed like jams, spread on bread, and young people even eat it by spoonfuls.

(2) Product distribution system

Nationwide dairy products distribution is performed on company owned trucks, which bear the company's trademark. Milk caramel 500g containers are vacuum shaped. This product is retailed at groceries. Primary packing bears a polystyrene cap that protects the internal aluminum foil lid. Special pallets with boxes (12 units each) are used for domestic transportation.

Product exportation to Chile started in 2006. Transportation control is performed by the Chilean company. Cardboard boxes are used for product exportation (4 rows x 3 x 2 layers= 24 units). There is no septum between layers; therefore the pots are piled up one on the other. There are vertical septa inside the boxes which separate 6 unit groups across both layers (see Fig. 7.3.5-2). The boxes are loaded on trucks in upside-down position for further transportation.

Source: JICA Study Team

Fig. 7.3.5-1 Milk Caramel pot

Source: JICA Study Team

Fig. 7.3.5-2 Boxes without Interlayer Septum

The pots have to be placed upside-down because air trapping occurs during the container filling process. When this air trapped appears as bubbles, the product's visual aspect is disgusting to consumers. Bubble transference to the bottom of the pot is difficult because of the product's high viscosity.

For product transportation to Chile boxes are placed as follows: 8 boxes x 5 layers piled up like bricks, per pallet. Inside the trailer, they place 2 longitudinal rows of 13 pallets each (total= 26 pallets).

The route from Buenos Aires to Mendoza city (nearby Chile) is plain and 1,000 km long, while the one from Mendoza to Santiago crosses the Andean ridge at 3,200 m ASL, and is 380 km long.

(3) Packing Design Improvement

7.3.5.1 Task: Milk caramel container redesign

Milk caramel has been exported since long time ago to Russia and the USA, and in 2006 started being exported to Chile. At this time, claims arouse due to product leakage through pores in the aluminum lid. Leak points were located peripheral on the lid seal, but no pores were detected on the lid central portion. The primary container bears an outer PS lid to cover the aluminum foil one.

7.3.5.2 Hypothesis about the origin of the fault

There are three possible causes of pinhole existence, as follows:

(1) Damages are due either to the presence of 7 bulges on the plastic lid, which are formed during its manufacturing process, or to vibrations on contact points of the aluminum foil lid edge and the plastic lid. Friction pinholes could be responsible for the faults.

(2) The aluminum lid is subject to repeated deformation (it blows up and flattens) by vertical vibrations, with the subsequent material fatigue. Material bending fatigue could be responsible for the faults.

(3) The product freezes during the Andean ridge crossing, and frozen product's sharp edges stab across the aluminum lid. Punching pinholes could be responsible for the faults.

7.3.5.3 Vibration test research and results (Fig. 7.3.5-3)

(1) Vibration test method (Fig. 7.3.5-1)

The protective PS lid is designed to allow container stacking. The containers are packed upside-down in two layers, without any kind of cushioning between layers.

Vibration tests were performed in order to determine the origin of the faults, even though test conditions are different from actual transportation conditions. The test was performed applying 5Hz sinusoidal waves, and 1G acceleration during 30 minutes. Visual checking was performed at 15 and 30 minutes. Horizontal vibration tests were also performed, with 5Hz horizontal sinusoidal waves x 1G.

Vertical vibration phenomenon was mimicked testing two pots which were stacked upside-down (upside-down/upside-down) with the results shown in the Test No. 1 (Table 7.3.5-1). Small pinholes were detected after the first 15-minute period. These pinholes enlarged allowing product leakage during the second half of the test for another 15 minutes (Fig. 7.3.5-4). Under the stereomicroscope, it was proved that the pinholes didn't belong to the material embossing lines (Fig. 7.3.5-5).

Source: JICA Study Team

Fig. 7.3.5-3 Vibration Test on Stacked Boxes (5 Layers) - Bottom Box

Source: JICA Study Team

Fig. 7.3.5-4 Pinhole in the Aluminum Foil Lid

(2) Analysis of the product packing style into the boxes

Milk caramel pots were packed into boxes in different styles, in order to test the packing process. Style combinations were as follows: upwards/downwards, downwards/upwards (See Tests No. 2 & 3 in Table 7.3.5-1), downwards/downwards with 0.86mm cardboard spacer (See

Test No. 4 in Table 7.3.5-1). Vibration tests with different packing style combinations didn't show remarkable improvements on product damage records. Notwithstanding that, the number of fault points increased with the test duration, and they concentrated along the lid perimeter, close to the seal. On the other hand, leaks occurred with horizontal vibrations as well (See Test No. 8 in Table 7.3.5-1).

Therefore, they stated the hypothesis under which the faults were due to the friction between the peripheral area of the aluminum lid and the plastic cap (See Fig. 7.3.5-6).

(3) Transportation simulation test (See Test 10, 11, and 13 in Table 7.3.5-1)

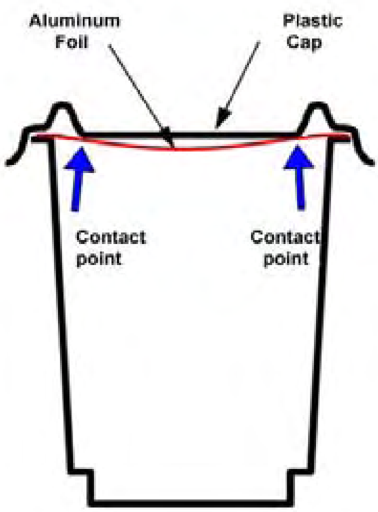
Further vibration tests were performed simulating product transportation from Buenos Aires to Mendoza (1,000 km), and from Mendoza to Santiago de Chile crossing the Andean ridge (380 km). Simulation setup was based upon the data compiled during the Transportation Environment Study.

They were random tests (5～150Hz, Grms:0,4 vertical wave) performed in two stages: the first one for 1 hour and 45 minutes, and the second one for 1 hour. Horizontal vibrations were determined to be not significant from Buenos Aires to Mendoza, despite the long way. On the other hand they were significant from Mendoza to Santiago, crossing the Andean ridge, due to the great number of turns, and despite the short way.

Therefore, horizontal vibration simulation tests were performed with random waves in two stages: the first one during 30 minutes and the second one one during 60 minutes (so as were the vertical vibration tests). Fault conditions were also reproducible after horizontal vibration tests, too.

Source: JICA Study Team

Fig. 7.3.5-5 Microscopical View of the Pores in the Aluminum Foil Lid



Source: JICA Study Team

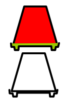
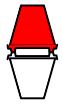
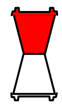
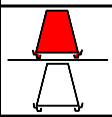
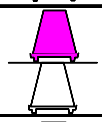
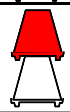
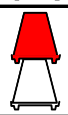
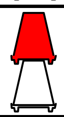
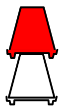
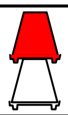
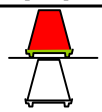
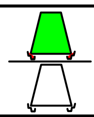
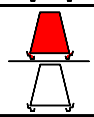
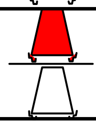
Fig. 7.3.5-6 Contact Points between the Aluminum and the Plastic Lid

(4) Pot testing using an internal cardboard（Fig. 7.3.5-7）

A 0.86mm thick cardboard disc (diameter= aluminum lid diameter) was placed between the plastic cap and the aluminum lid, in order to prevent permanent contact between them.

Vibration tests were performed as above, and only 2 pinholes were detected and no leak faults occurred after 30 minutes' test. Therefore, there was an effective improvement (See Test No. 5 in Table 7.3.5-1).

Table 7.3.5-1 Vibration Test Method (Milk Caramel)

Test Nbr	Vibrat. Cond.	Duration	Packing Style	Id. Nbr	Qty of Faults	Damage location upp/bott	Damage Location periph	Damage Location central
1	Vert 5Hz,1G	15min		001-024	1	Upp1	3	1
		30min			3	Upp3		
2		15min		201-224	3	Bott3	10	3
		30min			6	Bott1,Upp5		
3		15min		301-324	1	Bott1	6	1
		30min			4	Bott3,Upp1		
4		15min		401-424	2	Upp2	6	2
		30min			5	Bott2,Upp3		
5		15min		601-624	2	Bott1,Upp1	2	0
		30min			0	0		
8	Horiz 5Hz, 1G	15min		2001- 2024	2	Upp2	2	0
		30min			0	0		
10	Vert Simulation	BUE-MDZ 105min MDZ-SCL 60min		101-124	2	Upp2	8	3
					5	Bott3,Upp2		
11				6001-6024	2	Bott2	21	9
					13	Bott6,Upp7		
13	Horiz Simulation	BUE-MDZ 30min MDZ-SCL 45min		2301-2324	0	0	2	1
					2	Upp2		
6	Vert 5Hz,1G	15min		801-824	0	0	0	0
		30min			0	0		
7		15min		5001-5024	0	0	1	0
		30min			1	Upp1		
9	Horiz 5Hz,1G	15min		2101-2124	0	0	0	0
		30min			0	0		
12	Vert Simulation	BUE-MDZ		2201-2224	0	0	0	0
		MDZ-SCL			0	0		
14	Horiz Simulation	BUE-MDZ		2401-2424	0	0	0	1
		MDZ-SCL			1	Upp1		

Source: JICA Study Team

(5) Ring-type caps test on milk caramel pots（Fig. 7.3.5-8）

These tests were performed in order to check the probable contact between the aluminum foil lid and the peripheral zone of the plastic cap. The central portion of the plastic cap was cut out by a grinding machine and removed, remaining the outer ring only. This ring was replaced on the pot, and therefore the plastic cap and the aluminum lid were completely apart. The pots were placed as follows: one layer of upside-down pots, a horizontal cardboard spacer, and a second layer of pots.

Vertical vibration tests were performed for 15 minutes, and horizontal vibration tests were performed for 30 minutes, and one leaking point was found (Table 7.3.5-1 Tests No. 6,7,9). Transportation simulation tests were performed as well, and no faults were detected (Table 7.3.5-1 Test No. 12), except for the horizontal simulation test, where only one fault was detected during the second stage (Table 7.3.5-1 Test No. 14). The faults were located at the central part of the disc, therefore being a consequence of material fatigue, and not of mechanical contact.

Source: JICA Study Team

Fig. 7.3.5-7 Cardboard Disc to be used in Tests

Source: JICA Study Team

Fig. 7.3.5-8 Modified Cap to be used in Tests (Ring-type Cap)

7.3.5.4 Material fatigue and microscopical view of the aluminum foil lid

(1) Microscopical view of the aluminum foil lid (Fig. 7.3.5-5)

The thickness of the raw material for the aluminum lid is 35 to 40μm. It is embossed in order to improve its properties such as printing, mechanical handling, and safety (Fig. 7.3.5-9). After this, its thickness increases 100 - 110μm, while its mechanical strength lowers.

The aluminum lids were examined under a stereomicroscope (10 X). Microscopical cuts were observed, some of which paralleled the emboss lines, but were not related to them.

(2) Relationship between material fatigue in the aluminum lid and natural frequencies of the pot

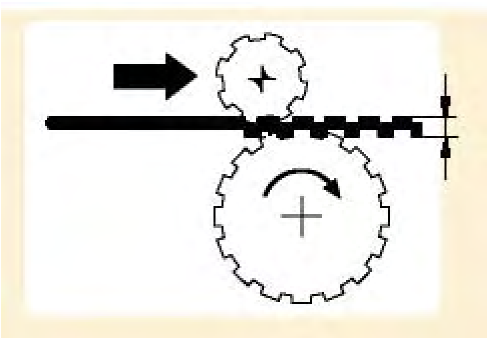
The tests performed using the ring-type plastic cap showed that pinholes appeared regardless mechanical contact between the aluminum lid and the plastic cap. Moreover, the size of the pinholes increases along the test performance.

Further tests were performed removing the plastic cap. Vibration of the aluminum lid was detected with a stroboscopic light (Fig. 7.3.5-10), between 20 and 40 Hz, at 1G acceleration.

Pinhole formation was detected after 1 hour at 40 Hz, and leaks occurred thereafter. Leakage was detected during horizontal and vertical vibration tests as well, and at similar frequencies in both cases.

PSD curves built along the Transportation Environment Study in MERCOSUR countries showed three typical peaks at 3～4Hz, 15Hz and 30Hz. Therefore, we can say that the pinholes detected on the aluminum lids at 30Hz can be due to natural frequencies of the pot.

Finally, in order to fix the leak faults the aluminum lid has to be replaced for either an aluminum-laminated plastic one or for an aluminum-deposited plastic lid.



Source: JICA Study Team

Fig. 7.3.5-9 Emboss Process Layout for the Aluminum Lid

Source: JICA Study Team

Fig. 7.3.5-10 Aluminum Lid Vibration at 20 to 40 Hz

7.3.5.5 Investigation: Product freezing due to low temperature and low pressure by the Andean ridge crossing

Temperature decreases during the Andean ridge crossing, compared to the base plain lands, because the crossing is performed 3,200m above sea level. According to the US Standard Atmosphere studies (1976), there is a 0.65ºC decrease every 100m higher above sea level (up to 11,000m height). The study also shows the corresponding atmospheric pressure variations in a table. The table values indicate that taking a 15ºC temperature for the plain base land, the temperature at 3,200m height should be -5.8ºC, and the pressure 983.4 mBar (513 mmHg). Should the temperature at the base plain land be 0ºC, the temperature at 3,200m height will be -20.8ºC.

The milk caramel was taken to -12ºC for 18 hours during the test, but it didn't freeze. Moreover, the temperature was lowered to -18ºC for 66 hours and then to -27ºC and it didn't freeze either. The product's texture was kept like an ice cream's.

Therefore, it has to be considered that there is no product freezing during the crossing of the Andean ridge. The hypothesis under which sharp ice portions tapered the lid, generating pinholes shall be discarded.

Source: JICA Study Team

Fig. 7.3.5-11 Aluminum Foil under Normal Pressure (Curved down)

Source: JICA Study Team

Fig. 7.3.5-12 Aluminum Foil Flatten at Low Pressure (Crossing Andes Rockies)

The milk caramel pot is filled with product at high temperature. The aluminum lid curves down when the product cools to room temperature, because of volumetric contraction of the product and of the air chamber above it (Fig. 7.3.5-11). The atmospheric pressure during the Andean ridge crossing is 510 mmHg. A test was performed placing the pots in a vacuum chamber and lowering the pressure to 250 mmHg only, and the aluminum lid turned to a flat position (Fig. 7.3.5-12). Should this pot now be submitted to continuous vibration, pinholes will be likely to appear in the central part of the aluminum lids.

Mastellone Company stated that they will make some improvements on the plastic cap geometry (between 1-2 mm).

The use of an aluminum foil laminated plastic lid is recommended for a complete solution of this problem.

A lot of improved samples will be prepared in order to perform vibration tests. Should these tests be positive, transportation tests will be performed during the fifth stage of the study.

7.3.5.6 Compression tests on pots and caps

Source: JICA Study Team

Fig. 7.3.5-13 Compression Tests of Pots and Caps

The pot's cap is manufactured in a soft material, therefore it depresses when pressed in its central area. The tested product is packed in two layers, without spacers, the lower layer receiving a pressure load. Compression tests were performed on the pots and on the center and peripheral protruding areas of the cap in order to prove the pot's endurance (Fig. 7.3.5-13). Results are shown in Table 7.3.5-2.

The cap's central area showed 7mm and 13mm deformations for 5kgf and 10kgf loads, respectively. Therefore the plastic cap touches the aluminum lid when little loads are applied.

Table 7.3.5-2 Compression Tests on Pots

Figure	Description	Load kgf	Displacement mm
Fig. 7.3.5.13－1	Plastic cap, central area	5.0	6.7
		10.0	12.8
Fig. 7.3.5.13－2	Pot + cap (center)	52.4	3.2
Fig. 7.3.5.13－3	Whole pot	49.9	2.6
Fig. 7.3.5.13－4	Plastic cap	15.5	2.7
Fig. 7.3.5.13－5	2 pots, piled up, upside-down	39.2	9.3

Source: JICA Study Team

7.3.5.7 Laboratory tests on redesigned packaging

(1) Re-designed packaging samples

1) Re-design of the plastic lid of a pot

Since there were problems with plastic lids when the peripheral part contacted the aluminum foil lid, as shown in Fig. 7.3.5-6, the design was modified. The lid was improved by reducing the central disk depth from 4 mm to 2 mm so as to avoid contact with the internal aluminum lid.

Since during transportation pots are upside down and piled in two layers, so that the bottom of the lower pot holds the upper one, the lid is curved due to its weight. In addition, the plastic lid material has also been modified making it more resistant to avoid contact with the internal lid.

2) Redesign of an aluminum foil lid

A material combining aluminum and a 12 μ PET plastic film was tested. As a reference, this material has been used by the company in its marmalade pots for 3 years. In this case, the laminated material was used because sugar chemically affects aluminum so the PET film is used to avoid direct contact.

Source: JICA Study Team

Fig. 7.3.5-14 Improved Pot Cap (with protuberances)

An aluminum-based alternative is the following (AL50μ/PET12μ/Lacquer): This laminated material has an aluminum foil that not embossed but has numerous protuberances on the PET film (see Fig. 7.3.5-14). Those protuberances prevent closing machines from taking several lids.

At present, the thickness of the aluminum lids used for milk jam (*dulce de leche*) is 50μ. The proposed improvement aims at reducing the thickness of the aluminum by 10μ, i.e. the final specifications of the material would be (AL40μ/PET12μ/Lacquer). The purpose is to obtain an embossed material, fit for the production line.

(2) Types of packaging samples

The samples of pot lids subject to vibration tests were the following:

[1] Current Aluminum Lid + improved plastic lid, piled in two layers with no separators

[2] Current Aluminum Lid + improved plastic lid, piled in 2 layers with a separator

[3] Current Aluminum lid+ current plastic lid, piled in two layers with no separators

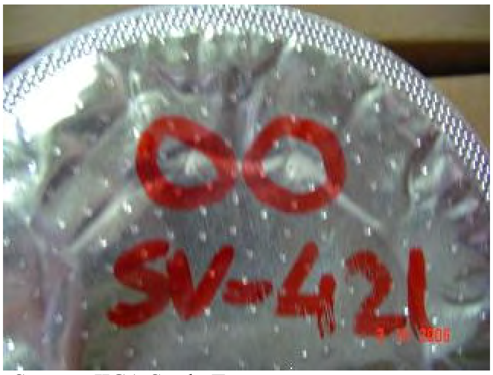
(3) Method used in vibration tests and results

The method described in the items 1) to 3) of the Clause 7.3.5.3 was used to perform vibration tests. That is a 5 Hz sinusoidal wave, 1G accelerations and vertical and horizontal vibrations were applied for 15 minute and then 30 minute periods. Besides, simulation tests of the routes corresponding to the Buenos Aires-Mendoza and Mendoza-Santiago stretches with vertical variations were carried out.

Both for samples 1) and 2), and for all the mentioned methods, no failures were identified. However, the improved lids were difficult to separate in the production line.

As regards sample 3), tests were performed applying 5 Hz vertical vibrations and 1G accelerations during 15 and 30 minute periods. As a result, pin holes were found in the aluminum lids, 3 cases in the upper layer and 1 case in the bottom layer. But due to the protection provided by the PET film, no leaks were found (Fig. 7.3.5-15 and Fig. 7.3.5-16).

Besides, the aluminum lids of the products placed in the upper layer had circular marks caused by contact with the bottom of the pots in the bottom layer. This happened with all the samples and can be solved by using separators, so it is not considered critical.



Source: JICA Study Team

Fig. 7.3.5-15 Improved Aluminum Cap Showed Pin Holes

Source: JICA Study Team

Fig. 7.3.5-16 Improved Cap (without protuberances) Showing Cracks

Subsequently, vibration tests were performed through transportation simulations. Since no new samples were available, those used in other tests were used. Along the Buenos Aires-Mendoza stretch, pin holes were found on 10 pots (upper layer) and along the Mendoza-Santiago stretch, pin holes were found on 3 pots (upper layer). No leaks were found. However, there was only one leak on the bottom layer.

(4) Horizontal vibration tests on pots with aluminum lids

A concavity is found in aluminum lids when subject to atmospheric pressure. As indicated in the Clause 7.3.5.5, said lids become flat when crossing the Andes due to the lower pressure. Therefore, the area of contact between the plastic lid and the aluminum foil increases so the possibility of pin holes is higher.

In order to verify the influence of these changes in the shape of aluminum lids, the following tests were performed.

Air was injected with a hypodermic needle into pot samples, flattening the aluminum lids, as follows:

Currently used pot -------→ 15 ml of air

Pot with improved lid ------→ 20 ml of air

Notwithstanding the difference in the volume of air injected, in both cases lids were almost flat. Besides, no separators were used between the two layers of pots. In addition, since there were no new pots available with improved Aluminum lids, samples used in other tests were used.

Vibration testing conditions were only those corresponding to the Mendoza- Santiago stretch and the testing times were 50% of the actual duration of the trip because the test was carried out under the assumption that "flat" lids only occur when crossing the Andes at 3,200m SNM. During actual transportation, the shape of the Aluminum lids changes from concave to flat during the ascent from the valleys to the mountains.

In fact, during the tests, 30 minutes of vertical oscillation and 22.5 minutes of horizontal oscillation were applied.

As a result, no failures were found in the currently used pots subjected to horizontal vibrations while some were found in 3 pots on the upper layer.

In the case of pots with improved Aluminum lids, no leaks were found although the pots used in this test had already been used in 2 or 3 vibration tests.

(5) Results in respect of improved aluminum lids and piling methods

The results of the tests performed on improved aluminum lids were satisfactory. However, when piled in two layers upside down the lids of the products on the upper layer were marked by the bottom of the pots placed under them.

Besides, pin holes were found in the upper layer pots but no product leaks. However, under worse conditions of transportation, failures are very likely to occur. To protect the pots from damage, a cardboard separator should be placed between the two layers.

7.3.5.8 Steps taken to avoid the increased costs of improved aluminum lids

Pin holes can be found on aluminum lids due to the chemical effects of the product contained in the pot. Tearing can also occur when opening the lid. Besides, pin holes may be due to friction or material fatigue during transportation. An alternative to solve these issues is the use of plastic laminated materials (specifically 12μPET). In this case, if the current Aluminum base material is used not modifying its thickness adding a PET-12 film costs would increase. To avoid this, the thickness of the aluminum foil should be reduced.

Besides, when reducing the thickness of the aluminum, the laminated film "curls" becoming mechanically unfit. To avoid this, the material is embossed, such as the currently used material, thus increasing its apparent thickness. For example, the original aluminum foil used in milk jam pots is 50μ thick but after the embossing process its thickness increases up to 110 to 130μ.

The costs of cases (1) and (3) can be analyzed based on the following specifications.

(1) Current material: 50**μ** aluminum foil /Lacquer

(2) Improved material -1 : 50μ Aluminum fiol/PET12μ/ Lacquer ⇒ Cost increased

(3) Improved material -2 : 40μ Aluminum foil/PET12μ/ Lacquer

The aim is to reduce costs through reduction of the aluminum foil thickness in several stages.

The reference prices used in this case were packaging materials unit prices in force in Japan. However, the price of aluminum depends on the London Metal Market (LME) based on which the other markets establish their own prices, so the international price is almost the same.

For this analysis, the prices of packaging materials were defined as follows:

Aluminum Foil (20～40μ) : US$ 6.00 , Density: 2.7g/cm^3

PET Film (12μ) : US$ 3.50 , Density : 1.4g/cm^3

Lamination costs US$ 0.10 per m^2

Taking into account that the diameter of the aluminum lids of milk jam pots is 100 mm, it can be estimated that 100 lids can be obtained from 1 m^2 of material.

Once the 100 lids are obtained, the subsequent processing costs can be calculated as follows: in case (1) < Current material: 50μaluminum foil /Lacquer > and (3) < improved material-2 : 40μ aluminum foil /PET12μ/ Lacquer > respectively, pursuant to the following formulae.

(1) Current material:

50/10,000cm×10,000cm2/m2×2.7g/cm3＝135g ⇒ US$ 0.81 / 100 lids

(3) Improved material:

・Cost of 40μ Aluminum : 40/10,000cm×10,000cm2/m2×2.7g/cm3＝108g ⇒ US$0.648/100 lids

・Cost of 12μ PET ; 12/10,000cm×10,000cm2/m2×1.4g/cm3＝16.8g ⇒ US$0.0588/100 lids

・Dry lamination costs : US$ 0.10 /100 lids

Total = US$ 0.807 /100 lids

Result: the increased costs of laminating the current material with PET12μ can be set off by reducing the thickness of the aluminum by 10 microns. If it could be further reduced, costs would also be lower.

7.3.5.9 Reduction in the consumption of aluminum lids and CO_2

The reduction in the consumption of aluminum implies lower CO_2 emissions, which is positive from the point of view of reducing the emission of greenhouse gases.

Aluminum is made from bauxite, treated with sodium hydroxide. After extracting the alumina (aluminum oxide) it is melted and subject to an electric separation process.

Consequently, a significant amount of electric power is used to produce aluminum, this is why it is also called “canned electricity”.

Within the MERCOSUR, the main source of energy is hydroelectric power but it depends on each country. In some countries, the use of thermoelectric energy is very high, even exceeding 52% of the total generated power.

Based on information provided by the Japanese Aluminum Producers’ Association, 20 Kwh of energy are required to produce 1 kg of new aluminum. To such end 9.35 kg of CO_2 are generated, i.e. almost 10 times of its weight. To produce 1kg of metal from recycled material, only 0.31 kg of CO_2 are generated. I.e. aluminum can be recycled by using only 3.3% of the energy used to produce it.

The aluminum foil used in food packaging is difficult to recycle. Consequently, the reduction in the use of aluminum does not only imply lower costs but also a significant contribution to the reduction of CO_2 emissions.

7.3.5.10 Vibration tests of pouch packaged milk (Argentina)

During the studies carried out in Uruguay, they were tested the milk pouch of the Company C, which showed leakages for drop tests and compression tests. The vibration tests for the same product have been developed under a frequency of 5 Hz, 25mm displacement and during 90 minutes test. However, they did not show leakage failures.

In case of Argentina, a similar test have been carried out by using commercial milk in pouches, and testing 1 product having “3 side seal” and 4 products having “pillow type seal”.

For the tests, they were selected samples of product “A”, which showed failures during drop tests and compression tests. Also, products “B” have been selected with pillow type seal. For each product, the selected samples were 10 units each, placed in a basket for the vibration tests. In order to produce the failures, deliberately, the tests have been done at more severe conditions compared to those of Uruguay tests. For Argentina’s tests, it was observed visually that the pouches are jumping in the baskets during the tests.

The vibration conditions were: acceleration 1.5 G; frequency 5 to 9 Hz; test duration: 30 minutes. After that, it was added an additional period of 15 minutes (see Table 7.3.5-3).

Table 7.3.5-3 Vibration Tests: Times and Failure Points (1.5G×5～9Hz)

	Leak place	Test duration (min)		
		30min	45min	60min
Company A	Upper seal			2
	Other parts		2	
Company B	Upper seal	2		
	Body seal		1	1
	Other parts	1	1	

Source: JICA Study Team

As shown in the table, when elapsed 30 minutes, failures were observed for the Company B, and at 45 minutes for the Company A. The leakages were located in the upper side seal and on the body of pouch, respectively. Also, pin holes were found in other parts of the pouch, in the plastic film. The origin of the pin holes are not well known, but the possible origin could include the puncture due to edges in the basket, friction against the basket wall, friction between pouches, etc. This phenomenon can be analyzed through deeper studies and tests of these products.

Chapter 8 Transportation Tests (Model Project)