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CONSOLIDATION OF CAPACITY OF INSTITUTE OF FOOD TECHNOLOGY THROUGH CREATION OF A NATIONAL FOOD PACKAGING CENTRE

DP/BRA/82/030

BRAZIL

Technical report: Flexible packaging materials *

Prepared for the Government of Brazil
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

Based on the work of Dr. Gert Wille,
Expert in Flexible Packaging Materials

United Nations Industrial Development Organization
Vienna

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CONTENTS

ABSTRACTS

KEY WORDS

Flexible packaging, plastic packaging, food packaging, composite materials, metallized material, packaging solutions, machineability, consumer packaging, transport packaging, testing methods, internal seminars, future projects, deep temperatures.

1. INTRODUCTION

The UNIDO/Brazil Food Packaging Center Project is identified as the Project BRA/82/030 with the duration of five years. One of the more important activities of this project is the development of the CETEA'staff through training in the field of flexible packaging materials.

According to the job description, following activities should be developed during the mission.

1. Short courses and internal seminars related to the use of different types of flexible packaging materials and related quality control tests.

2. Appraisal of the existing equipment in the Center and suggestions for its complementation in the area of flexible packaging material and food packaging system.

3. Training the personnel of the Center in equipment already existing in the laboratories.

4. Visit to industries related to the food and flexible packaging material in order to analyse the main problems related to these areas in Brazil.

5. Assist the Center personnel in the solution of the problems during the mission.

6. Evaluation of the main projects already existing in this area as well as orient in the program for future projects.

(Programme see Appendix 1).

2. SUBSTANTIVE SECTIONS

2.1. Short courses and internal seminars

Courses and seminars were performed for the staff of CETEA (over view about the contents of the main discussions see Appendix 2).

Referring to the problems

- Machineability of flexible packaging materials
- Tensile indicees of plastic films under low temperatures
- Testing Laboratory for transport packages

Short reports are made (see Appendices 3, 4, 5).

2.2. Appraisal of the existing equipment

The test laboratories for flexible packaging material have a good basic equipment to carry out the main tasks.

Evaluation of single equipment:

1- Test equipment for gas barrier and water vapour transmission: Equipment has a high level and good quality, it can be used the next years, no additions required.

2- Test equipment for mechanical indicees:

. The tensile tester "INSTRON" is an old model with a small measurement range; it should be renewed by a new equipment with test loads until 500kg.

. ELMENDORF - Tester, BURSTING - Tester and DROP-Tester have a proper quality, they are useful for the next years.

. PUNCTURE - Tester has the same level as in other countries (e.g. EUROPE), this equipment should be repaired and used for the next years.

. CRUSH - Tester is useful to test samples; it should be used in the next years and renewed until 1990 by equipment with bigger plates (e.g. 25 X 25cm) and automatic recording of the indicees.

. The other equipment has a present standard, renewing immediately is not necessary.

3- Test equipment for packages:

. HYDROSTATIC Pouch Burst Tester and BURSTING TESTER with compressed Air have a good standard, no additions are required.

. Impact Tester ("FALLING DOWN DESK") has also a good quality.

Remark: In EUROPE the surface is inclined 10°, this should be considered if a new equipment will be constructed (for comparing the values and indicees in the international literature).

. PRESSURE Tester is usefull to fulfil the present tasks. In connection with creating a test laboratory for transport packaging it should be added by a new Pressure Tester (American or European Standard) with bigger load and plates (see chapter 3.2.).

2.3. Training the personnel of the Center in equipment.

Laboratory work was carried out to test the CRUSH TESTER for using as a method to value plastic bags (bags hot sealed ,filled with air, compression test).

2.4. Visits to the industry
No visits planned by CETEA.

2.5. Assistance in the solution of the problems during the mission. During the courses and seminars (s. App. 2) actual problems were discussed, especially in relation to the conditions of Brazil.

2.6. Evaluation of the main projects existing in this area as well to orient in the programme for future projects.

The most important project is to develop the Packaging Group to a National Food Packaging Centre and in this connection also to a training centre for Latin America.
The creating of CETEA in this direction is necessary for the food industry in Brazil and will promote the whole work of UNIDO in Latin America. CETEA has the possibilities for this project. The graduated specialists, the technicians and the assistants have a good standard in knowledge and practical work in the laboratories, it is a young team and should work together

for a long period.

The future training centre should perform:

- Lessons and seminars in the whole field of food packaging (materials, auxiliaries, adhesives, foods, packaging machines, applications, tests and special problems, for example recycling, environmental protection, technical- economic analyses).
- Practical works (in the test laboratories of packaging machines and transport packagings).

This requires to increase the number of people in CETEA to about 50 persons and the area for the laboratories.

The Lessons and seminars should be performed with assistance by the University of Campinas and selected producer's of packaging materials and packagings, for example problems in the field of plastic extrusion, of printing and special techniques (injection moulding, blow moulding, foaming, welding/hot sealing).

The opinion of the expert is, that this training centre for Latin America should not concentrate its work only in the field of application of packaging materials and test Laboratory - the work must include an exhaustive programme in the field of food packaging.

3. SUMMARY OF RECOMMENDATIONS

3.1. Recommendations concerning projects of Plastic Packaging Group

1- Repair the "PUNCTURETESTER" and use it to test the whole range of materials, this type of equipment is widely used (also in EUROPE), so that the indicees can be compared directly (see ASTM D 781-68).

2- Buy a new "Tensile Load Tester", applicable for all flexible packaging materials and carton, corrugated board (load range to 500Kp) with climate chamber (temperature range - 30°C to about 80°C) for testing the behaviour of flexible packaging material under different temperatures.

3- Buy an equipment for UV-tests ("Xenon radiator") to test packagings and packaging materials after radiation.

4- Collecting knowledge in the field of transport packagings incl. testing laboratory for transport packaging and load units.

3.2. Recommendations concerning further development of CETEA

1- Decreasing the equipment under the aspects of the future projects (National Food Packaging Centre, Training Centre for Latin America):

a) Buy and installate a climate chamber with temperature range - 30°C to +60/70°C, sizes inside about 2.5 x 2.5m, 2m height to perform tests with the full testing equipment within the chamber (for example ELMENDORF Tester, PUNCTURE-Tester, DROP Tester, Bag's Falling down Tester und climatized pallets and load units); handling inside or from outside.
The chamber should be performed at different humidities.

b) Buy a Laminating machine for laboratory investigations:

. Width of the rolls about 300 - 400mm.
. Applicable for laminating of paper, foils, aluminium foil.

This equipment is necessary to develop new composite films and coated materials and further as a training equipment.

c) Buy a typical form-fill and seal-machine (packaging machine) to make investigations in the field of machineability of flexible packaging materials and use its as training equipment.
This machine should be us·able for single plastic films, coated papers and composite films (with aluminium foil too), working direction "vertical", with filling and dosing station, alternating sealing tools (width, surface), width of the rolls max-400mm.

2- Create a testing Laboratory for transport packaging

. First step:

Work out a project for such a Laboratory with assistance by UNIDO experts; 1986. (First idea see appendix 5, Fig. 8).

. Second step:
Training the specialists of CETEA in developed institutes in this field (for example: Packaging School/University

of Michigan, USA and Packaging Centre of Dresden, GRD), 1986/87.

- Third step:
  Installate the necessary equipment
  Pressure Tester (buy from Sweden)
  Vibration Tester (buy from Sweden, USA or Japan)
  Fall TEST Equipment (selfmade; know how from GDR)
  Inclined Track (selfmade; know how from GDR)
  1988 - 1990.

Complete this basic equipment step by step with other special equipment, 1990 - 1995 (see Appendix 5, Fig.7).

3. Create a Training Centre for Latin America in the field of food packagings:

- First step:

  Work out a project for such a centre with assistance by UNIDO experts, 1986.

- Second step:
  Collect knowledge and experiences in the field of realization training courses (for examples: Packaging School/University of Michigan, USA and Packaging School of Altenburg, GDR); 1986-88.

- Third Step:
  Accomplish the project (1988-89) and begin the first course about 1989.

4. GENERAL SUGGESTIONS

a) Collaborating with plants of the industry to develop "complex packaging solutions" (multilate applicable basic solutions), this requires:
   - specialists in the field of graphic/design
   - specialists and equipment to make samples (know how about necessary equipment can be delivered by Packaging Centre Dresdey, GDR)

b) Initiate a National Packaging Competition in Brazil (to promote progressive packaging solutions).

   Contents:
   - Good design and graphic realization
   - Good construction of the packaging
   - Economical production.

c) Issue a special Brazilian Packaging Journal by CETEA (for the first time without fixed termination, later 4 or 6 journals per year).

With the realization of suggestion No. 4 references for CETEA are supplied. This suggestion should also be seen under the aspect of creating a training Centre for Latin America.

APPENDICES

1. Programme of the work

2. Overview about internal courses and seminars (mainly problems)

3. Machineability of flexible packaging material

4. Tensile indicees of plastic films under low temperatures

5. Testing laboratory for transport packages

APPENDIX 1

PROGRAMME OF THE WORK

23.10.85: Visit of ITAL, Packaging Div., information

24.10.85:
- Information about packaging problems and organization of packaging industry in Brazil
- Informations about packaging industry in GDR, about work of Packaging Centre in Dresden
- Possibilities to supply ITAL/Pack. Div. by the Packaging Centre Dresden
- Experiences in the field of development of packagings/ complex solutions

25.10.85: Behaviour of plastic films, coated papers, composite films on the different types of packaging machines

29.10.85: Production and application of metallized materials

30.10.85: Special test methods of packaging materials (for example: hot sealibility, UV-test, testing of plastic bags,...)

31.10.85: Valuation of the existing testing equipment in ITAL, possibilities of combination the testing results (espec. tensile indicees);
suggestions for completion.

01.11.85: Tensile indicees of plastic films under low temperatures

04.11.85: Packag ing machines:
- Hot sealing systems
- Packaging machines made in GDR
- Aspects of machineability

05.11.85: Special economic problems in the field of application packaging materials (e.g. analysis of packaging, processes, automatization,packaging cost-structure, high speed machinery; further development).

06.11.85: Packaging processes to produce transport packages

07.11.85 to 08.11.85 Transport packaging testing (transport loads, theoretical aspects, test methods, test equipment, suggestions)

11.11.85
to - Final report
12.11.85

13.11.85: - Discussion about recommendations and valuation of existing equipment in CETEA

- Problems and possibilities to create a packaging training centre for Latin America (discussion)

14.11.85: - New developed packaging systems in EUROPE - examples (e.g. pasteurized pouches, PET-bottles, special films and foils)

18.11.85: Final discussions about special problems

APPENDIX 2

OVERVIEW ABOUT INTERNAL COURSES - AND SEMINARS

(mainly problems)

1) Necessary steps in the field of "Development of Complex Packaging Solutions"

- Investigations/Information about the expected loads, the climate (temperature, humidity), chemical loads a. other Make a "check list"; analysis of the expected conditions in general (for example the transport-system, normal conditions/tropical conditions).

- Selection of material (incl. auxiliary material)
  - . Testing the material in Laboratory
  - . Cleaning prices
  - . Cleaning supplying problems
  - . fix the amount of production

- Make samples
  By hand in laboratory

- Testing the samples
  - . Without the good   in laboratory
  - . With the good   and/or in practic (lorry, railway)

- Design
  - . Graphic layout
  - . Printing; colours

- Fixing the packaging process
  - . by hand or
  - . by machine (types, systems)

- Fixing special conditions for transport, handling and storage
  (For example against shock load, rain, high temperatures or system of transport).

- Suggestions for environmental protection

The principal solution should be used multivalent in the industry (only change design).

2) Behaviour of plastic films, coated papers, composite films on the different types of Packaging machines.

- Basic methods to produce combined materials
  - . Combination of layers without adhesive
  - . Lamination with adhesives ("cacheer process")
  - . Extrusion Lamination
  - . Coextrusion

- Basic packaging systems for consumer packages (15 pictures given to CETEA)

- Special experiences in the field of using materials on packaging machines (useful - mistakes):

  Roll system
  - . blocking effet
  - . web changes
  - . slits in the web

  Forming station
  - . no full forming
  - . damage the web

  Filling station
  - . electric load
  - . dirt in the package (contamination)

  Hot sealing station
  - . no full sealing
  - . damage of the seam
  - . wares in the sealing aerea

  Packaging situation
  - . no sliding of the bags on transport tion belt
  - . destroying the surface of bags (falling down)

3) Experiences in the field of production and application of metallized materials

- Two types of basic-techniques
  - . Semi-continuos (for packaging material)
  - . air to air (for metals)

- steps of the technological process

- metallizable materials (thicknessess, kinds)
- types of indicees for good metallizing quality
    - . thickness of Al-surface (optical density, electric resistance)
    - . temperature of the boats
    - . vacuum
- typical mistakes
- application of metallized materials
- behavior of packaging machines:

  T_{met} about $0.9...0.8T_{al}$ - sealing temperature

  P_{met} about $0.9.P_{al}$ - sealing pressure

  t_{met} about t_{al} - sealing time

- melting process by electronic beam
- metallizing of paper
    - . direct metallizing
    - . transfer metallizing
- cooling with liquid N_2

4) Special test methods of packaging materials

- Hot sealability
  (Hot sealing process, importance of the indicees, mistakes, usefull equipment, valuation of the indicees, courves).

- UV - stability
  (Test equipment XENON-radiator, tensile test of UV-radiated materials, courves, protection against UV-radiation, useful damages).

- Testing of plastic bags
  (Bags filled with air, pressed in CRUSH-TESTER, typical courves).
  Tests are made in laboratory.

- Falling down test of bags
  (Direction of loads, experiences, number of falls until break, valuation).

APPENDIX 2

- Long time tensile test of seams
  (Duration until 5 days, equipment and realization the test by selfmade equipment, important under different conditions, e.g. temperatures, atmospheres, aerosols, liquids).

5) Special economic problems in the field of application packaging materials

- Aspects of analysis of packaging processes (check list)
- Packaging costs (machine costs, salary, material cost in dependence of the daily degree of using the packaging machines), differences between
  . packed by hand
  . partial automised
  . fully automised

  Usefull degrees of automatization in dependence of productivity,
- Possibilities and examples of useful max. productivities in packaging machines,
- Further development in the field of packaging machines.

6) New developed packages in Europe - examples

- Composite films for pasteurized and sterilized foods, indicees for composite films made from OPP/Al/PE and PE/PA; temperature resistance -20°C to 120°C.
- PETP bottles for drinks;
  2ℓ = 80g weight of the bottle;
  recycling of the bottles.
- Ovenable board; 2 systems "RUBEPRESS" and "TRAYTITE", no aluminium foil.
- Thermoformable composite film with Al-layer, OPP/Al/PVC/OPP;
  elongation of the composite film about 25%
  (single Al-film only 5 - 15%)
- Thermoformable PA-Composite films with 6 layers (PA/PE/PVDC, different thicknesses),
  pasteurization to 90°C,
  for meat, long shelf life
- Tendences in the future of plastic packages

Machineability of flexible packaging material

APPENDIX 3

In practice, only very few reference values are available on machineability of flexible packaging material. The following results based on tests with a useful form, fill-and seal machine (60 bags/min.).

1. Most important indicees
   - Bending stiffness mNm²/m
   - Tensile strength (MD, CD) Nm
   - Coefficient of sliding friction on forming shoulder
   - Take-off force (force to draw the web over the forming shoulder) N/r
   - Thickness of foils µm

2. Results
   a) Tested materials, values for thickness, bending stiffness, tensile strength, coefficient of sliding friction, take-off force and kind of material on the side of the forming shoulder - s. table 1.

   b) General conclusions:
      . good machineability: PE, cellophane, PP
      . medium machineability: PA, PVDC
      . difficult machineability: Layers with paper

      The machineability depends on:
      . thickness of foil (Fig. 1 and 2)
      . stiffness of foil (Fig. 3)
      . coeff. of sliding friction (Fig. 4)
      Increasing of these indicees means bad machineability.

   Relationships:
      There is no full relationship between
      . coff. of sliding friction and take-off force (Fig.5)
      . take-off force and stiffness (Fig. 6)

   Summary:
      Stiffness
      Less than 10m Nm²/m - good machineability
      10 -80m Nm²/m - different machineability
      More than 80m Nm²/m - bad machineability

   c) Influence of forming shoulder:
      - Angle of feed (a) - Fig. 7

and kind of shoulder material
see Table 2.

Conclusions:

Big angles delivers more less take-off forces with bronze shoulder. On plastic schoulder take-off forces decreases with until angels from 60 to 70°. This means in practice that for each material the best indicees for the forming shoulder should be investigated. The take-off force increases with decreasing angles of feed (s. Fig.8, 9).

It is not possible, to work with any different materials on one machine with constant parameters with the same productivity.

d) Influence of edge-radius of the forming shoulder (see Fig.7).

Take-off force(N/m)

For edge-radius	0,25mm:	0,5mm:	1,0mm:
LDPE	189	151	163
OPP	174	144	152
paper/Al/PE	501	391	279

Conclusions:

Small amounts of edge-radius give big take-off forces; big amounts give smaller take-off forces.

Optimum: r = 0,5mm for thin foils
r = 1,0mm for thicker foils.

3. Suggestions for the practical work

- The machineability of films and foils can be appraised by investigations of
  - . thickness
  - . tensile strength
  - . bending stiffness
  - . coefficient of sliding friction.
- Measure of take-off force is difficult (only usuable for laboratory investigations).
- Machineability of thin layers is generaly better than those of thicker layers (composite film).

- Composite films with paper have a difficult machineability.
- The machineability can made be better by tapes of TEFLON on the shoulder-surface.

(Results based on evaluation of the international literature).

TABLE 1

Material		thickness µm	tensile strength Nm MD	CD	Bending stiffness E.Jx10^-3 m Nm²/m	Material on shoulder-surface	Coeff.of sliding friction	Take-of force N/m
1) Cellophane	NC-Laquer	22	720	1400	2,8	cellophane	0,21	125
Cellophane	PVDC-Laquer	22	1220	2350	3,8	cellophane	0,18	121
2) LDPE with lubricauts		50	523	1380	6,0	PE	0,13	95
HDPE without lubricauts		50	1940	2100	13,0	PE	0,21	141
3) PETP/PE		62	2960	2620	23,0	PETP	0,21	196
PETP/PE		62			23,0	PE	0,22	196
4) PA/PE		87	3050	2120	23,0	PA	0,11	190
PA/PE		87			23,0	PE	0,15	210
5) PP/PE		93	6280	2000	53,3	PP	0,26	361
PP/PE		93			53,3	PE	0,29	340
6) Paper/PVDC		65	2760	4070	72,4	Paper	0,35	604
Paper/PVDC		65			72,4	PVDC	0,27	302
7) Paper/Al/PE		102	6560	4630	105,0	Paper	0,28	992
Paper/Al/PE		102			105,0	PE	0,39	613

APPENDIX 3

TABLE 2

Material	Bronze shoulder			Plastic (phenolic) shoulder		
	Take-off force N/m			Take-off force N/m		
	angel of feed 17°	45,4°	63°	46,5°	60,5°	74,5°
Cellochan NC-laquer	96	82	80	72	62	96
OPP	196	175	176	69	99	85
LDPP	199	145	180	79	121	106
PETP/PE	326	214	153	95	96	89

APPENDIX 3

APPENDIX 3

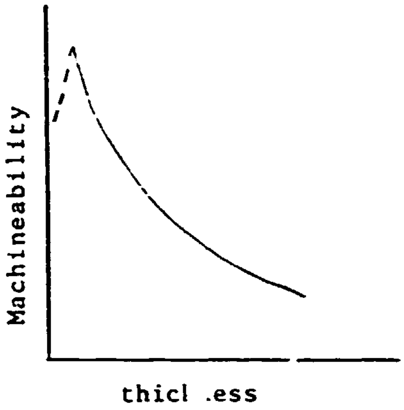
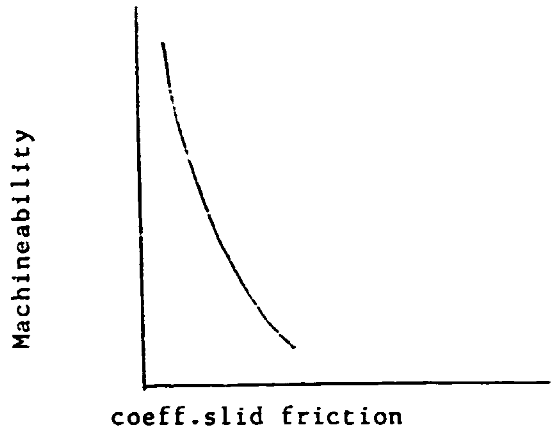


Fig.1

Fig. 2

Fig. 3



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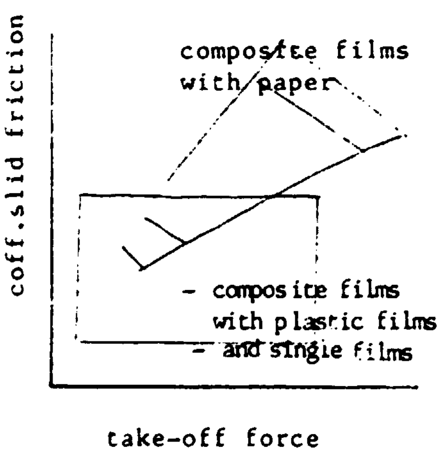


Fig. 5

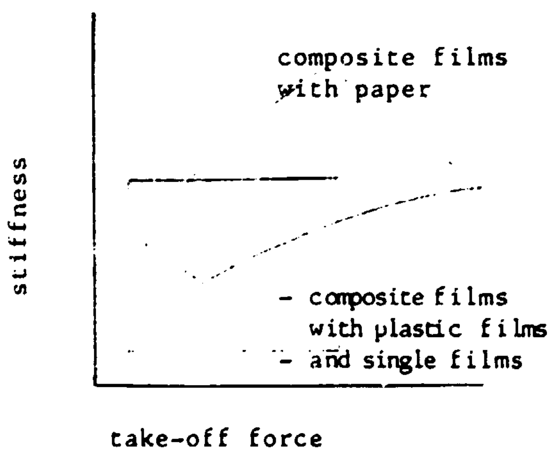


Fig. 6

APPENDIX 3

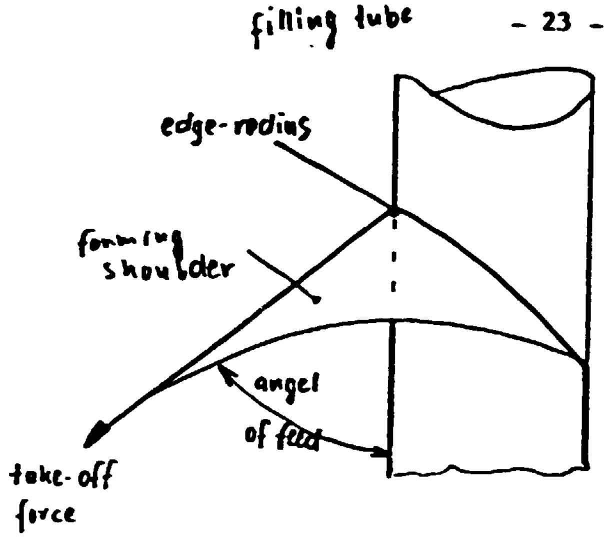


Fig. 7

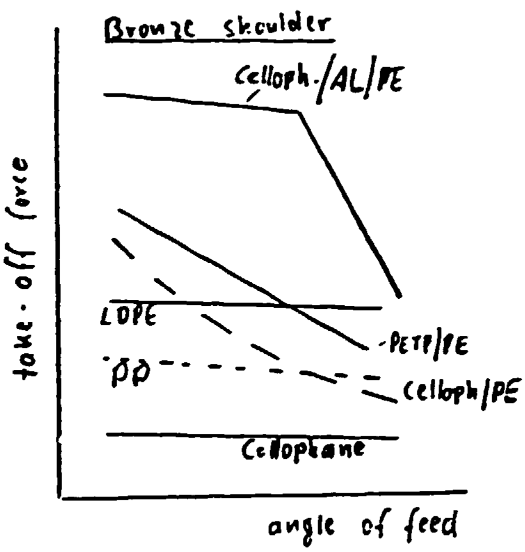


Fig. 8

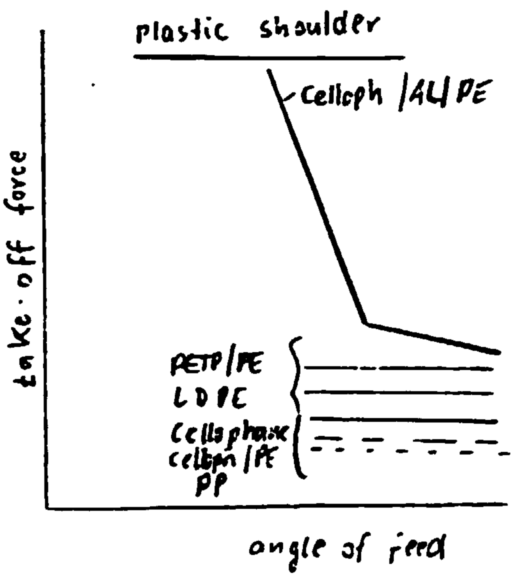


Fig. 9

APPENDIX 4

Tensile indicees of plastic films under low Temperatures

(Based on investigations of the expert in the packaging Center of Dresden/GDR)

O- Introduction

Plastic materials change their properties with changing of temperature (s. Fig.1).
Important is the Glass Transmission Temperature as the temperature range from "rubber like" to "glassy".
This temperature range depends on:

. molecular weight
. chemical structure
. arrangement of chains

With decreasing temperatures the interatomic distances and the molecuar motions decreases too.
In this field, especially for the behavior of plastic films and foils for packagings, not enough investigations are made so that the results of the following tests were necessary.

1- Test materials and test conditions

- LDPE-foil 0,030mm thickness
  non orient. PP-foil, 0,030mm

- bags made from both foils
  15 X 15mm, 4 seams, filled with 20g plastic - balls with a diameter of 15mm

- temperature steps/$0^{\circ}C$
  -30, -20, -10, 0, +10, +20

2- Test results

2.1. Testing of foil samples

. tensile strength - s. Fig.2
. elongation - s. Fig.3

Only the elongation decreases with decreasing temperature, tensile strength increases.

Cause: With decreasing the interatomic distances and the molecular motions the material get more strength (VAN DER WAAL'S FORCES increasing, elongation is "freezed").

This problem is better shown in Fig. 4 and 5 (tensile stress-strain curves).

- ELMENDORF TEST
  s. Fig. 6
  With decreasing temperatures decreases the indicee to (the same tendence like elongation).

- PUNCTURE TEST
  s. Fig. 7
  Same tendency like elongation and ELMENDORF indicee.

Summary:

Not all test methods and indicees are usuable in the field of low temperatures.

To win a first over view of the behavior of plastic packaging films under low temperatures the indicees

- elongation
- ELMENDORF indicee
- Puncture test indicee are usuable.

2.2. Testing of plastic bags

- Bags falling down test until break of the bag, fixing the "number of falls until break", n_{Br} -
  Tendences s. Fig. 8 and 9
  With decreasing temperatures n_{Br} decrease too.
  PP-foil is under +10° to 0°C very sensitive against low temperatures (small numbers of break).

- Place of damages on the bags - tendences:
  . in the foil - s. Fig. 10
  . nearby the seam - s. Fig. 11
  . damage the lower surface - s. Fig. 12
  . total damage of the bag - s. Fig. 13

  With increasing temperatures the amounts of damages in the foil and total damage of bags decreases.

  Cause: Freezed elongation under low temperatures, material is no more able to absorb energy.

- Sizes of damages
  Big damages increases with decreasing temperature - s. Fig. 14.

2.3. Tests with other conditions

Tests are made with

- other corn-sizes (peas, sand)
- bigger bags
- bags positioned in box,

all tests showed the same tendences, like Nr. 2.2.)

3. Practice importance

- Best results are delivered by the "bags falling down test" (impact load)
- For a first appraisal "elongation" and "ELMENDORF indicee" can be used
- Application of bags under low temperatures - suggestions:

. Bags made from no orient. PP

-30° to 0°C - no applicable, are only with soft product (textiles) and without mechanical load (transport, handling).

0°C to 10°C - no more than 1kg product, no shock like loads

+10°C and more- until 2kg.

. Bags made from LDPE

-30°C to -20°C - applicable without impact load to the package, no more than 1kg

-20°C to 0°C - 1 to 2 kg (froozen fruits, chicken)

0° to 20°C and more - more than 2kg (depending on thickness of foil).

s. Fig 15 (tendences and differences between the both materials).

APPENDIX 4

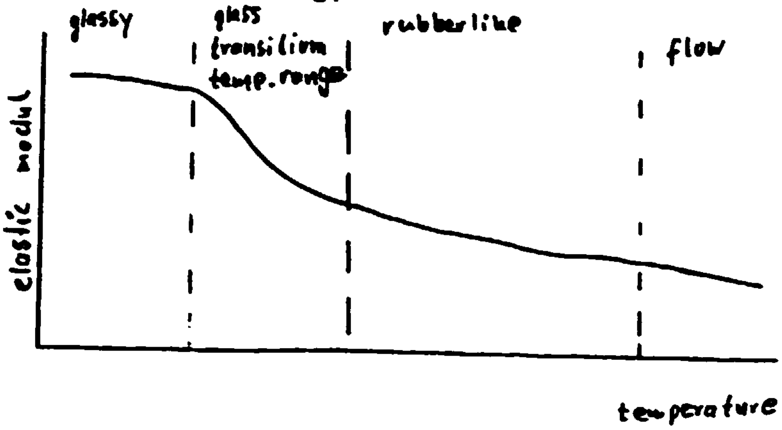


Fig. 1

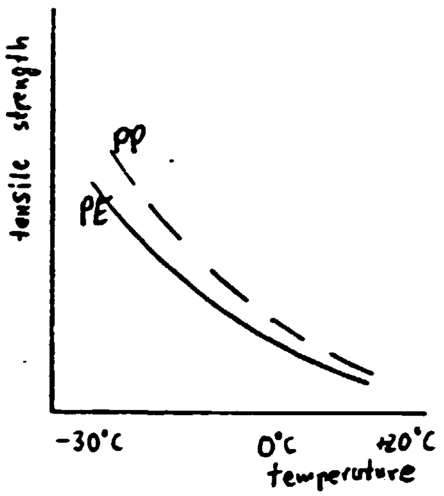


Fig. 2

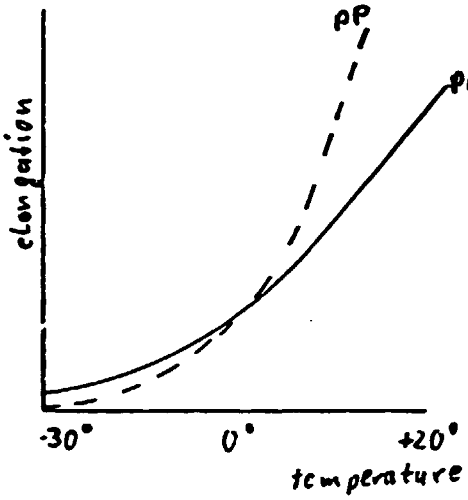


Fig. 3

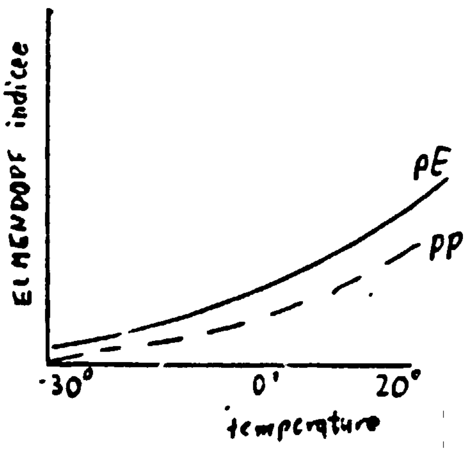


Fig. 6

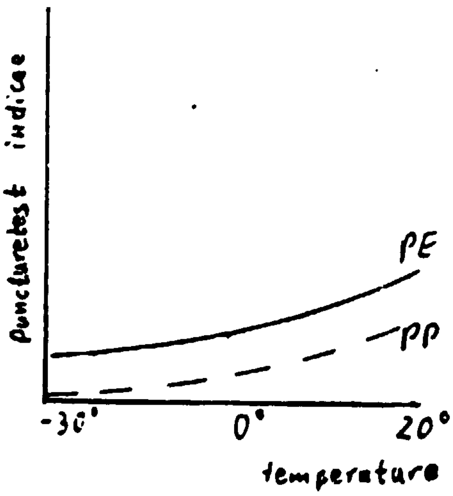


Fig. 7

APPENDIX 4

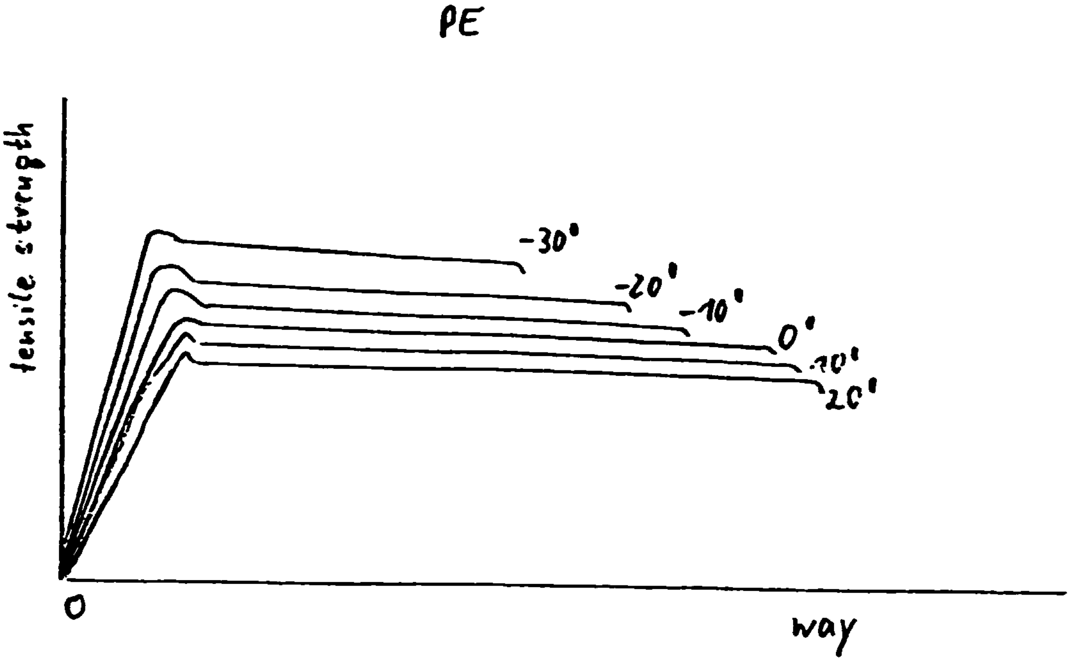


Fig. 4

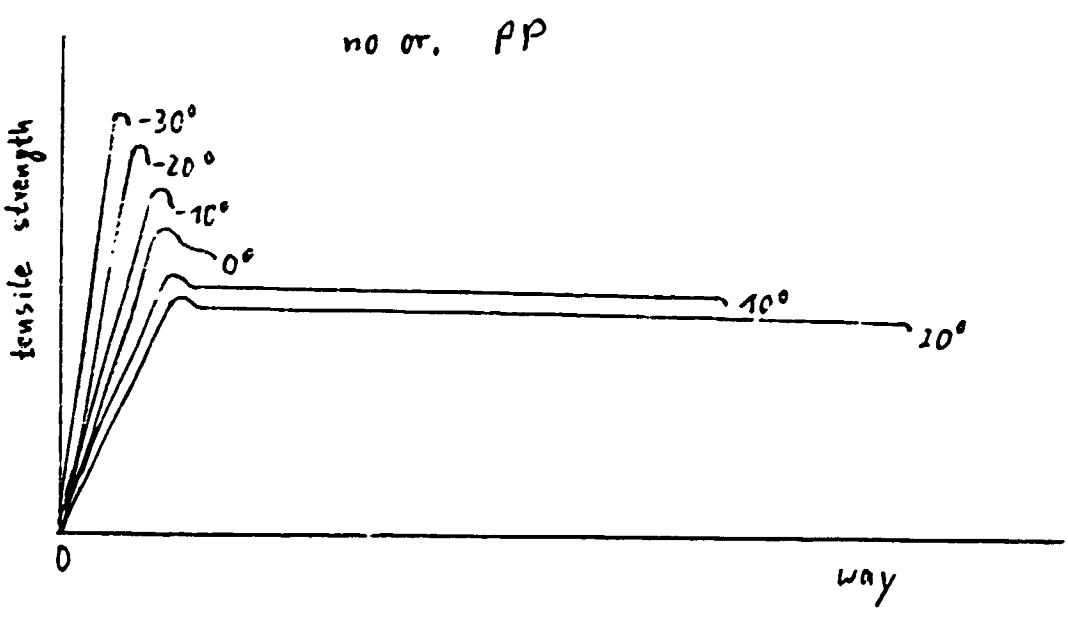
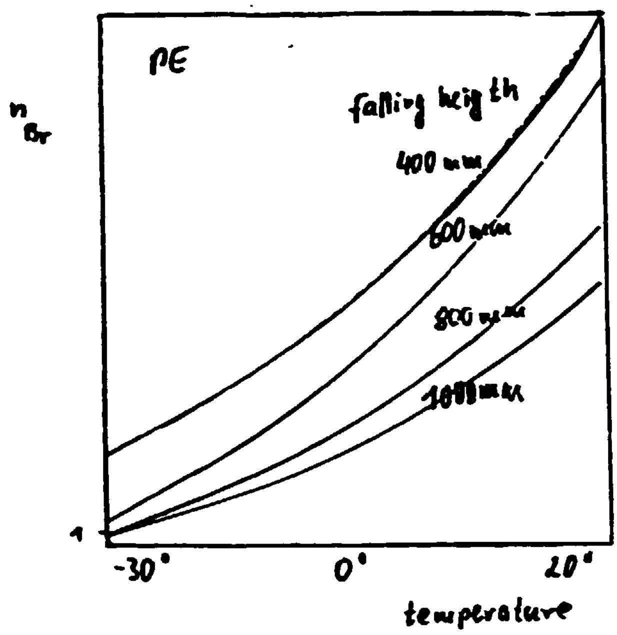


Fig. 5

APPENDIX 4



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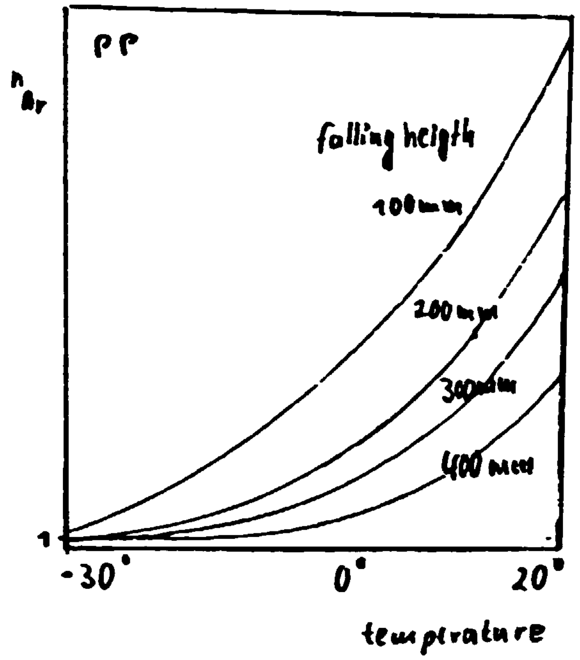

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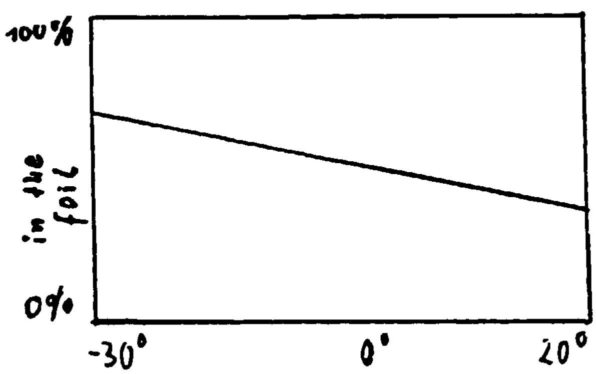


Fig. 10

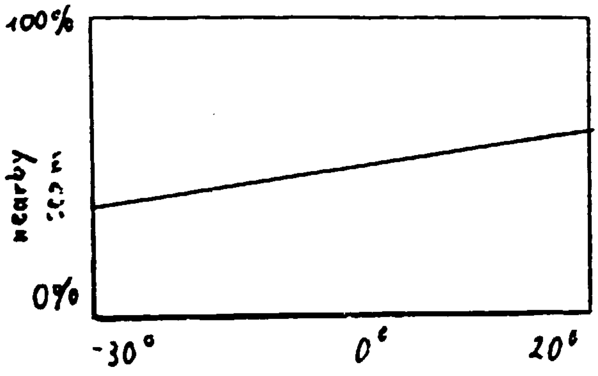
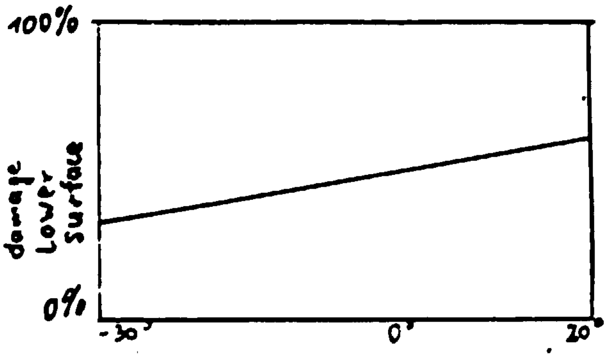
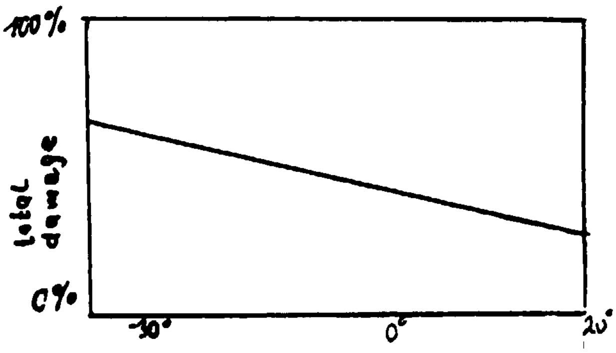
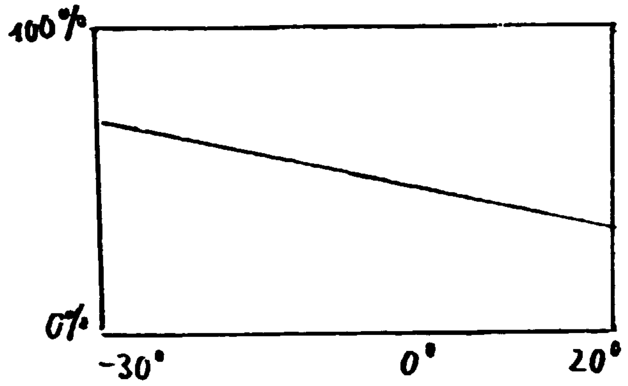


Fig. 11





APPENDIX 4



amount of sizes with 50% and more in comparing the length of the bag

Fig. 14

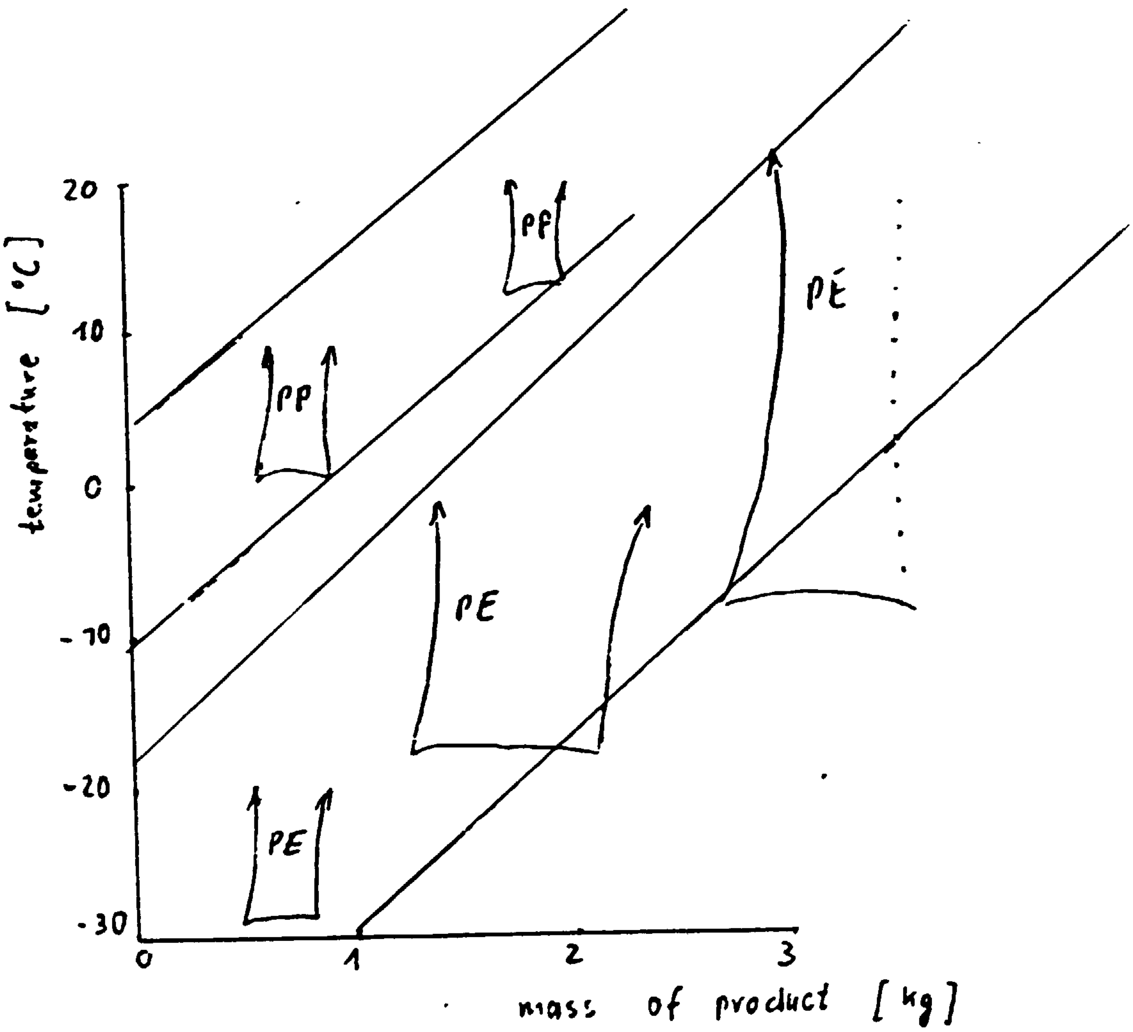


Fig. 15

APPENDIX 5

Testing Laboratory for transport packages

(Introduction in theorie, practice and testing)

When a package moves through distribution there is a lot of static and dynamic loads:

. Man handling: Dropping, throwing and other abuses applied by the manual loading, unloading and movement of packages.

. Warehouse handling: Stresses applied by mechanical handling equipment, for example lifts, conveyers, hand-cars.

. Vehicle impacts: Starting, stopping and other motions of trucks, railcars, ships and aircrafts.

. Vehicle vibrations: Resulting from the motion of engines and moving contact of the vehicle with surface of the street or rails.

. Storage pressure: Pressure of packaging in warestores, for example columns of boxes or load units.

The problem in practice is, that these loads are combined with another, there are influences of each other.

The task of the transport packaging testing is to find out the amount of the loads and the behavior of different types of packagings under this loads.

Test results shall give suggestions and recommendations to provide damages of products.

1. Damages

Generallyspeaking, we have a damage, when a packaging and/or a product will be so influenced, that a technical and/or economical disadvantage for producer or consumer follows.

To investigate nature and direction of damages, so called "damage models" are developed for each concrete damage case (examples see Fig. 1, 2). The most hazardous load is mechanical load.

2. Theoretical aspects about loads

For use in practice knowledge about amount and place of loads is important. For calculating and dimensioning of transport packagings it is necessary to know these loads in ports, airports, on railway stations, during transport distance a.s.o.

Example: Observe the falling height of boxes in a port, there are different numbers of falls from different falling heights (s.Fig.3). This result can be pictured like Fig. 4 as a statistic problem.

Based on the way of this example, all loads can be determined. Result must be a "Catalogue of Transport Loads" (like in Packaging Centre Dresden, GDR).

3. Practic-like loads

- Static pressure:

  Is the cause of deformation (elastic, plastic) of packagings, for example boxes, load units; it depends on the mass of package columns in a store;

- Vibration:

  In practice we have many kinds of harmonic and disharmonic vibrations (springs and cushions); measurement to measure vibrations is a piezoelectric accelerometer; vibrations encountered in distribution see Fig. 5.

- Shock (impact) load:

  Throughout the distribution packages are handled in various ways - they are dropped, thrown, kicked and other wise roughly abused; they may fall down from veyors of forklifts, they are appearing when trucks starting or stopping, when railcars humping.

  So we have different types of shock loads.
  Generallyspoken, "shock (impact) load" appears, when an objects position, velocity or acceleration suddenly changes, this means a rapid increase in acceleration followed by a rapid decrease over a very short period of time (any milli-seconds).

The most usefull way to protect products against mechanical load is the use of cushioning material (for example expanded

Polystyrene, Polyethylene, PUR foam, rubber, corrugated board or other upholstery material).

4. Test methods and test equipments

a) Basic methods and equipment
(see Fig. 6)

- INCLINE IMPACT TEST

Apparatus: Inclined track, dolly with/without bulkhead, back stop.

Procedures: Different possibilities in regarding to bulkhead, distance of track (velocity of dolly), back load, box with/without interior.

- IMPACT DROP TEST (espec. for boxes)

Apparatus: Hook to lift the box or special moveable gripes (so possibilities to realize falls on sides, corners, edges - construction Like Packaging Centre Dresden/GDR); Steel plate (mass = 50 x mass of the box), thickness minimum 2cm;

Procedures: Falls from constant height or progressive increasing height.

- VIBRATION TEST

Apparatus: Common vibration test machine, horizontal rigid surface; vertical component of the motion is approximately sinusoidal; accelerometer signal conditioners, data display or storage devices to measure and control the accelerations.

Procedures: Repetitive Shock Test (increasing frequency until test specimen leaves the platform); Single Container Resonance (increasing and decreasing frequency); Unitized Load or Vertical Stack Resonance Test (full-size unitized load, vertical column of boxes, increasing/decreasing frequency).

- PRESSURE TEST

Apparatus: Common pressure tester; small plates for boxes or bigger plates for pallets.

Procedures: Pressure until damage; constant pressure over a spec. time; swinging pressure.

b) Another method and equipment (see Fig. 7)

- Long time pressure test (for boxes, containers, drums, metal bottles)
- Inside pressure test (for bottles, containers, metal drums)
- Evacuation test (for bottles, metal drums)
- Revolving hexagonal drum test (for boxes, drums - filled with product)

c) Standards

- Incline impact test	ASTM D 880-79
- Impact drop test	ASTM D 775-61
- Vibration test	ASTM D 990-75
- Revolving hexagonal drum test	ASTM D 782-68
- Pressure test for pallets	ASTM D 1185-73
- Compression test for shipping containers	ASTM D 642-76
- Standard methods of testing pallets	ASTM D 1185-73
- Water resistance of shipping containers by spray method	ASTM D 951-51
- Drop test for cylindrical shipping containers	ASTM D 997-50

APPENDIX 5

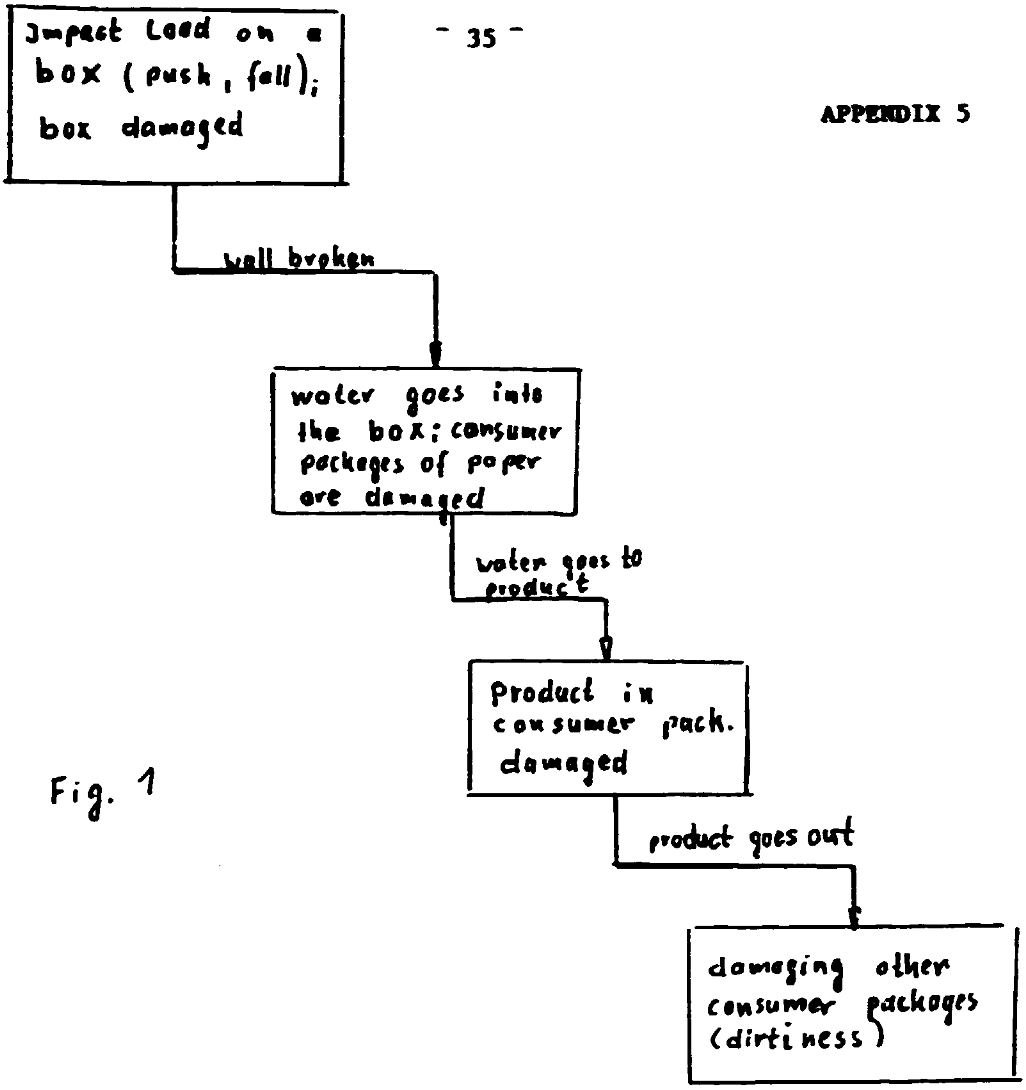


Fig. 1

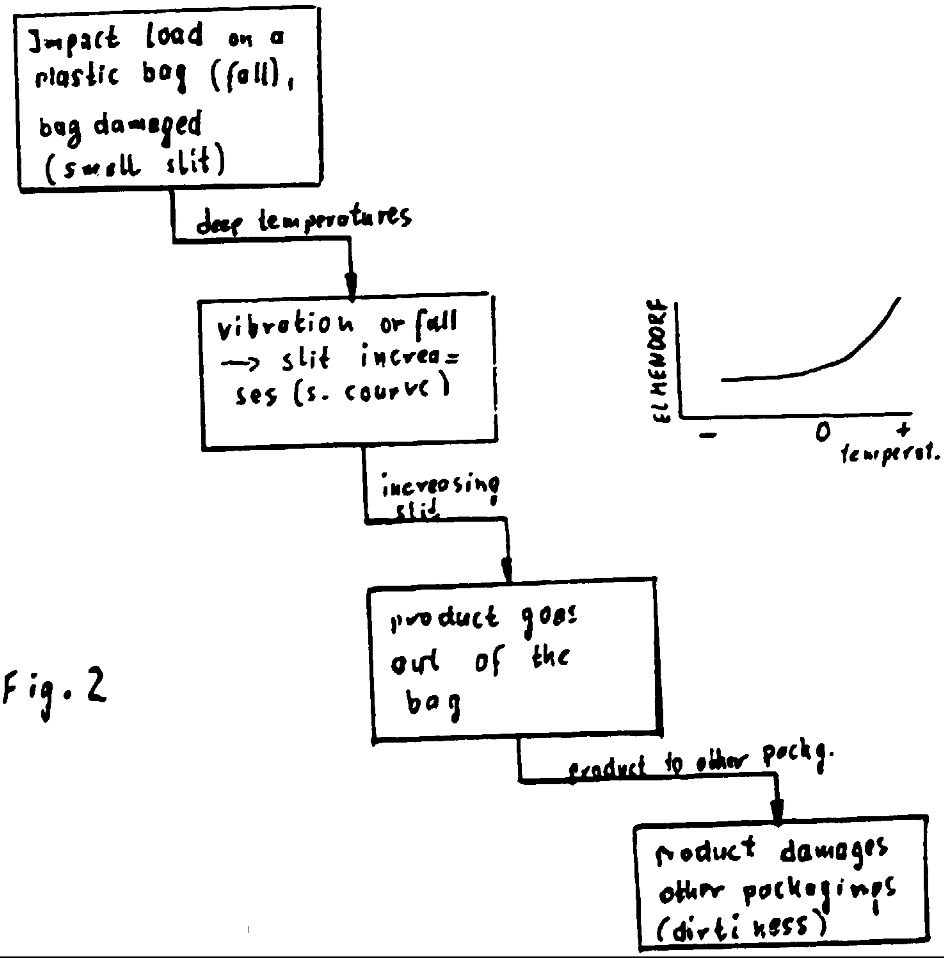


Fig. 2

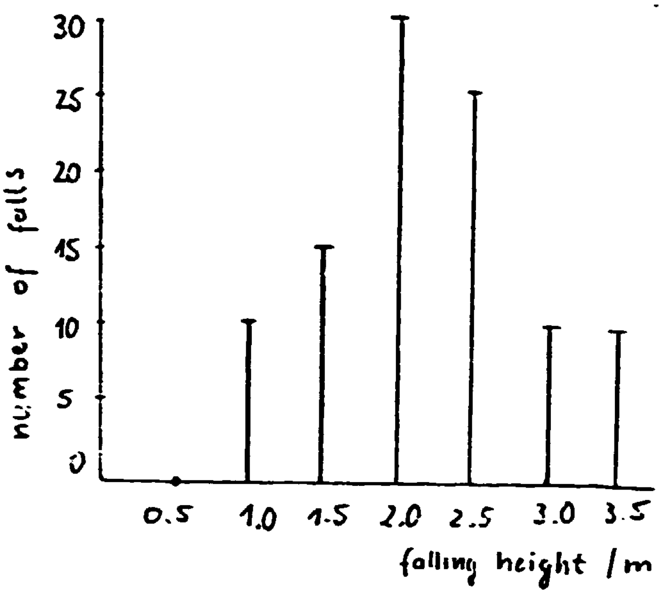

number of falls
30
25
20
15
10
5
0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
falling height /m

Fig. 3

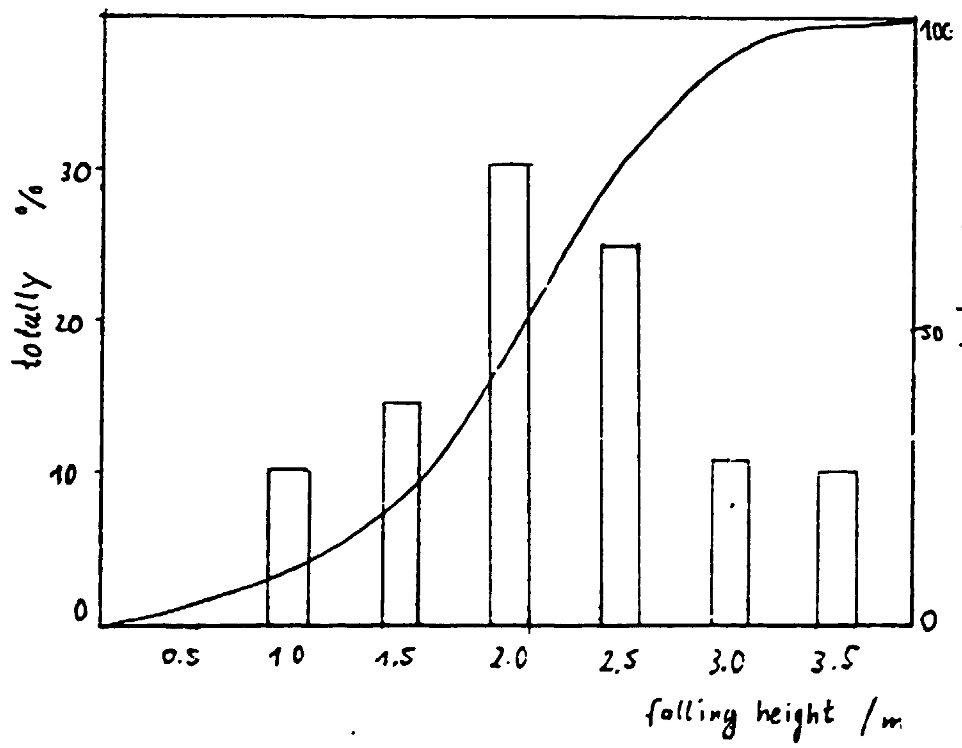

totally %
30
20
10
0
cumulate %
100
50
0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
falling height /m

Fig 4

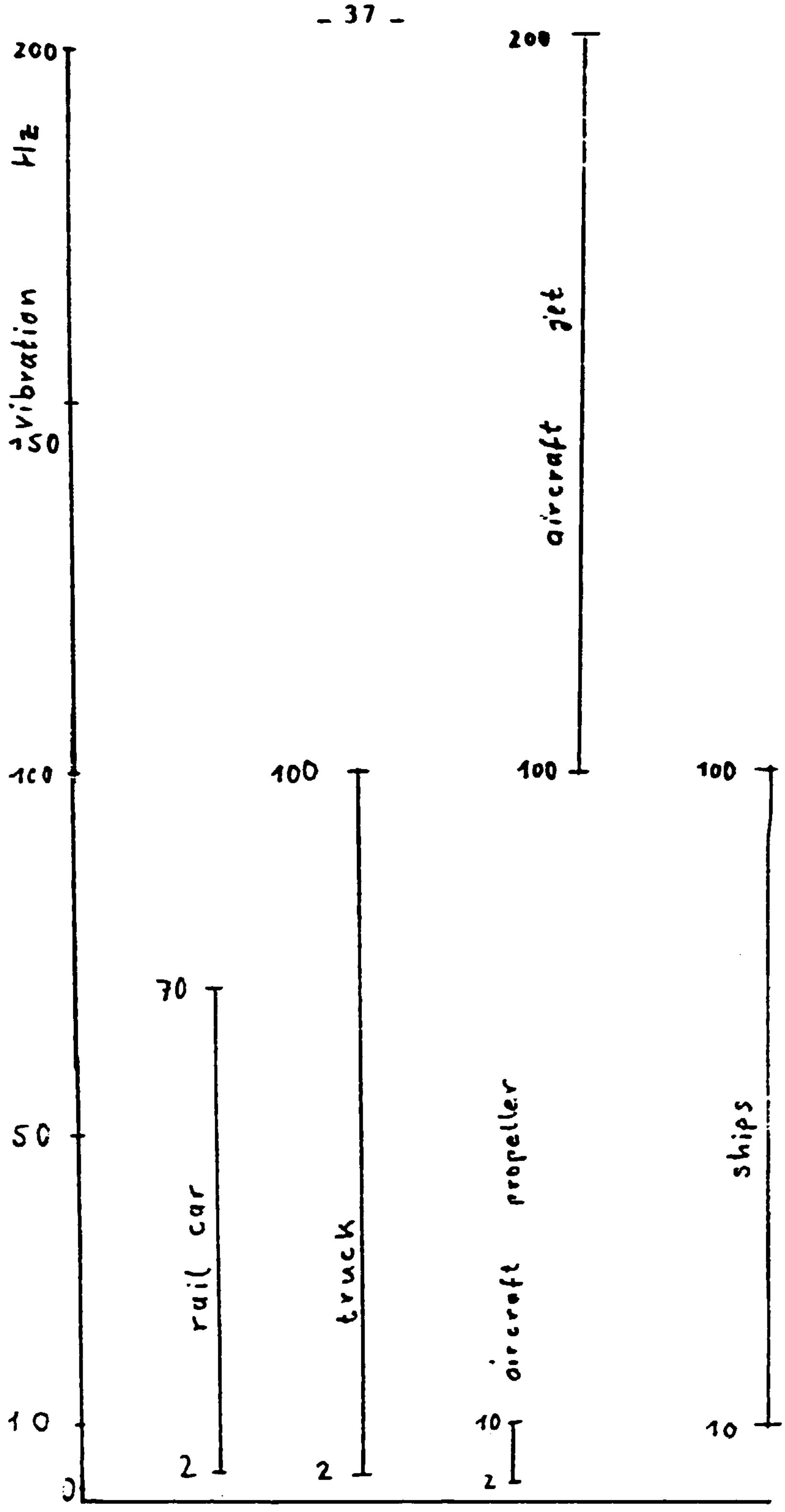
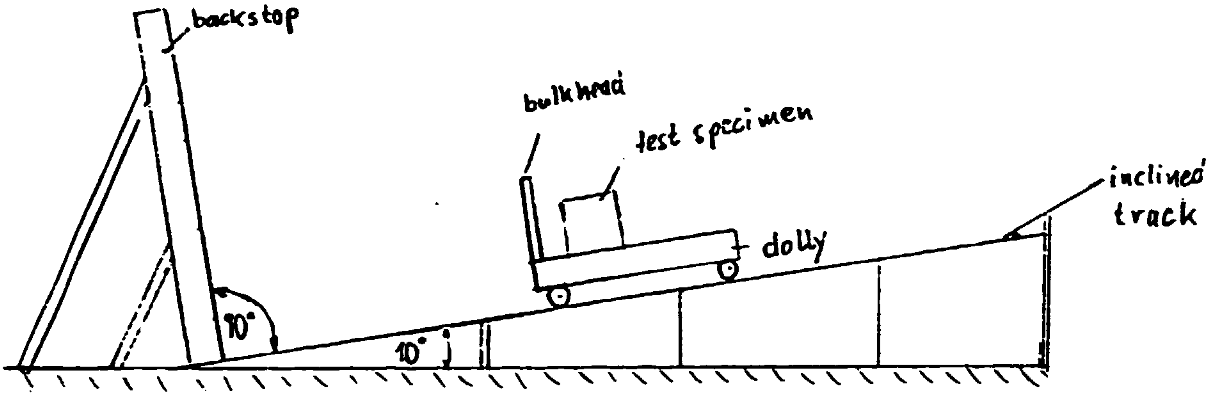


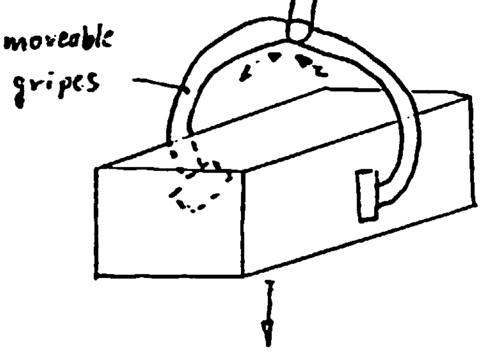
Fig.5
Vibrations encountered in distribution

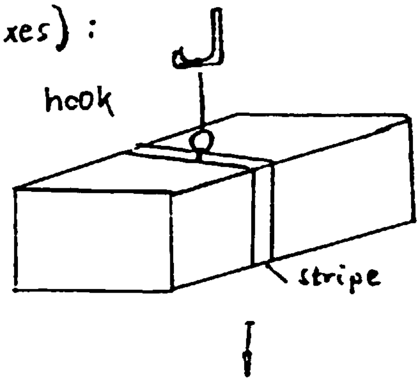
APPENDIX 5

INCLINE IMPACT TEST :

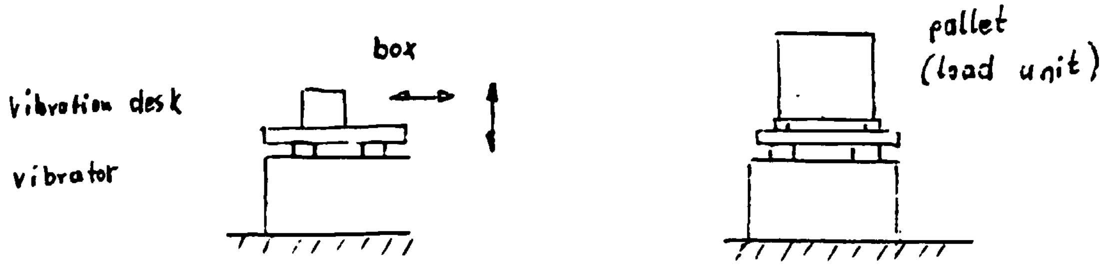


IMPACT DROP TEST (boxes) :

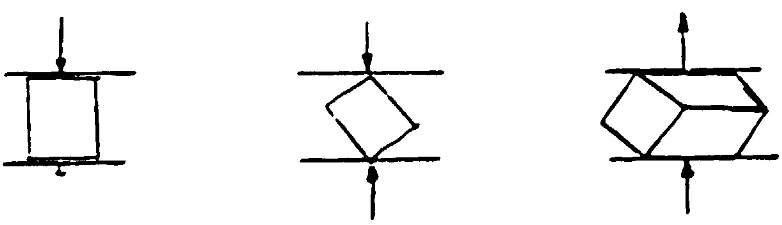




VIBRATION TEST :

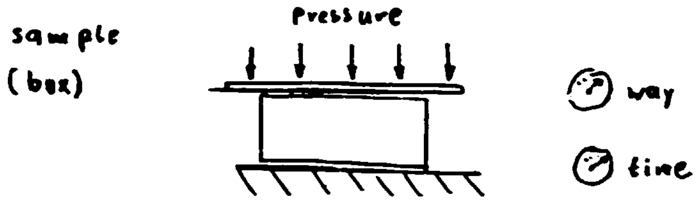


PRESSURE TEST :

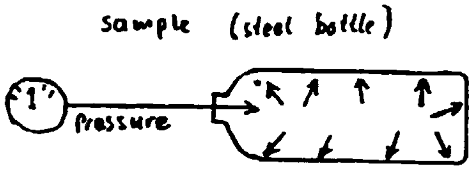


LONG - TIME PRESSURE TEST :

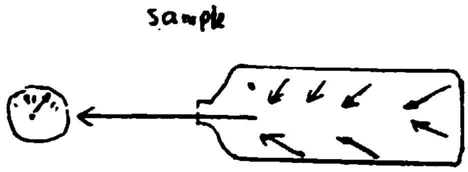
APPENDIX 5



INSIDE PRESSURE TEST :



EVACUATION TEST :



REVOLVING HEXAGONAL DRUM TEST :

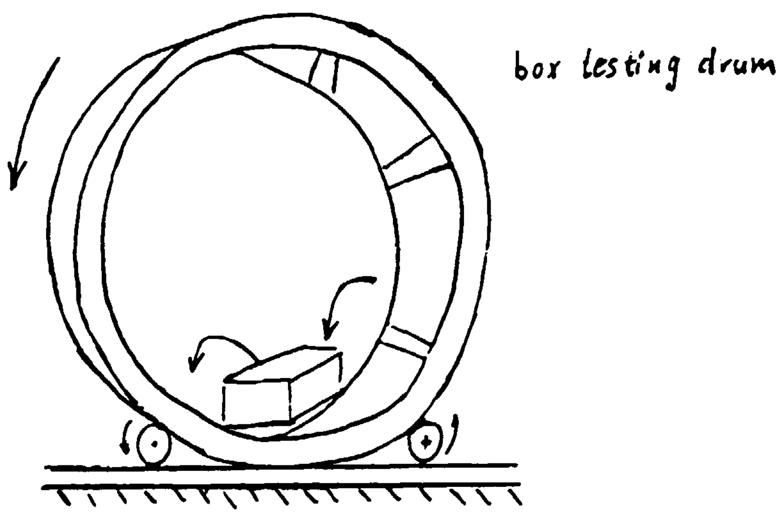


Fig. 7