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ESTABLISHMENT OF THE ARAB REGIONAL PACKAGING CENTRE

DP/RAB/83/020

(2) AIDC :?

Technical report: Course on packaging technology with special accent on paper and board transport packages*.

Prepared for the Arab Industrial Development Organization
by the United Nations Industrial Development Organization
acting as Executing Agency for the
United Nations Development Programme

Based on the work of George Wm. Arndt, Jr.
Consultant in Packaging Technology

United Nations Industrial Development Organization
Vienna

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CONTENTS

SUMMARY

This report describes the work performed by George Wm. Arndt, Jr., Packaging Engineer, under Project DP/RAB/83/020/11-75/317E. The report consists of this document and an appendix which includes lecture notes. Lectures were prepared prior to departure. Upon arrival at Casablanca, I was informed that the course would not be upon general packaging concepts, but would focus upon corrugated and board transport packages. It was therefore necessary to reorganize lectures along these topics. Following presentation each lecture was provided to IMEC for typing and subsequent translation.

The specific aim of this project was for the participants to take part in the lecture and discussion of paper and board transport boxes for agricultural products. Topics covered included Packaging Functions, Packaging Economics, Environmental Factors Affecting Paper and Corrugated, Product Marketing and Distribution, and Current Developments and New Packaging Technology. The lecture on Cost Analysis and Optimization of Production Economics was not presented since Mme. Bennani of the faculty of IMEC spoke on this topic. My lecture was provided to IMEC for inclusion into the course book.

This project was part of a broader program undertaken by The Moroccan Packaging Institute (IMEC) to broaden the range of training, technical studies, and research services provided by IMEC to members of the Arab Industrial Development Organization (AIDO) to encourage the expansion of IMEC's role to that of an Arab Regional Center (ARPAC).

It is concluded that:

1. Attendance at training courses at IMEC or other suitable sites is an effective way:

   a. of improving technical packaging knowledge for representatives of Arab country government or industrial agencies.

   b. of exchanging ideas on methods for identifying and solving packaging problems,

   c. and of promoting good will and cooperation through personal contacts and technical and cultural exchange.

2. Repetition of this training course for other attendees would be worthwhile with fewer lectures, more hands-on laboratory experiences, and a shorter time span.

3. Development of specialized training courses with more intensive coverage of narrower subject areas would be of even further value.

4. An exchange of Arab and U.S. faculty and students researching Arab regional packaging problems is strongly recommended.

INTRODUCTION

Aim of Project

This report describes the work performed under project DP/RAB/83/020/11-75/317E. Course on Packaging Technology, With Special Emphasis on Paper and Board Transport Packages.

The specific aim of the project is stated in the Summary section of this report. An ancillary aim of the project was to explore further means of continuing cooperation between IMEC and the School of Packaging of Michigan State University in the providing of similar training courses, either in Arab countries or at MSU (East Lansing, Michigan, USA).

APPENDIX 1

November 1, 1985.

MEMORANDUM

To: R.G. Griffin, Jr.
From: G.W. Arndt, Jr.

Subject: Course on Packaging Technology with Special Accent on Paper and Board Transport Packages at Casablanca, Morocco (October 14 - 23, 1985).

Have presented information provided by you with reorganized emphasis on paper and board transport packages to attendees and members of the faculty of IMEC. Technical subjects of mutual interest were discussed with valuable contributions by all parties. Original lectures have been provided to IMEC and copies of each are attached for your review.

Despite the language barriers, a good impression was made on the participants. Very friendly relationships were established with plans for for continued correspondence and exchange of technical information were established.

Suggestions were made as to the import of used US packaging machinery for Moroccan industries, and export of various food products to the US. It is strongly recommended that the School of Packaging continue to develop a cooperative program with IMEC for participation in future seminars, exchange of faculty and students, provide special training courses, and assist in their effort to develop specifications, standards, proposed regulations, and economic analysis which will benefit Morocco and the Arab Nations.

Regards,

George Wm. Arndt, Jr.
Packaging Engineer

Lecture 1 Monday, 14 October 1985

Packaging Functions And The Importance of Packaging

I/- Basic Thesis

The development of societies and the development of packaging are parallel events.

Those basic packaging functions we seek to achieve today are no different than those functions which packages provided in ancient societies.

The example is the amphora which contained wine for ocean export 2000 years ago.

Changes in civilizations have been created by different modes of transportation.

The distribution system:

1. Hand carry
2. Ocean vessels
3. Carts
4. Railroads
5. Automobiles
6. Air transport

Different containers fulfill the packaging requirements for food products in each system.

1. Clay pots
2. Clay pots, amphora
3. Baskets and bags
4. Wooden boxes
5. Corrugated boxes on pallets
6. Cargo boxes made to fit into airplane body.

II/- The narration or text of the lectures follows.

III/- Lastly, the material for overhead display is attached. Key words are written on the display chart during the presentation to emphasize significant steps in development and major package functions.

George W. Arndt, Jr

Packaging Functions and Importance of Packaging

Development of Societies Runs Parallel to Packaging Technology

I/- Introduction

Packages are secondary products.
They serve a limitedpurpose and are discarded.
An inspection of packaging tells a great deal about the Society

You know the bird by examining a feather.
You know the giant by the size of his little finger.
You know the society by their packages.

II/- Primitive Society used only "Primary Packaging".

Store + convey foods by carrying them by hand.

leaves, bark, tree, sea shells are all natural containers
Products are not stored because technology for food preservation does not exist.
Society is a gathering society
Transportation is by carrying products in the hand or on a sling over the shoulder.

III/- Early villages

Clay pots, stone jars, baskets, crude bags.
Foods were preserved by drying and salting.
Containers were transported by cart.
These carts required larger packages.
The package required strength to prevent damage to the product
Now we see the first specialization of packages.
Stone jars were too heavy and fragile (they were used primarily for home storage).
Clay pots were lighter than stone, they also were hand carried and too fragile for carts.
Baskets are strong and light and are thus suitable for carts.

Baskets wear out and break due to the motion of the cart.
Thus we see the advent of woven bags. They are strong and will not break due to shock impacts.

One great advantage is that when the bag is empty it does not take up any great room within the cart.

1) Now we have the ability to carry different types of products in two directions on the same cart. Great economic advantage of collapseable containers.

2) If the product requires the container, the buyer has to provide his own container or buy the one the merchant wants to sell.
A new economic consideration : the cost of packaging.
The cost of individual packaging is much greater than the cost of bulk packaging.
The consumer will either be forced to provide his own container or pay the merchant's price for the package the product comes in.
The merchant is quick to recognize that the customer desires the best product at the lowest price. The cost of the package must be as low as possible and still be functional to ensure the optimum selling situation.

3) Packaging economics are as old as trade. The basic cost factors are the same today as they were 10,000 years ago. Let us examine how they have evolued till today.

IV/- Shipping

1) The Phenecians who tradied in Morocco 2000 years ago used important packages. They are not so different from packaging used by us today.

Cosmetics - small bottles or stone vials for salves and medicines.
Grains - bags
Pottery - baskets Pottery - all types of products
Wine - bottles

For example Amphora Wine bottle was the "First Returnable Bottle".

This created the economic problem of the bottle deposit to ensure return.

Jacques Cousteau, the famous French Oceanographer in 1962 found a ship wreck in the Agean Sea which was 2000 years old. In this shipwreck he found hundreds of amphora, many still sealed. Upon tasting the content of the amphoras, it appeared that they contained wine which tasted good.

You must admit that 2000 years is not too bad a shelf life for a returnable bottle.

2) Look at the technology of the amphora

Contact surface curved to resist impact forces.

Small area to stand flat or
place in sand or frame to stand erect.

The amphora is made to stand erect so solids could settle to the bottom, this process develops a clear wine.

The handles are above the point of impact for stacking as a group.

The amphora is open only at the top so that the wine won't leak out.

The top opening is small to minimize evaporation and maintain an internal atmosphere of wine boquet.

The amphora is made of low-fired clay pottery to permit gases to permeate slowly thru the walls without evaporation of liquid. This process allows the wine to "breath".

Sealing wax is used to prove to the customer that he wine is good. The wax had the wine markers' stamp pressed into it as a certificate of quality, this was the label of today.

Wax also used to affix tax stamp.

This was an : indication of governments' approved inspection as well as an indication that bottle has import or export duty paid by the importer.

The English word "sealed" comes from packaging for ocean voyages.

Sea = "ocean"

V/- Inland from the port

1) Exchange of goods from central market to the surrounding economic area.

Economic problems of shipping.

The shipment volume from the manufacturer to the shipper to the consumer is one of a small product in a big package to be sold in a smal package.

Example : sugar packet

When manufacturered sugar is packaged in bags weighing 50kg each

shipper : by boat from Cuba to Morocco 1.000 000Kg/boat
consumer : small packet uses 20gm/packet for tea or coffee.

We make a simple observation for all products in all markets.

Small packages cost more than large packages and the consumer are willing to pay for convenien.

2) 1800 development of the railroad and steam river boats.

The first railroads ran from ports to central economic areas within the economic hinterland sorrounding the port.

New packaging concept - "Secondary Packaging"

To prctect the package from damage during shipment.

a) Railroad cars have a limited and expensive cargo area.
Mechanical handling, mechanical damage
padding - straw, cloth - wood boxes

b) Stackable shapes to fill rail cars
square and rectangular

c) Advert of shipping cases - wooden boxes
Too expensive to return empty.
Economic requirement - disposable packaging
"make as cheap as possible yet must be functional.

3) 1900 development of automobile and truck
Travel outward from rail station
There are no paved roads so damage is common.
Package must protect contents from vibration.
But packages which were not damaged by ships or trains are now damaged by trucks.

Problem : Merchant requires the transportation agent to pay.

The transportation agent says he is not responsible.

This situation was resolved by the development of insurance for goods during shipment. The insurance companies, seeking a satisfactory method to minimize shipping damage were responsible for financing much of the early scientific packaging studies. The U.S. Rule 41 is one such document. Rule 41 summarizes the packaging requirements for hundreds of common products.

Packaging Functions

Four basic functions:

I. Containment

II. Protection

III. Information

IV. Utility of Use

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I. Containment

- To enable the product to be moved from one location to another

- To enable groups of products to be moved as a unit

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II. Protection

A. Protect the Product

1. From environmental factors

   Temperature extremes

   Water

   Gases

   Dust, etc.

2. From contamination

   Vermin

   Human

   Microbial, etc.

3. From distribution hazards

   Shock

   Vibration

   Compression

4. From loss and theft

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B. Protect the Environment

- From hazardous items

- Waste problems

- Child-resistant packaging

- Protection is product-specific

- Package life must equal or exceed expected life of product

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III. Information

A. Identify the product

B. Inform the consumer

C. Motivate the consumer to buy

D. Satisfy legal regulations

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IV. Utility of Use

A. Place utility

- transportation

B. Time utility

- storage

C. Quantity utility

D. Ease of use

convenience

dispensing features, etc.

MAJ
11/2/84

Lecture 2 Monday 14 October 1985

The Environmental Influences on Paper, Cardboard And Corrugated Containers During Distribution

I/- Thesis

A brief narrative will serve to intrcduce the importance of the chemical structure of cellulose. The important fact is that paper is similar to many sugars, starches and has polymer characteristics. Namely, the interaction of hydrogen bonds between layers of cellulose molecules.

The weak hydrogen bond is readily broken by the molecule of water vapor. The water molecule is attracted more strongly to bonding sites than the hydrogen ion. Hence moisture easily disrupts thepolymer and changes physical properties.

The structural advantages of long and short fibers are outlined

Changes in the manufacturing processes bring about changes in the paper. Different papers may be produced for different specific applications.

The different grades and types of paper have differentphysical properties. Three tests are commonly used to analytically measure these specific properties.

Environmental factors influence the structural properties of paper, corrugated and paperboard. To illustrate these factors we have described their effect on corrugated shipping containers.

II/- The narration or texts of the lectures follow

III/- Materials for overhead display and key terms and concepts which were used for presentation of this topic are attached.

George Wm Arndt, Jr

I/- Paper manufacture

A. Paper and paper board are materials produced from natural cellulose fibers found in trees of the world's forests. Most paper is virgin pulp.
The forests of the US have been greatly depleted as have those of Canada.
The paper industry of the US was once located in the north central U.S. Since 1950 the industry has recognized that it is not economical to import pulpwood and chips and has moved to the southeas US where trees can be grown more rapidly than in the cold north climates.
In Canada it takes 50 years to grow a tree to the size necessary to harnest economically for pulpwood. In Newfoundland an Island provence of eastern Canada, Bowater Ltd. Paper Company is experimenting successfully with willow bushes. This large bush grows in 3 years and its natural long fibers make excellent paper.
As the forests of Russia, Africa and South America are gradually depleted of inexpensive pulpwood, the world will look toward bush with long fibers as an inexpensive source of pulp for paper making

B. Recycled newspapers, kraft and cotton is a desirable source of fibers. Recycling was popular during a paper shortage in the late 1970's. During this period the paper industries took advantage of the high market price for paper and closed old inefficient mills. Many new paper mills were opened in the Southeast United States at this time. The high cost for paper made investment in new mill with high-speed, energy-efficient equipment more attractive to Banks and corporations. Recycling of paper and rags is no longer a major source for paper manufacture in the US.
Most recycled newspaper is shreaded to manufacture insulation for residental and commercial buildings. It is also an excellent fibre source for plaster.
The high price of plywood has led to the advent of "plasterboard Plasterboard is used to form the interior walls of homes and offices Plasterboard is manufactured by forming slabs of fiber reinforce plaster 244cm x 122cm x 1,5cm. Both sides are laminated with kraft paper.
Also in the construction of buildings "particleboard" is formed by gluing wood chips under pressure and heat. It is very dense, far cheaper and resists weather better.
It costs approximately 1/3 the cost of plywood. It has one disadvantage. When left unsupported is bends after a period of time. Both plasterboard and particleboard are popular substitutes for wood.
Similarly, expensive paper for bags is being replaced by plastic films which are far stronger and cheaper to make. They are less affected by water.

C. Paper has many structural advantages.
It is strong and light weight. It takes physical abuse well.
However, paper is expensive. The primary cost of paper is transportation of pulp and energy. Most of the energy is used to dry the paper.

Paper begins as a thick paste of wood fibres and water. The "slurry" is spread onto a moving belt. The belt is called the Fourdrinier after Henry and Seeley Fourdrinier who purchased the rights to the device from its inventer Louis Robert 200 years ago. The slurry is 99% water and 1% fibers. Water drains thru the slowly moving belt.

In the second drying step a vacuum is used to evaporate the water content to 90% moisture.

In the third process the paper is squeezed between slowly moving rolls.

Next the water in the paper is evaporated by heated rollers. The equipment is expensive. However the greatest cost is for energy to make steam heat. The final 1% water removed from the paper requires 77% of the total cost of water removal. There may be 30 to 100 steam heated rollers in one paper machine line.

To conserve energy costs paper mills utilize all burnable materials. This includes tree bark, brush from clearing forest land and plant wastes. In the modern paper mills in the southern USA, cogeneration of heat has been utilized to make the process more energy efficient.

In one unique experiment the University of Oregon, in the North Western US used the hot water steam condensate to irrigate fruit trees during the cold winter. The result was a staggering 400 % increase in harvestable peaches, apricots, and plumbs in the first season ! The hot water was sprayed into the air throughout the orchard. The water froze into the tree branches and served as protection for the buds in the cold winter months. In the growing season the warm water accelerated the growth rate of the maturing fruit. Additional water in the soil allowed the fruit trees to absorb nutrients at a faster than normal rate The long term effects are not yet known.

II/- <u>Types of paper and their use in packaging</u>

A. There are many chemical additives and process variations used in paper manufacturing. Each process is engineered to create a paper with desired properties.

The foremost research center in US paper technology is the Institute of Paper Chemistry in Appleton, Wisconsin. Most major US Universities maintain Forestry Departments which provide valuable research in paper manufacturing. Michigan State University has such a departement located adjacent to the School of Packaging.

B. The amount of fiber deposited into the Fourdrinier determines the thickness of the paper.

If the material is thin ($\leq$ 224 gm/m^2) it is paper

If the material is thick (> 224 gm/m^2) it is paperboard.

C. A smooth surface may be obtained by pressing the mat between steel rolls which compact it. This aids in the printing process later

D. Multilayered paper is formed by layering different solutions of fibers into the same mat. One solution usually contains recycled fibre Clay-coated newspaper is produced in this manner on the cylinder machine A number of mats from multiple Fourdrinier machines may be combined using an inexpensive fiber in the middle layers.

E. Chemical additives are added to the paper slurry to provide various resistance to water penetration.

Aluminium Sulfate ($AlSO_4$) disperses between the resins and makes the finished paper less susceptable to moisture.
Synthetic wood resins may be added to make wood less susceptable to moisture.
Natural resins are a valuable content in kraft paper.
The term for creating paper which is resistant to water penetration is "sizing"

F. Color may be added to the slurry to get even dispersion through the production batch. Color added to the surface of dry paper is not as uniform within the production lot as color added to the slurry.

G. After the mat has dried, coatings may be applied to the surface.
This is to obtain grease resistant materials as well as water resistant material
In addition starch may be applied to increase surface strength.
Most papers for printing are sized with starch.

III/- Grades of paper

A. Kraft paper is used where strength is the desired feature.
Uses include :
fiber cans, fiber drums, corrugated, multiwalled bags.
Polyethylene coated paper + wax coated paper are desired for freezing food.
The coatings reduce the rate of moisture transfer. Freezer burn occurs when ice evaporates from frozen food.

B. Container board is formed from 2 layers of kraft. The combined layers are formed into sheets. The flat sheets are used to sandwich a formed sheet.
The corrugations give compression strength and rigidity in the direction of the flutes.
The basis of the strength is in the curve of the arch.
The structural advantage of this shape can be seen in the shape of your finger nails. Which side is the strongest face or end ?

OVERLAY FLUTE DESIGN — The instructor shall point out the following features in the overlay : corrugated, single faced board, double faced, or single wall board, double wall board and tripple wall board.

OVERLAY	FLUTES/INCH		linear/meter	Flute height
		A	118/m	4.76mm
		B	168	2.38
		C	128 to 138	3.57
		E	316	1.9

IV/- Testing paper

A. Flat crush

corrugated
standard sample
cut in the shape of a circle US 10 inch square

4,5cm

area = 64,516 cm²

B. Edge crush
strength of sample

C. COMPRESSION TEST
Strength of shipping case
for stacking

D. Mullon burst test.

All tests are affected by humidity. Samples must be conditioned in a controled environment prior to conducting tests.

US ASTM Standard
≥ 72 hours
72°F ± 2° F
50% RH ± 1% RH

Moisture vapor reduces the strength of paper.
Moisture causes release of the hydrogen bonds between the layers of cellulose molecules.

OVERLAY Cellulose molecule

An organic Polymer of sugar
highly crystaline
very hydrophyllic
extensively hydrogen bonded at OH sites.

Molecules form densely packed sheets using the relatively weak focrces which characterize hydrogen bonding in polymers.

Water is a polar molecule

hydrogens having a + charge
are attached.

The dielectric attraction of cellulose to water is stronger than cellulose to cellulose. Hence as water is absorbed the paper loses its inter laminate strength.

The presence of water molecules weakens the hydrogen bonding allowing the molecular layers to separate. Separation makes entry of more water molecules easier. The process accelerates.

The strength of paper comes from strong hydrogen bonding. Strength is lost as hydrogen bonding is reduced.

Coatings of starch, wax, and plastic on the surface of paper all reduce the penetration of water into the molecular layers. Thus coating paper is one of the best ways to make paper resistant to moisture.

Other factors affecting paper are seen in evaluation of various samples by compression testing.

OVERLAY FACTORS AFFECTING STACKING HEIGHT

Compression testing and stacking are the same forces.
Only compression testing is faster and more convenient to test.

FACTORS AFFECTING STACKING HEIGHT

1) Product Moist products contribute water wapor which affects corrugated.
The amount of product in contact with the case is important. More free atmosphere permits easy axcess of water molecules.

2) RH. The most important factor.
The concentration of water vapor in the air directly effects the strength of the corrugated.
Paper is strongest at 5 % moisture, 30% RH.

3) Fatigue All materials under force will give way at various rates.
Fatigue is the breaking of molecular bonds by mechanical action. It is similar to tearing fibers apart slowly.
Molecules which can slide past one another without breaking are elastic. When they do break bonds these are reestablished when the material returns to its origional shape.
Fatigue in corrugated is observed as bulging around score lines due to compression and tear of fibers at corners.
One of the most classical examples of fatigue is the glass found in the windows of religous buildings older than 500 years. The bottom of the sheet of glass is tnicker than the top due to the pull of gravity for a very long time.

Temperature - for each 10°C of temperature increase chemical reactions double in speed.
Corrugated boxes stacked in a warehouse will fail more quickly at 40°C than 41°C.

Note : Interestingly - humid boxes which are frozen attaingreater stacking strength because the moisture vapor acts as a glue providing improved strength.
However, when they are thawed the box is weaker because the ice has caused fiber tear when it expanded between the paper laminates.

4) Stacking pattern

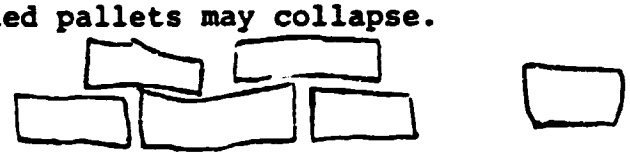
The strongest stacking pattern is vertical colums.
Corrugated boxes receive their strength primarly from the 90 ° corners.

When the corners are aligned vertically the greateststacking strength is possible.
The least efficient stacking strength is interlocking.
Interlocking places the vertical forces directly above the side of the box. This is farthest from the corners. Consequently the sides of the box bend outward.

Interlocking is used to stablize the stack during shipping.
The strongest and best pattern is vertical stacking using stretchwrapping to keep the unstable load from falling over.

5) Overhang on Pallet

Pallets in the USA are a standard size,40 x 48 inch.
Few shipping cases fit the pattern exactly.
There is an advantage in having a slight underfilling of the pallet so that cases are completely supported.
As we mentioned, the 90% degree angles of the case are essential in maintaining the flutes in a vertical position. Overhang causes cases to bow at the sides when the side of the is unsupported. Unless cases are stretch wrapped, the entire column of stacked pallets may collapse.



Front Side

This is a problem especially during the hot humid months.
The usual solution is to stack pallets 2 tiers high in the summer and 6 tiers high in the cold dry winter.

6) Pallet condition

Pallets must have no missing or broken boards.
Most US food companies purchase new pallets or contract to

have them repaired. Discarded pallets are common. Companies that manufacture health foods are very concerned about sanitation. They use only new pallets. All products are stored in steel racks. The racks have rollers so there can be no splinters or nails projecting from the pallets.

Broken boards will allow the shipping cases to sag and bulge reducing stacking strength.

Pallet condition should be checked when cased products arrive at the foodplant. Broken pallets should not be stacked. They should be repaired or discarded when found to be broken.

Uses of Paperboard

A. Boxboard

1. Folding cartons

- shipped and stored flat
- erected into rigid containers
- bending board

  clay coated chip

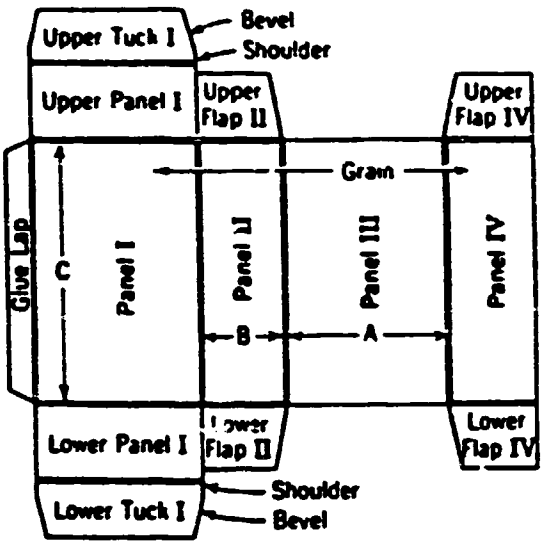
  solid bleached sulphate (SBS)

  solid unbleached sulphate (SUS)

  filled boards

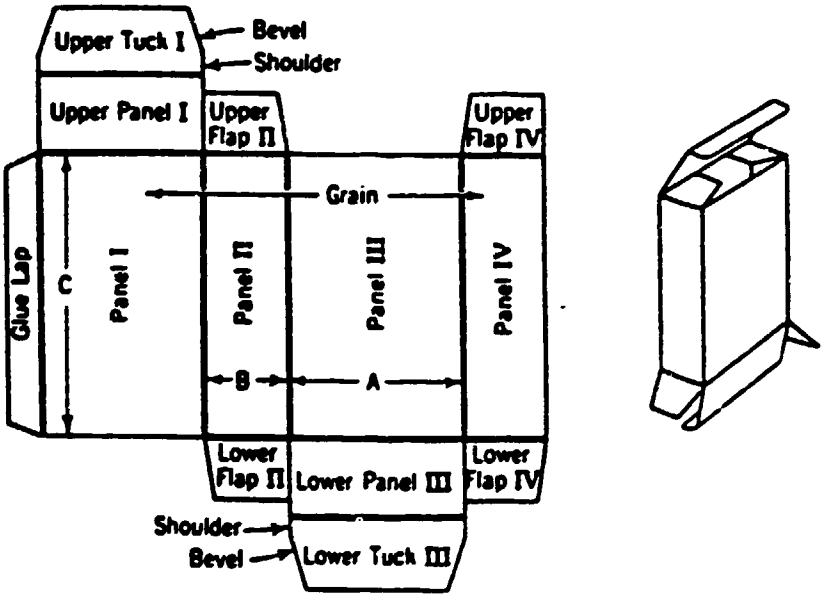
- grain directed around carton

Tubes



(e)

(*e*) Straight tuck

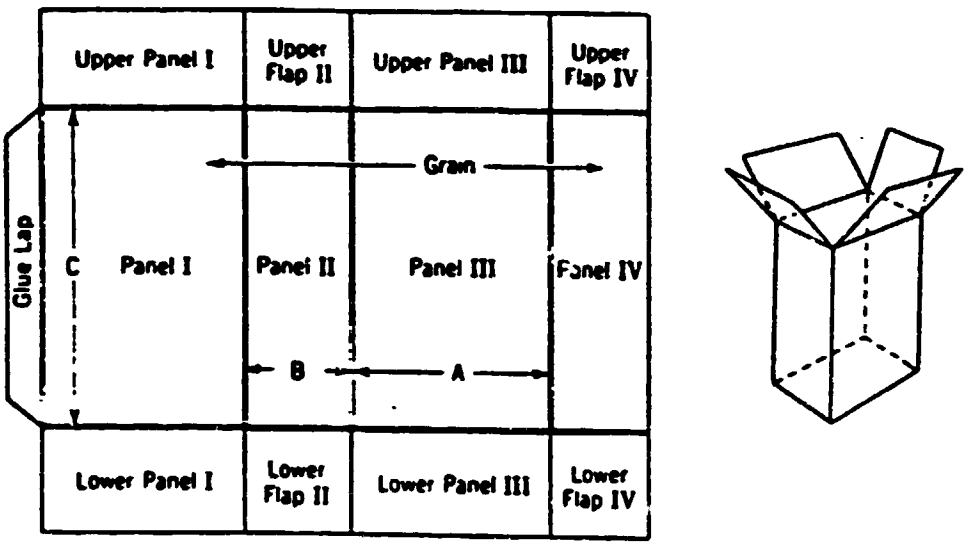


(f)

(*f*) Reverse tuck

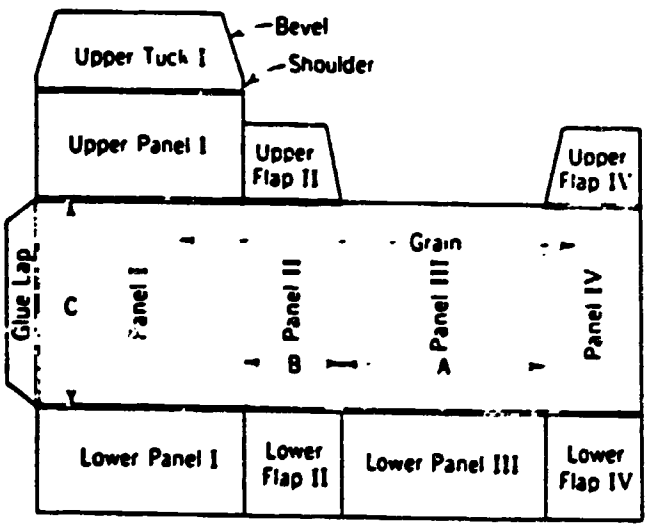
Tubes

Fig. 3-8 (*a-j*). Tubular carton styles. Courtesy Folding Paper Box Association of America.



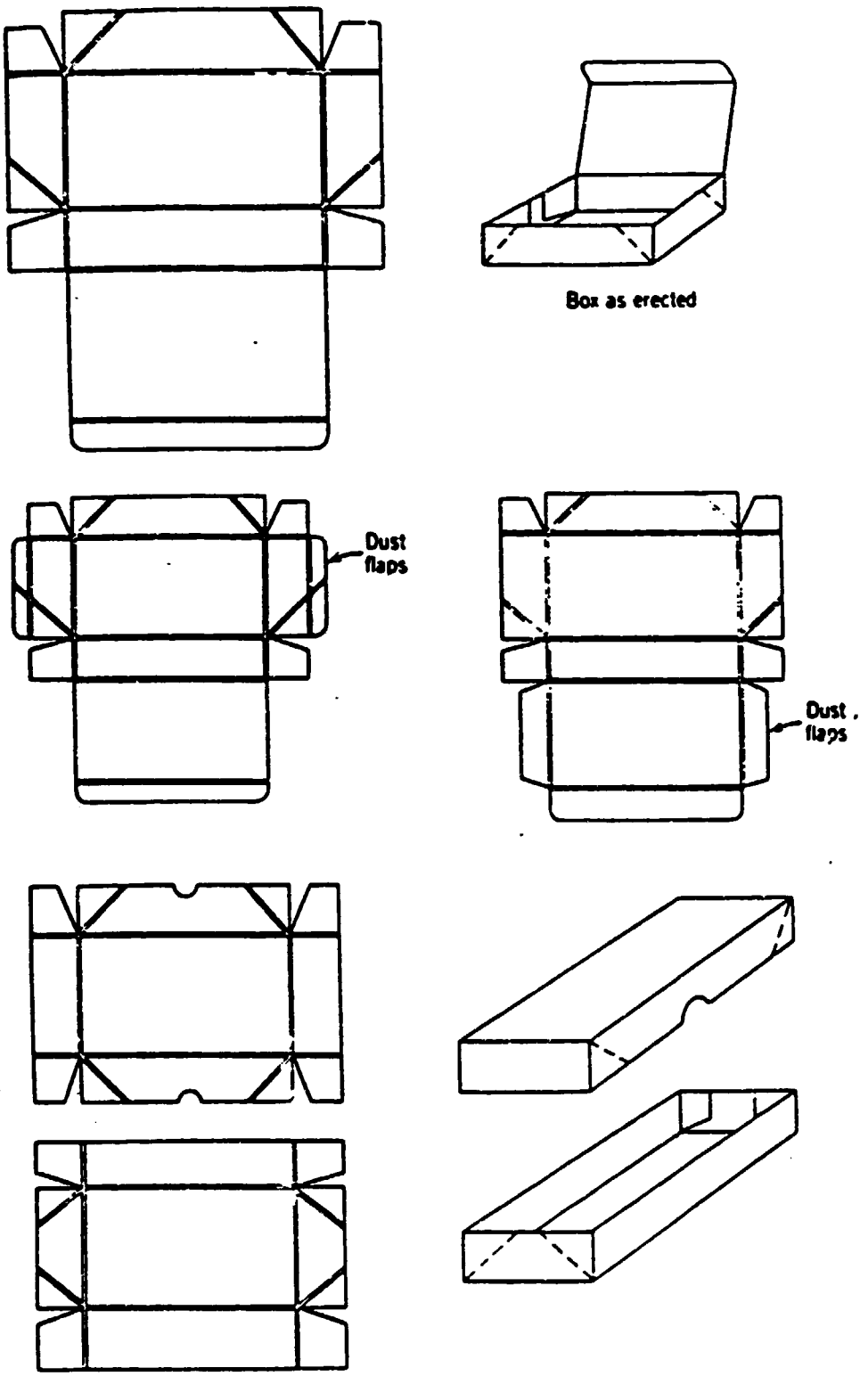
(a)

(*a*) Full seal-end



(b)

(*b*) Tuck-end, seal-end



(b)

(*b*) One- and two-piece diagonal fold style trays

2. Set-up boxes

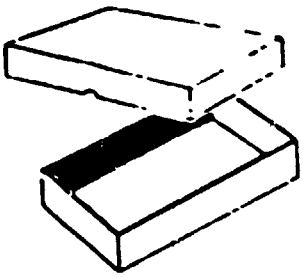
- made in final shape

- better rigidity, appearance

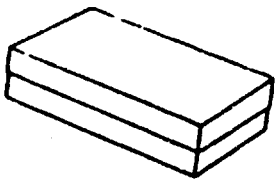
- nonbending board

- decreasing use

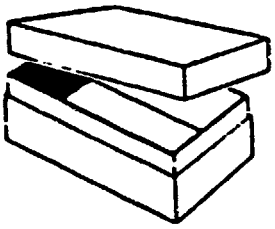
Styles of rigid boxes



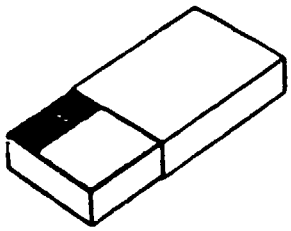
(a) Full Telescope



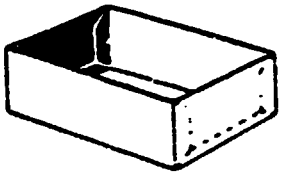
(b) Partial Telescope or Shallow Lid



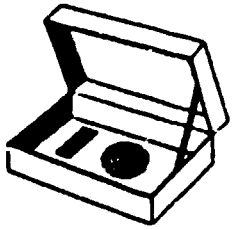
(c) Neck or Shoulder Style



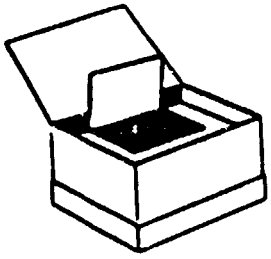
(d) Slide Style



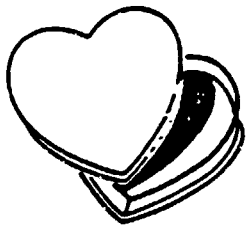
(e) Ended Box



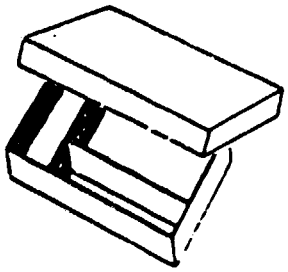
(f) Hinged Cover



(g) Box-In-Box

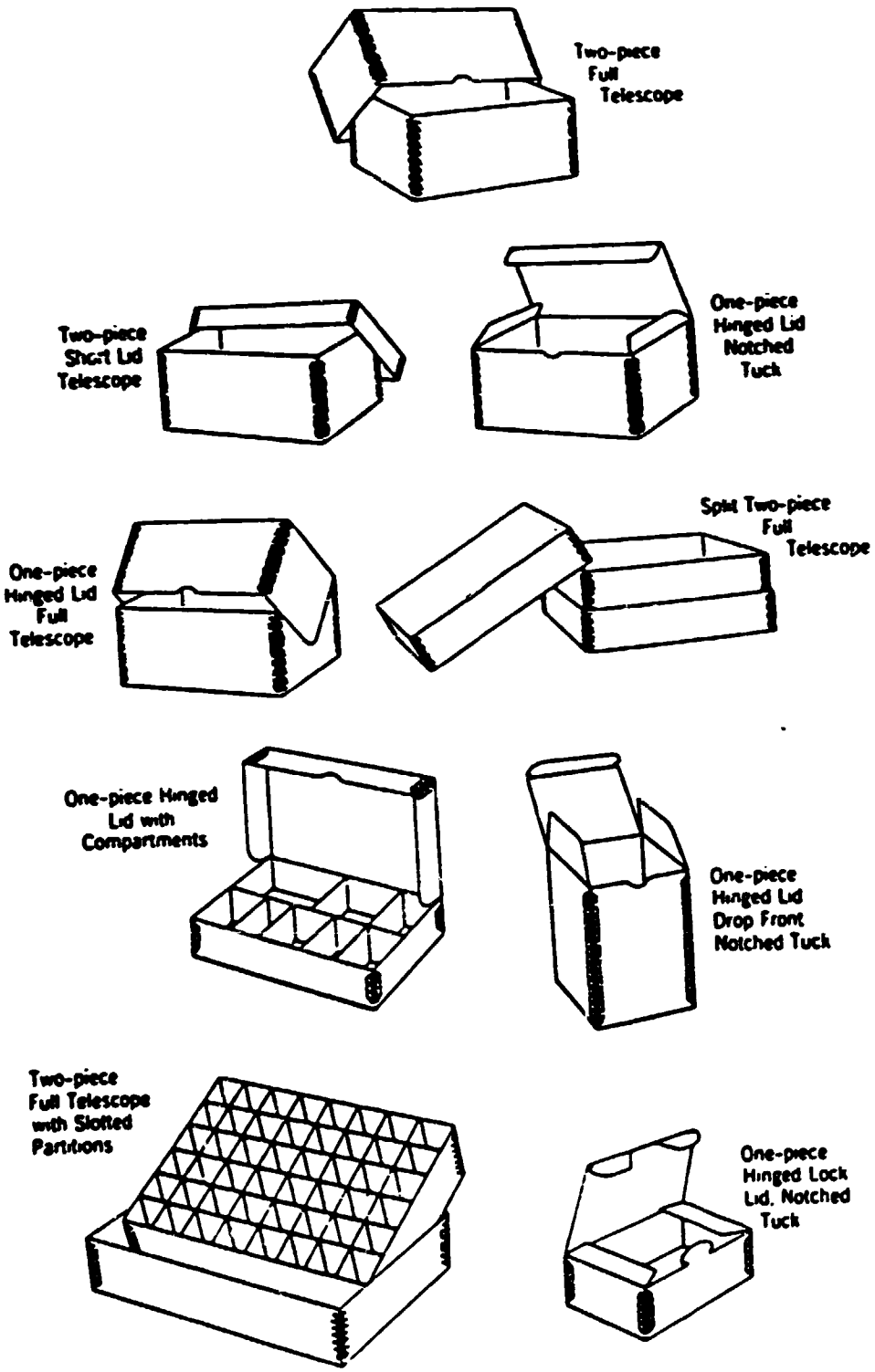


(h) Special Shape

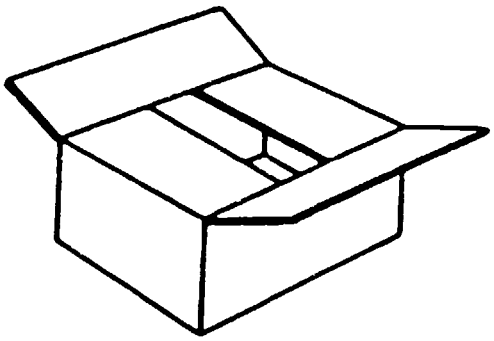


(i) Interior Partition

Styles of metal-stayed boxes

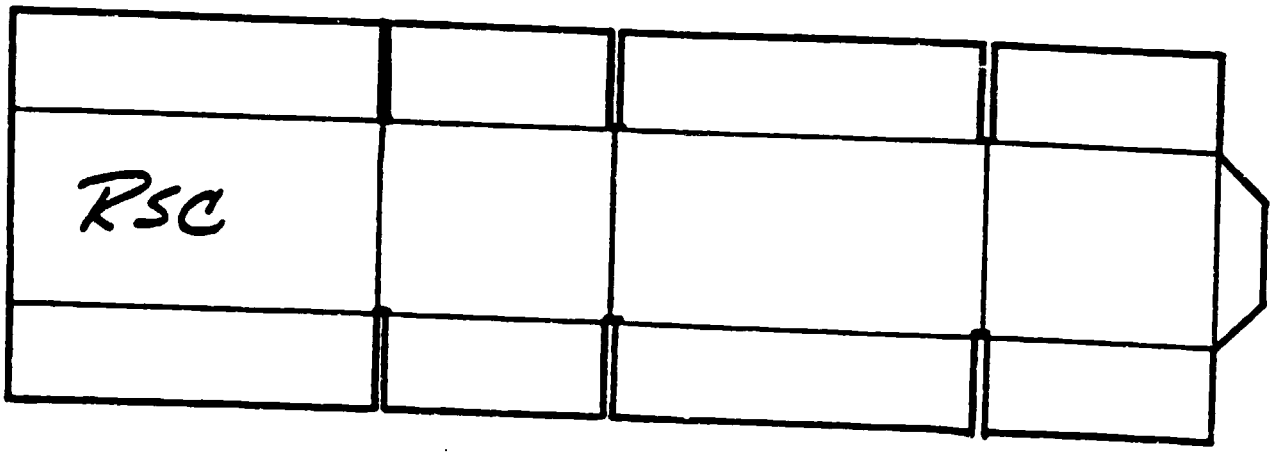


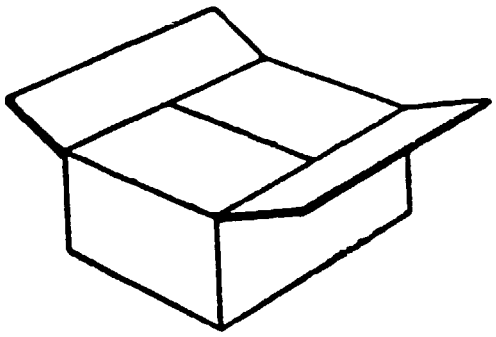
RSC - Regular Slotted Container



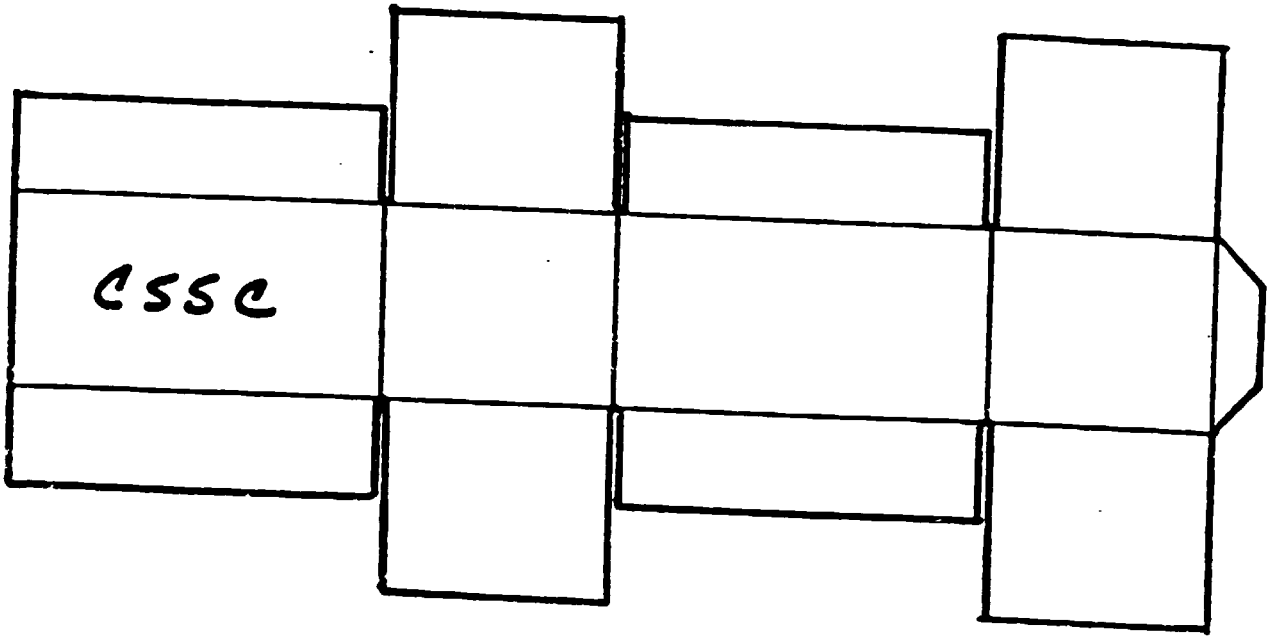
- most widely used
- most economical

side flaps meet, end flaps do not





- stronger than RSC
- all flaps meet
- provides level base for product



Strength greatest at 6% H_2O

RH = 30%

9 point, 26 pound

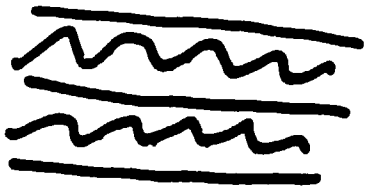
26-90 pound, 9-30 points

Corrugated

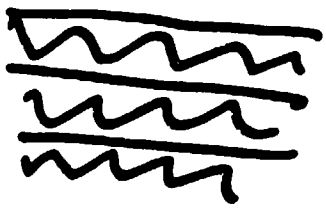
Single face

Wall 

Double face
Single wall



Double wall



Tripple wall

Corrugated

Flute	lineal meter	flute height mm
A	118	4.76
B	168	2.38
C	128 – 138	3.57
E	316	1.19

Stacking Strength - 34 - (Hanlon 14-7,8)

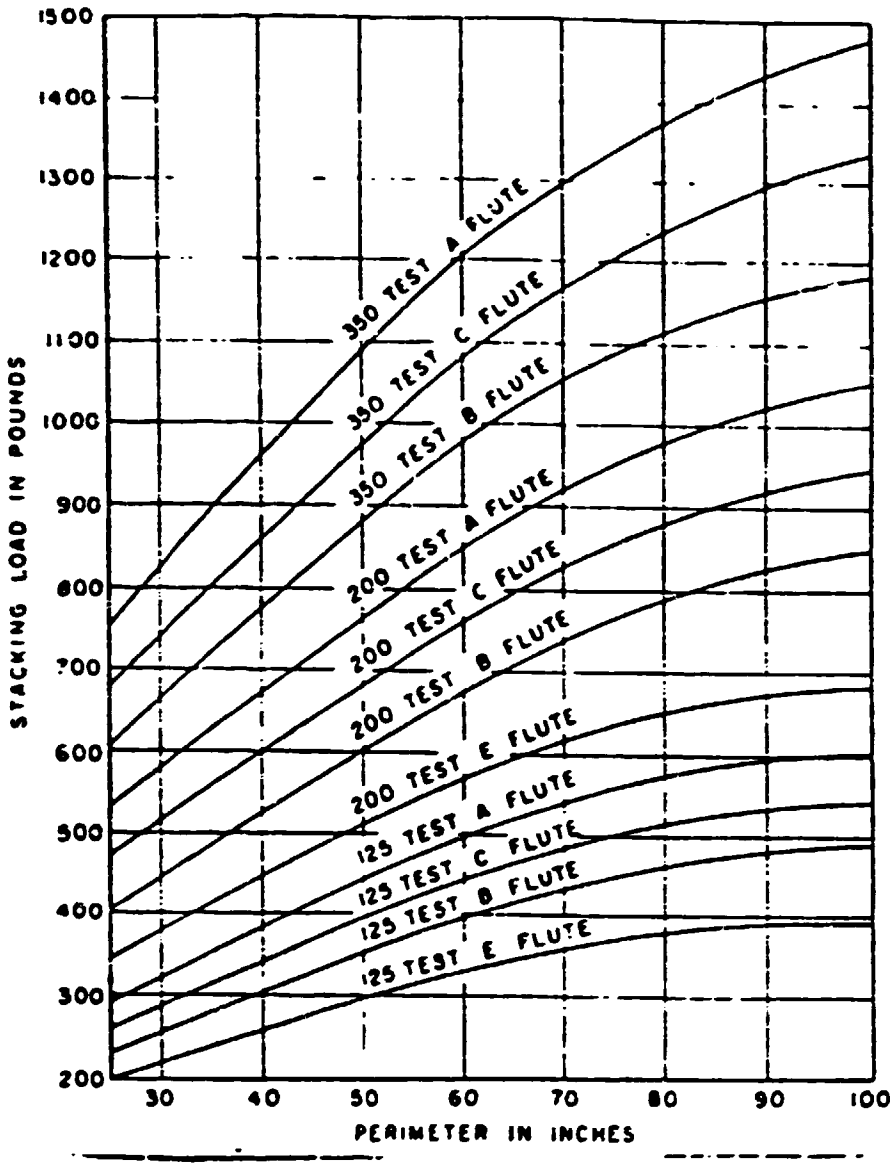


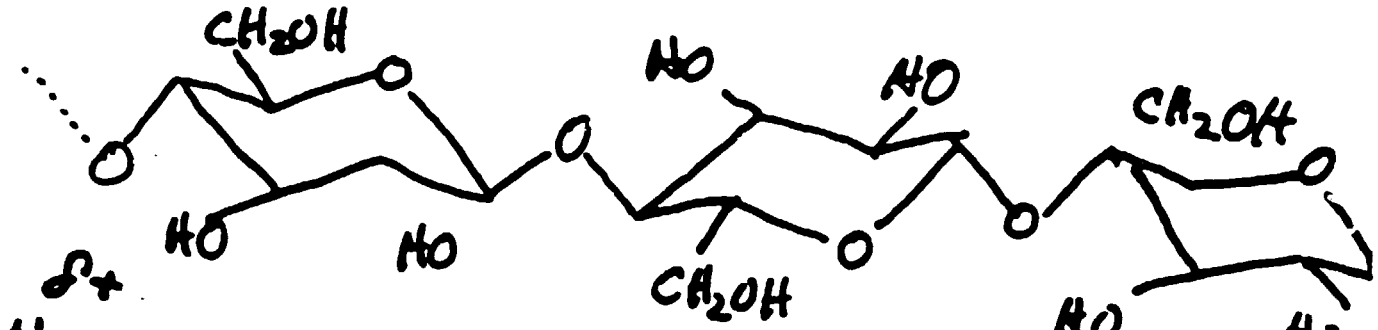
TABLE 5 Fatigue Factors

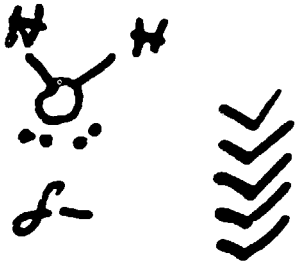
Duration of load	Stacking strength, percent
Short term	100
10 days	65
30 days	60
100 days	55
1 year	50

TABLE 6 Humidity Factors

Humidity, percent RH	Stacking strength, percent
Dry	100
75	90
80	80
75	65
85	50
90	40

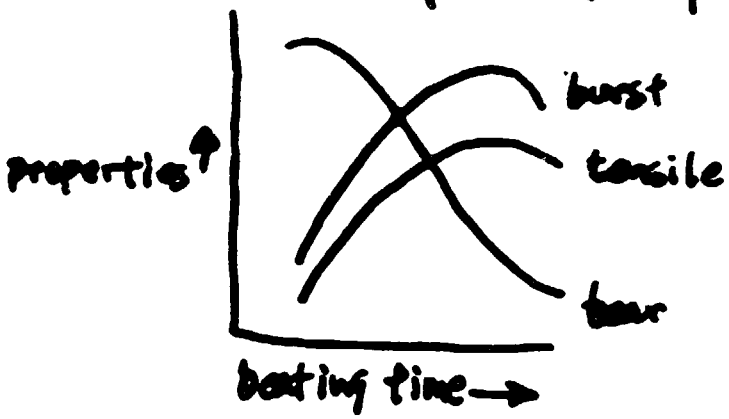
CELLULOSE





organic polymer of sugar residues
highly crystalline
strongly hydrogen-bonded
very hydrophilic

Fiber modification
beating and refining



Basis weight

paper pounds / 3000 ft²

Paperboard pounds / 1000 ft²

g/m²

FACTORS AFFECTING STACKING HEIGHT

1. Product Being Packaged
2. RH
3. Fatigue, T°
4. Stacking Pattern
5. Overhang on Pallet
6. Pallet Condition
7. Headspace
8. Printing
9. Amount of Glue on Flutes
10. Handling
11. Flute Arrangement
12. Box Manufacturer Q.C.
13. Octagonal Shipper (Design)
14. Joint Fitment
15. Dividers
16. Liners - Perimeters
17. Recycled/Virgin
18. Product Compatability

TABLE 1

SUMMARY OF PULPING PROCESSES

I. MECHANICAL

Process	Equipment	Feed	Temp °C	Cons %	Power HP days/ton	Product
Stone Grinding	Carborundum Grindstone	Roundwood	<100	2- 3	60- 90	Groundwood
Refiner Grinding	Disk Refiner	Chips	~100	8-20	70-100	Groundwood
Thermo-mechanical Pulping	Pressurized Disk Refiner	Presteamed Chips	120-140	10-25	100-140	High-strength Groundwood

II. FULL CHEMICAL

Process	Wood	Chemicals	Temp, °C	Time hr	Yield, %	Uses
Soda	Hardwood	NaOH 10 - 15%	150-170	4- 6	40-50	Book Paper
Kraft	All Species	NaOH-Na_2S 14-18% act. alk. 20-30% sulfidity	170-180	2- 5	45-55	All Grades
Sulfite	Nonresinous Softwood	Total SO_2-6-8% comb. SO_2-0.8-1.2%	130-140	6-12	40-50	Newsprint, tissue, dissolving grades
Bisulfite	Hardwood	Total SO_2-4-5% comb. SO_2-2-2.5%	140-160	4- 6	50-55	Printing tissue

III. SEMICHEMICAL

Process	Chemicals	Temp, °C	Time, hr	Yield, %	Use
NSSC	Na_2SO_3, $NaHCO_3$ Na_2CO_3	170-200	0.1-0.5	70-85	Corrugating medium
Cold Soda	NaOH	100	2-4	80-85	Newsprint
Chemical add'n in refiner groundwood	Na_2SO_3	Similar to chip groundwood		80-85	Groundwood printing
CTMP	Na_2SO_3	120-140	--	90-95	Groundwood printing
Arbiso	$NaHSO_3$	155-165	4-6	65-75	Newsprint

STRENGTHS AND WEAKNESSES IN PRESENT PULPING PROCESSES

PROCESS	STRENGTHS	WEAKNESSES
Groundwood Process	very high yield (almost 100%)	very weak paper
	excellent printability	limited use
	low capital cost	poor permanence
	relatively good environmentally	high power cost
Kraft Process	pulps any wood species	highly capital intensive
	high strength pulp	pulp costly to bleach
	versatile product	air pollution problems
	excellent recovery system	operating hazards
Sulfite Process	excellent pulp for fine papers	low yield
	relatively easy to bleach	sensitive to wood species
	some by-products attractive	no generally accepted recovery process
Neutral Sulfite Semichemical Process	excellent special purpose pulp	sensitive to wood species
	can practice "cross-recovery" with kraft	no generally accepted recovery process

PAPERS IN PACKAGING

Paper	Use	Special Treatment
bleached Kraft	Strong, flexible containers, bags, drums, cans, boxes	None
	Barrier and strength	Coated
	Stretch and Strength: Cushion	Creped
bleached Kraft	Fancy bags, envelopes, labels	None
	Overwrap and labels	Clay coated
	Greaseproof; Wrapper, Box	Highly beaten
Glassine	Grease and Oil Resistance Wrapper, Liner	Highly beaten and supercalendered
Parchment	Grease, oil and water resistance wrapper, liner, release surface	Acid-treated
Many of the above	Barrier and strength	Coated or laminated

PAPERBOARD IN PACKAGING

Corrugated Medium and Liner	Corrugated container board	Corrugating & assembly
Solid bleached Sulfate (SBS)	Stiff, strong, white for frozen food boxes, trays	None
	Barrier & strength - Milk or ice cream	Plastic coat or laminate
Solid unbleached Sulfate	Stiff and tear strength for heavy-duty boxes, beverage carriers	Non or clay or plastic coated and/or laminated
Chipboard and outlined chip	Stiff, strong — set-up boxes or folding box	None
fully coated and including chip	Stiff, strong, printable -folding boxes	none or plastic laminated

Paper, Paperboard and Corrugated

Composition:

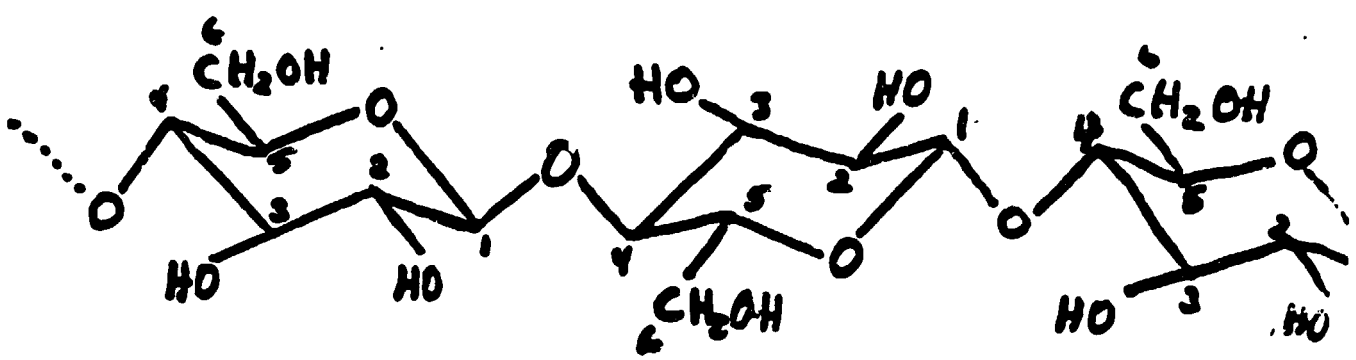
Fibers - cellulosic

organic polymer of sugar residues

highly crystalline

strongly hydrogen-bonded

very hydrophilic



Paper Manufacturing

A. Pulping

1. Selection of materials

virgin vs. recycled

softwood vs. hardwood

2. Liberation of fibers

Mechanical

Chemical

Kraft or sulphate

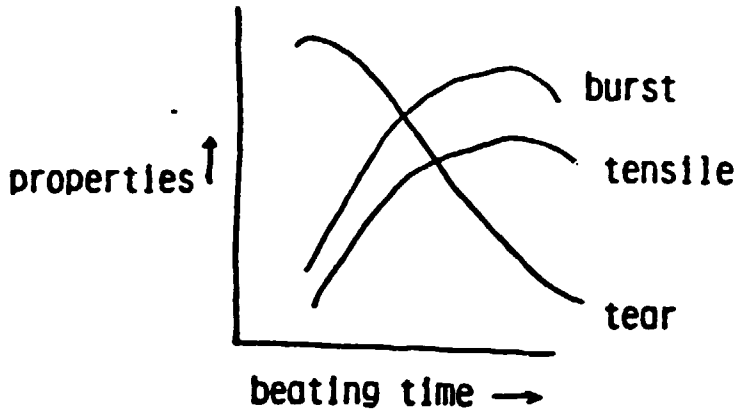
Sulfite

Others

B. Stock preparation

1. Fiber modification

beating and refining



bleaching

2. Additives

Fillers

Sizing

Binders

Colors and pigments

C. Paper Making

1. Fourdrinier

paper or paperboard

single ply

usually virgin fibers

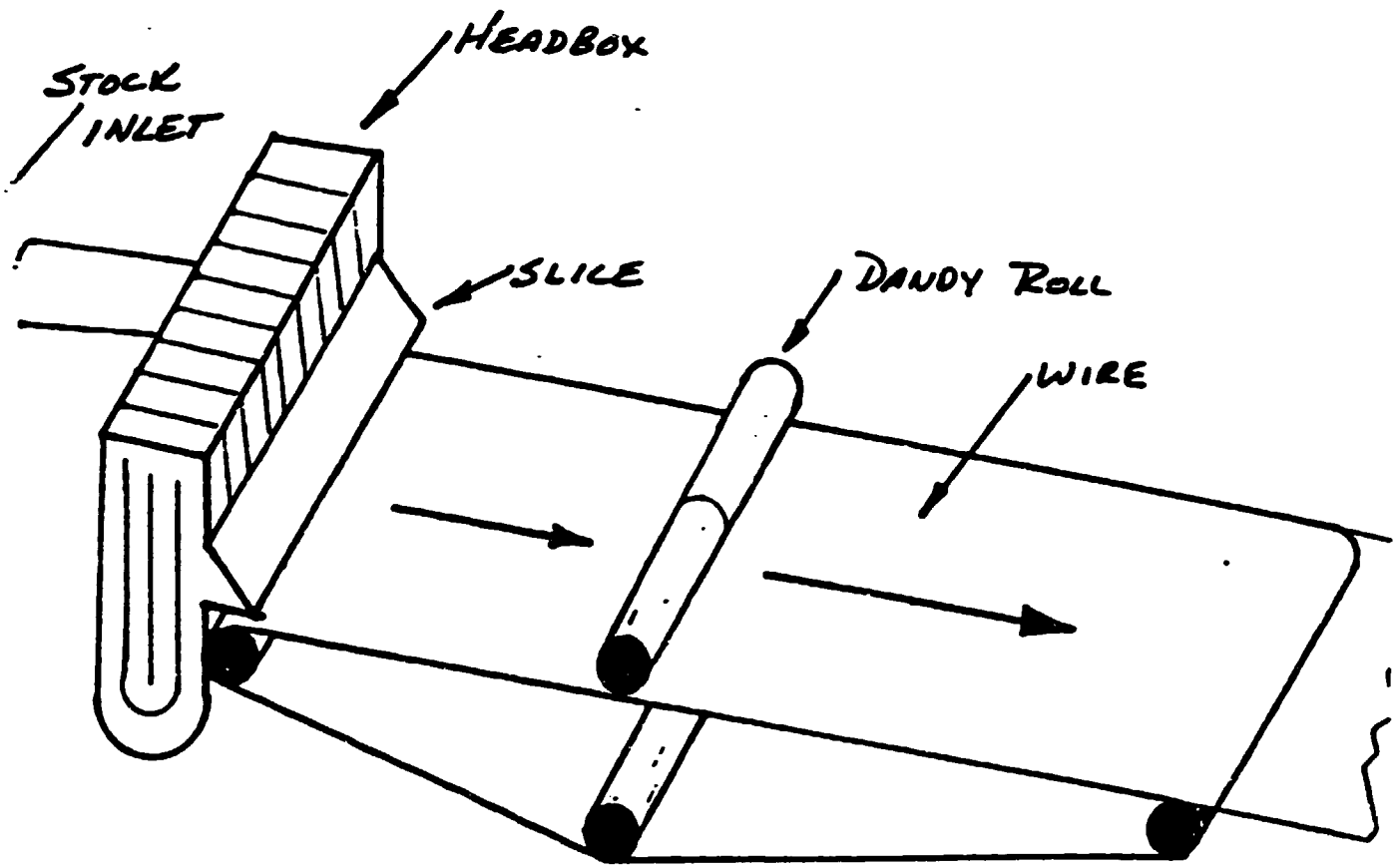
2. Cylinder

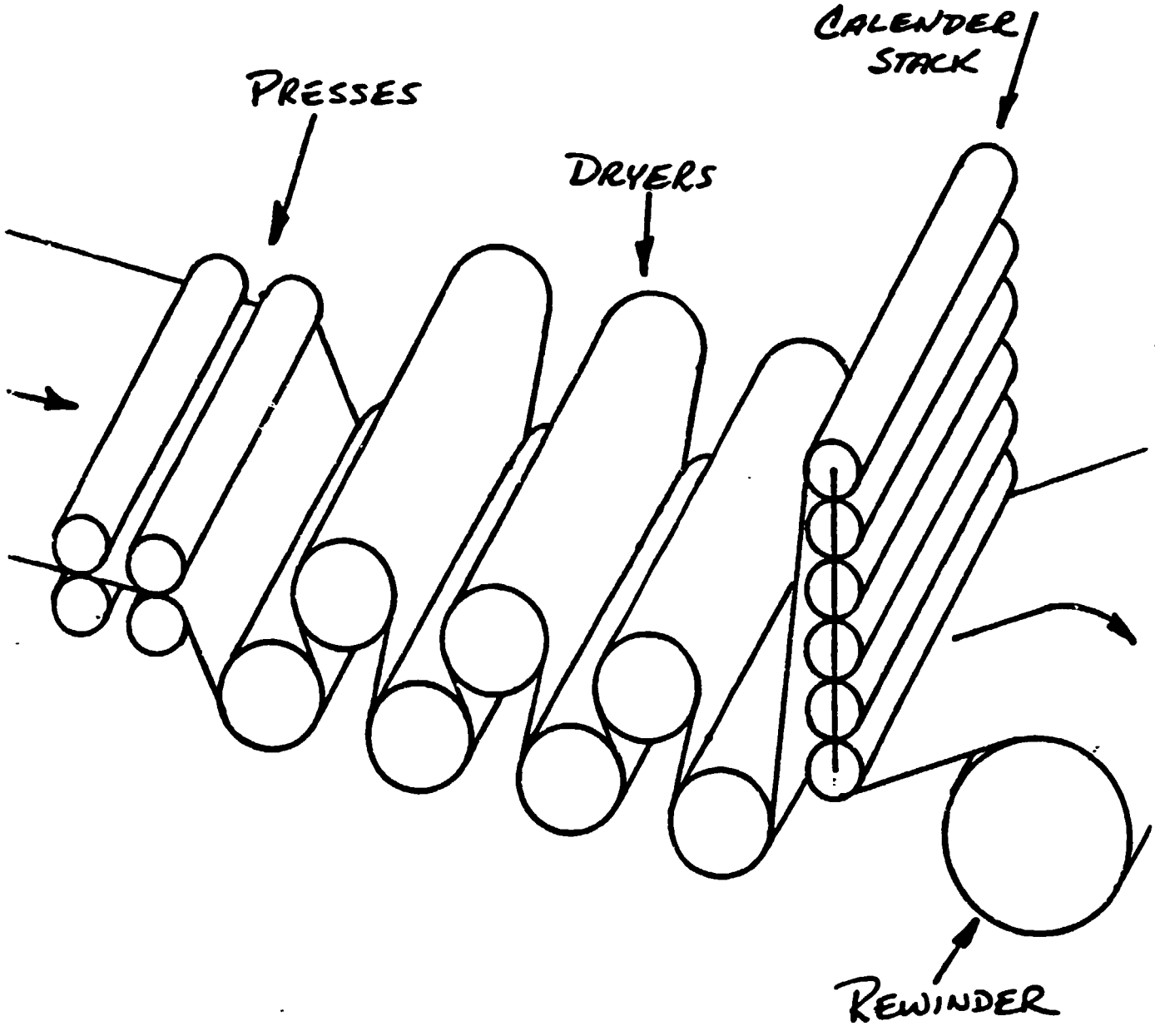
paperboard

multiple ply

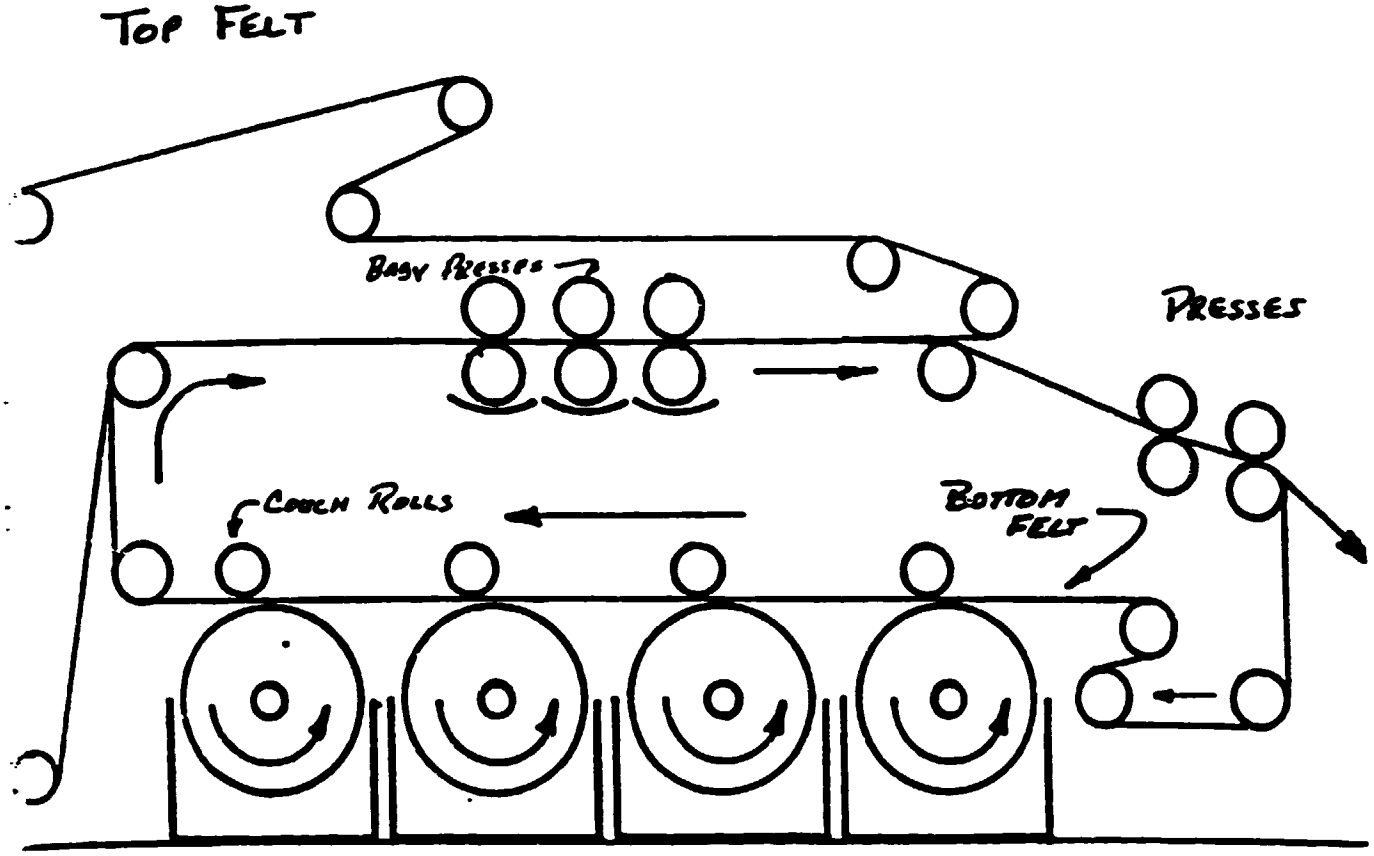
virgin or recycled fibers

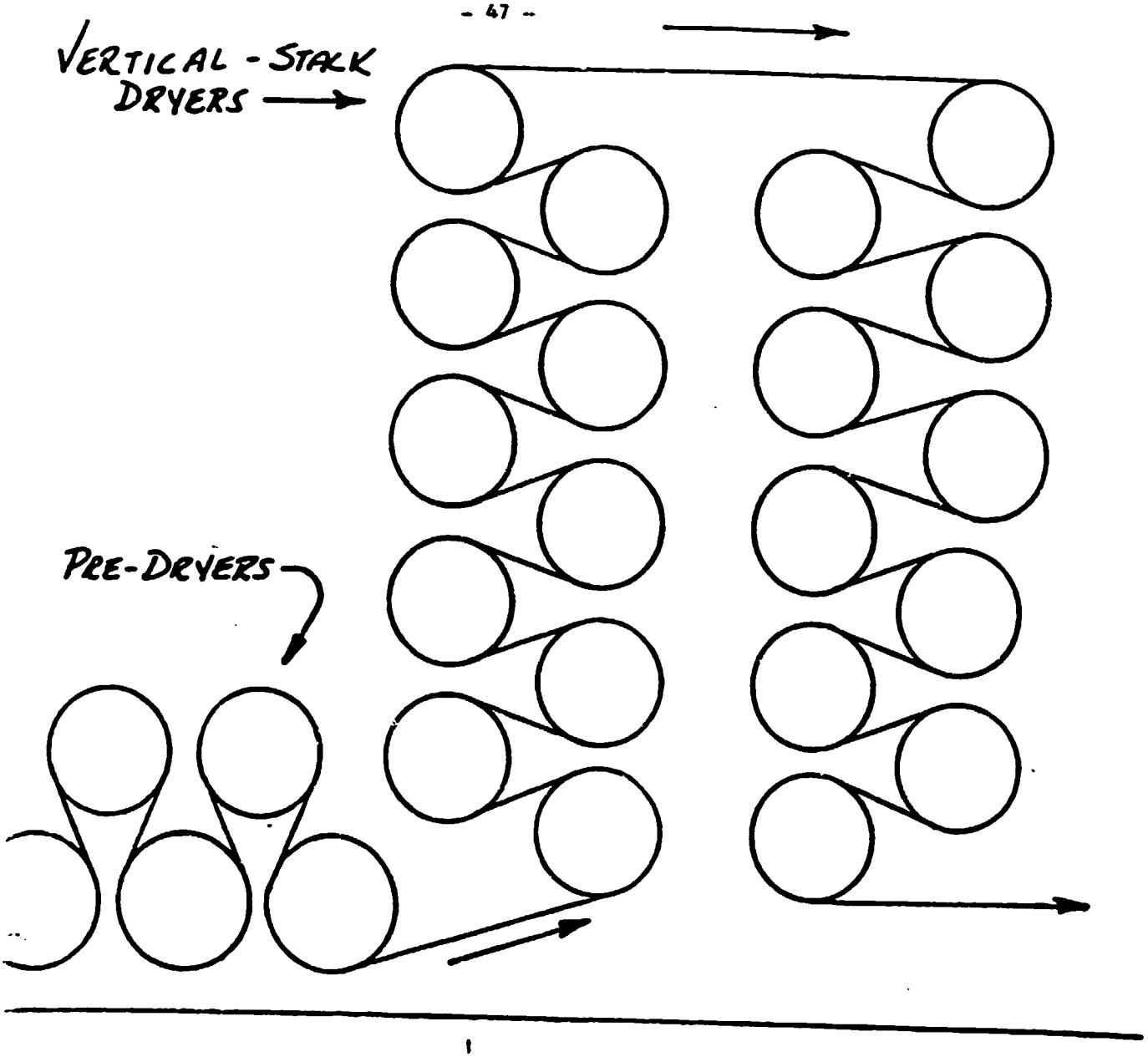
FOURDRINIER PAPER MACHINE




CALENDER STACK
PRESSES
DRYERS
REWINDER

Cylinder Board Machine




VERTICAL - STALK
DRYERS
PRE-DRYERS

D. Paper modification

1. Surface modification

Starches, gums, polyvinyl alcohol

Pigmented coatings

Solvent coatings - nitriles
cellulose acetate

Emulsion coatings - polyethylene
saran
wax

2. Physical modification

Calendering

E. Converting

Paper and Paperboard Properties

A. Thickness or caliper

1 point = .001 inch

B. Basis weight

Paper - lbs/3000 ft^2	16-90
Paperboard - lbs/1000 ft^2	25-206

Europe - grammage - g/m^2

C. Grain direction

Machine direction (MD)

Cross direction (CD)

D. Effects of moisture

Strength - greatest at 5% (30% RH)

Dimensional change

Flexibility/stiffness

Delamination

Printability/Appearance

B. Container board

- for corrugated boxes

1. Corrugating medium

9 pt., 26 lb.

semichemical hardwood pulp

2. Linerboard

26-90 lb., 9-30 pts.

Kraft softwood pulp

3. Adhesives

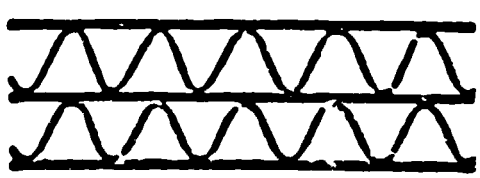
starch

TYPES OF BOARD

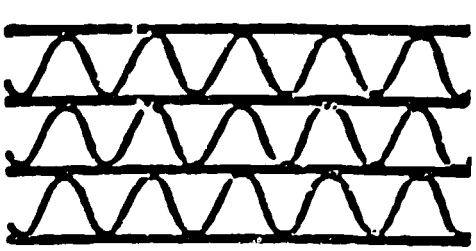
Corrugated Medium

Single-Faced Board

Double-Face or Single-Wall Board



Double-Wall Board

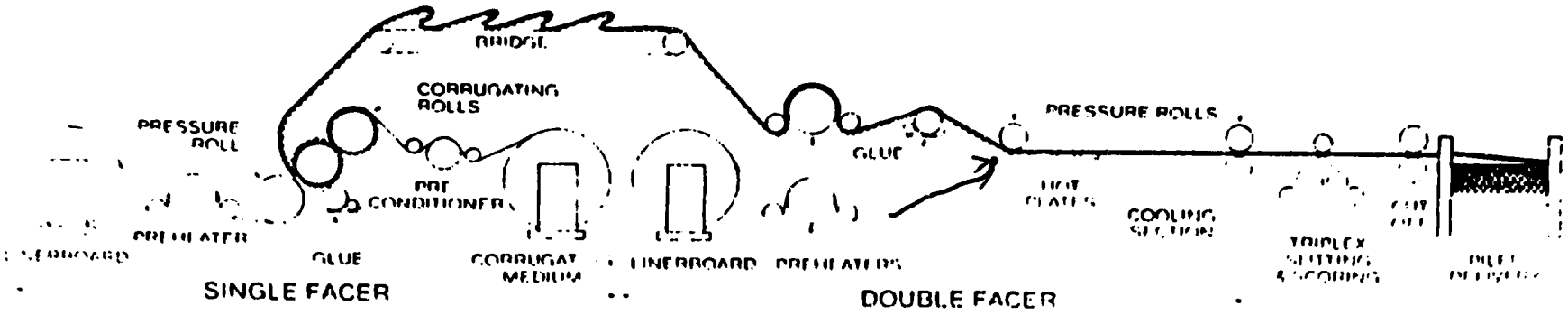


Triple-Wall Board

Illustrations of Types of Board

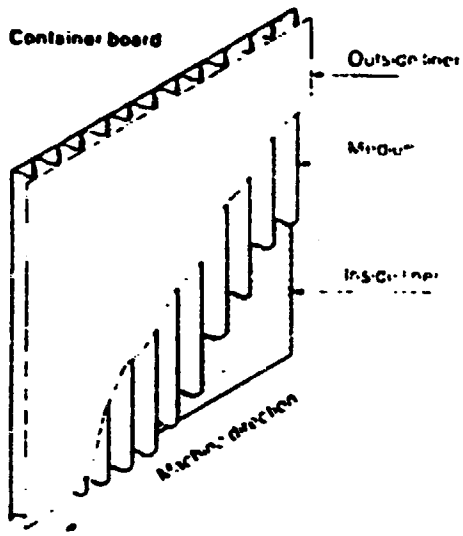
Schematic of a Corrugator

SIMPLIFIED AND CONDENSED



Flute	Number of flutes* per		Flute height*	
	Lineal foot	Lineal meter	Inch	mm
A	36	118	3/16	4.76
B	51	168	3/32	2.38
C	39-42	128-138	9/64	3.57
E	96	316	1/16	1.59

*Approximate
†Exclusive of liners.



Corrugated board flute sizes (Source Lowe 1975, p 100)

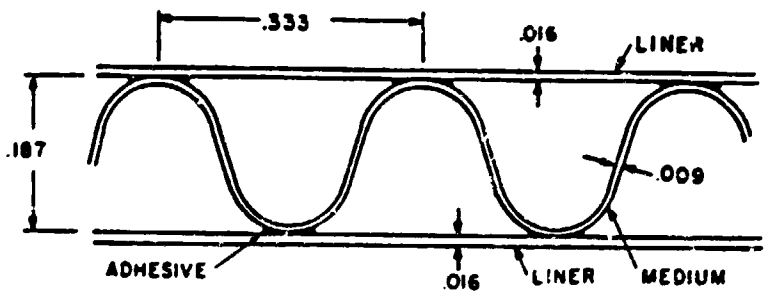


FIG. 3 Basic construction. Structure of corrugated board, showing typical dimensions for 200 test. A-flute board.

Lecture 3 Tuesday, 15 October 1985

Product Marketing and Distribution

I. Basic thesis

The three main areas of interest to the manufacturer and user of packaging material are as follows :

1. The package distribution system,

2. How distribution influences the package.

3. The social impact of packaging.

II. The narration presented during the lecture follows.

III. Attached are all of the overlays for projection as well as lists of key concepts and technical terms used in this presentation.

George Wm Arndt , Jr.

Product Marketing and Distribution

Introduction

There are three main areas of concern which we shall cover in the following order:

1. The package distribution system.
2. How the distribution system influences the package.
3. The social impact of packaging.

1. The package distribution may be shown in the following manner

OVERLAY 3 - 1 OVERLAY 3 - 2

The distribution system provides a rigorous test for all packages. The result of the test is described in terms of passing or failing. Containers which pass distribution are available for sale. Those which fail cause the manufacturer to suffer loss in 3 areas:

1. Loss of product and time invested in manufacturing.
2. Unnecessary use of expensive transportation.
3. Loss of market opportunity.

The solution to packaging for product protection during distribution falls into 3 categories:

1. Overpackaging - which ensures virtually all products will arrive in serviceable condition-is reserved for military packaging. Here the added cost is justified.

2. Normal packaging usually involves an acceptable level of damage to products. This is the area which interests us. It is the area of retail and consumer packaging.
3. Underpackaging may appear be less expensive for the manufacturer. However, consumers fail to make second purchases of the same product once they have purchased a product which failed to perform.

OVERLAY 3 - 3 CONTAINERS

Shows a list of commonly used containers.
We recognize three factors :

1. Each particular container has a specific group of food products which work best with this technology.
2. Each container is associated with a target market. People who regularly purchase food in each different container.
3. We recognize that each container has advantages and disadvantages in the distribution system.

OVERLAY 3 - 4 $\text{Packaging Requirement} = f\left(\text{product susceptibility} + \text{Environmental Severity}\right)$

The package requirement is a function of product susceptibility and environmental severity.

OVERLAY 3 - 5

The package must act as a barrier to protect the food product from outside forces which would destroy the product through climatic biological or mechanical changes.

No container is a perfect barrier. Our principle interest is to maintain those product attributes which make the product desirable to the consumer.

We introduce the concept of

SHELF LIFE OVERLAY 3 - 6

Which is the length of time a packaged product will remain saleable.

Our second topic this morning will be the influences of the distribution system and the effects on the package.

OVERLAY 3 - 7 ENVIRONMENT

There are three main groups of environmental factors which act upon the package during distribution.

These are 1) climatic forces, 2) biological forces and 3) mechanical forces.

When these forces are severe they cause the container to fail immediately. In most cases their effect is to shorten the product shelf life.

These forces act together in various ways and sometimes two forces acting together bring a quicker failure of the package than two forces acting separately.

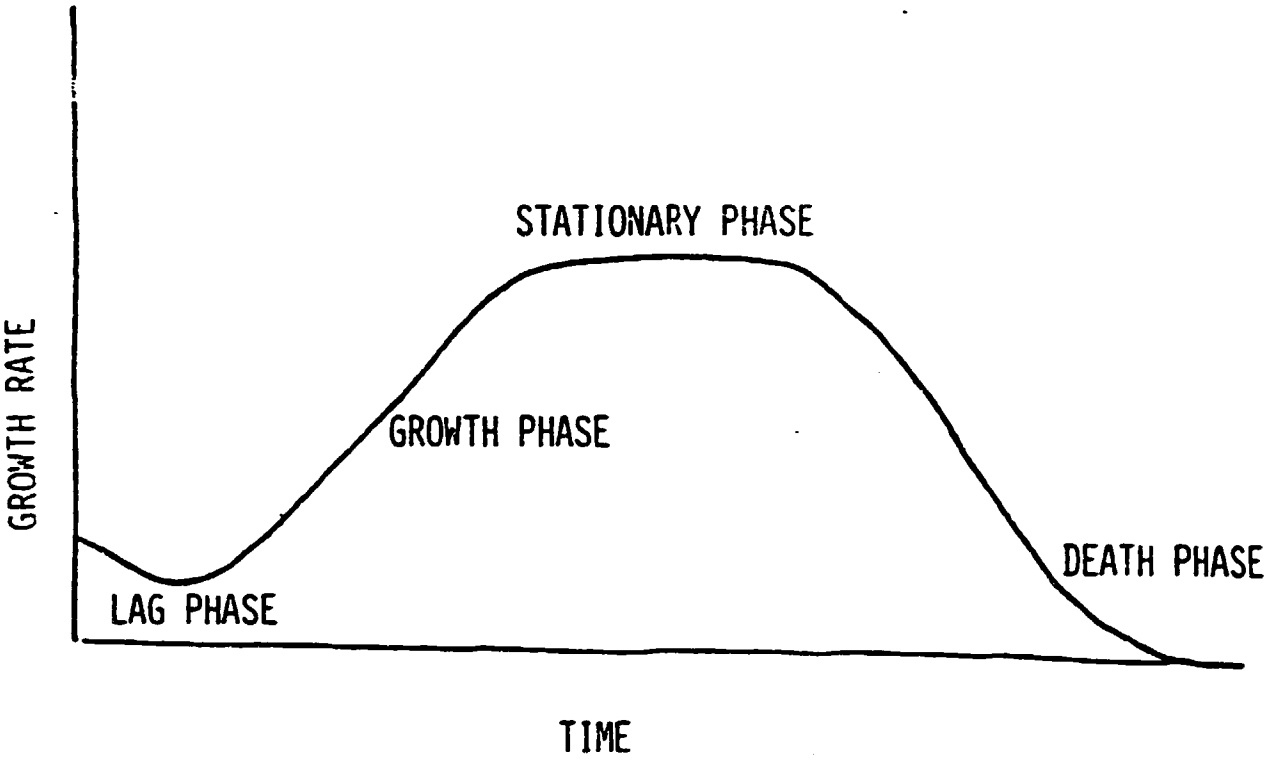
The present state of packaging technology enables us to measure these factors independently. The technology does not enable us to predict the effect of these environmental factors when many are acting in concert-each contributing some small part until the entire container fails.

OVERLAY 3 - 8
continue to
OVERLAY 3 -12

./.

- CAUSE SPOILAGE

- CAUSE ILLNESS



PRODUCT FACTORS:

- COMPOSITION
- STRUCTURE

ENVIRONMENT:

- TEMPERATURE
- RELATIVE HUMIDITY
- OXYGEN

PACKAGE:

- VAPOR BARRIER
- GAS CONTROL
- IMPREGNABLE
- TEMPERATURE COMPATIBLE

MOISTURE

Liquid

Solid

Gas

A. Relative Humidity (RH)

RH = P/Ps x 100%

P = Partial Pressure of Water Vapor in an Area

PS = Saturation Partial Pressure at T^{0} of Tested Area

B. Absolute Humidity

Moisture WT/Unit Volume

C. Effect of Temperature on:

1. RH
2. Absolute Humidity

D. Effect of RH on Products

E. Effect of RH on Packages

GASES

NATURAL ATMOSPHERE

1 ATMOSPHERE = 760 MMHG

- NITROGEN 78%
- OXYGEN 21%
- CO_2 - OTHERS 1%

A. PARTIAL PRESSURES

1. MMHG OR ATM's

PRODUCT NEED:

A. PROTECTION

B. RESPIRATION

PACKAGE ROLE

A. BARRIER

B. INDUCED ATMOSPHERES

Environmental Climatical C

LIGHT

$E = K/\lambda$ E = ENERGY

K = CONSTANT

λ = WAVELENGTH

GAMMA RAYS	.003 - 0.3 $\overset{o}{A}$
X-RAYS	0.3 - 100 $\overset{o}{A}$
ULTRAVIOLET	10 - 400 NM
VISIBLE	400 - 700 NM

LIGHT SOURCES :

- ULTRAVIOLET
- SUNLIGHT
- FLOURESCENT

PACKAGING'S ROLE :

- PROTECTION
- COLOR - GRAPHICS

TEMPERATURE

PRODUCT DETERIORATION IS ACCELERATION THROUGH INCREASED RATES. PACKAGING:

- OFFERS SOME INSULATION VALUE
- MUST BE COMPATIBLE WITH HIGH AND LOW TEMPERATURES

PHYSICAL DISTRIBUTION ENVIRONMENT

SHOCK:

- IMPACT DAMAGE TO PRODUCTS AND CONTAINERS

A. VELOCITY

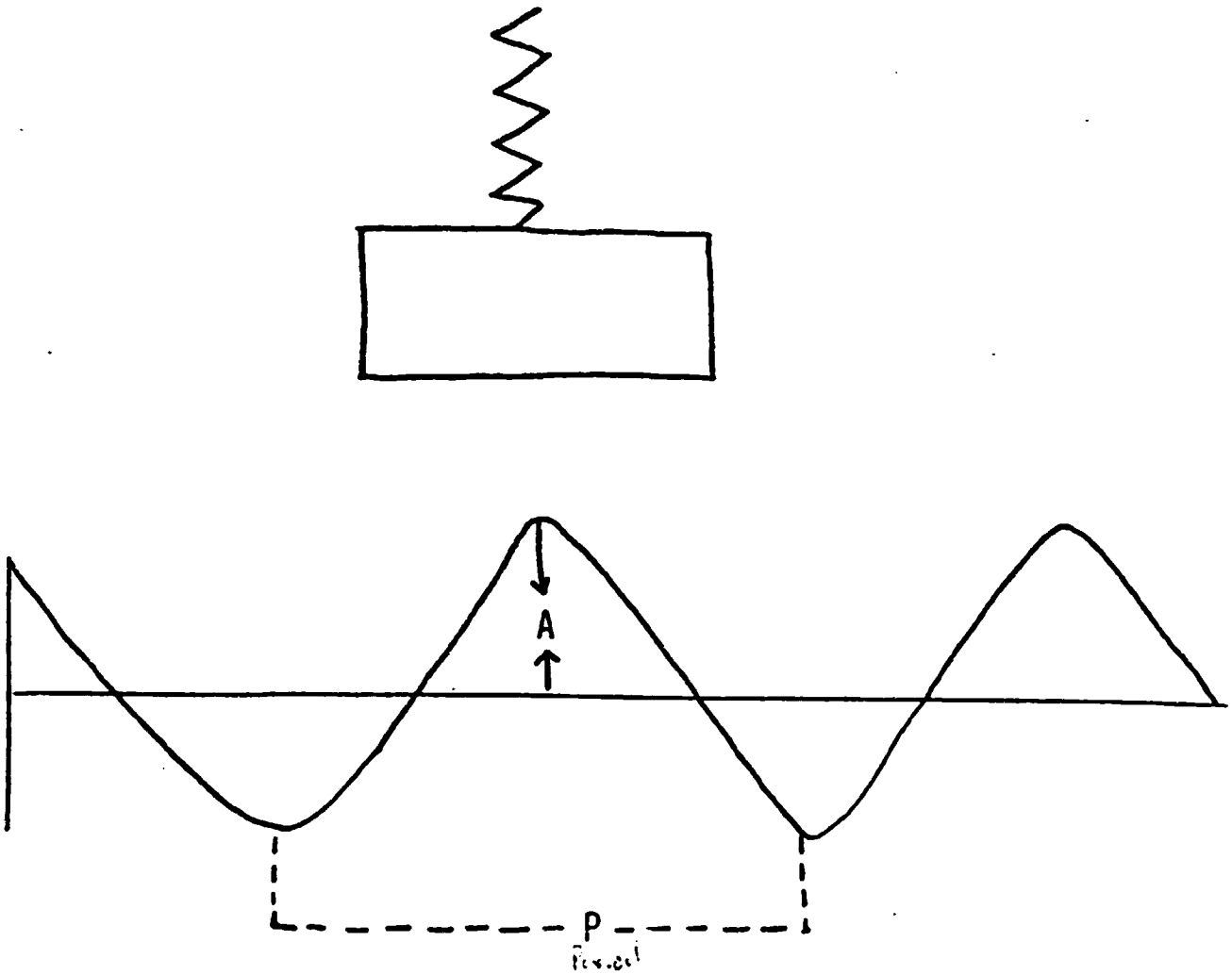
B. ACCELERATION

DAMAGE DEPENDS ON:

1. PRODUCT FRAGILITY
2. WEIGHT OF PRODUCT-PACKAGE
3. DROP HEIGHT
4. MATERIAL CONTACT SURFACE

VIBRATION

A. SPRING MASS SYSTEM



P = SECONDS/CYCLE

F = FREQUENCY = 1/P CYCLES/SECOND

A = AMPLITUDE (DISPLACEMENT)

NATURAL FREQUENCY:

A Characteristic of Any Spring Mass System

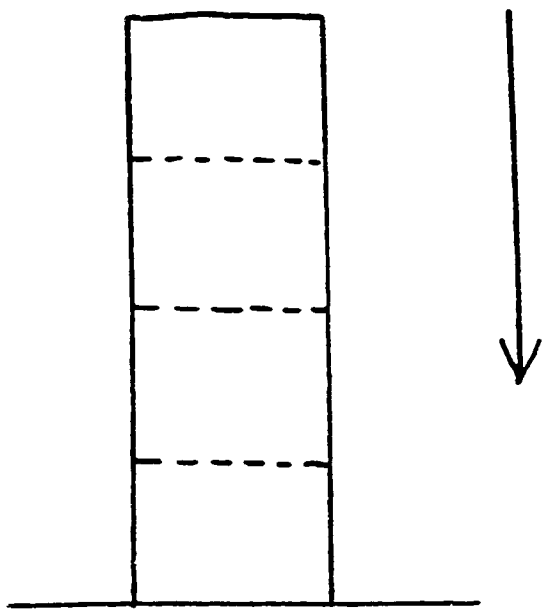
FORCED FREQUENCY:

A. Less than Natural F

B. Equal to Natural F, Results in Resonance (Amplifies)

C. Greater than Natural F, Attenuates.

COMPRESSION



FACTORS INFLUENCING:

- Shipping Container
  - Type & Quality
  - Alignment and Stacking Patterns
- Environmental Conditions
- Length of Storage
- Pallets or Slip Sheets
- Handling Operations & Mechanical Damage
- Printing
- Product & Headspace

HANDLING OPERATIONS

- Manual
- Mechanical
    A. Shock
    B. Dynamic Compression

WAREHOUSING

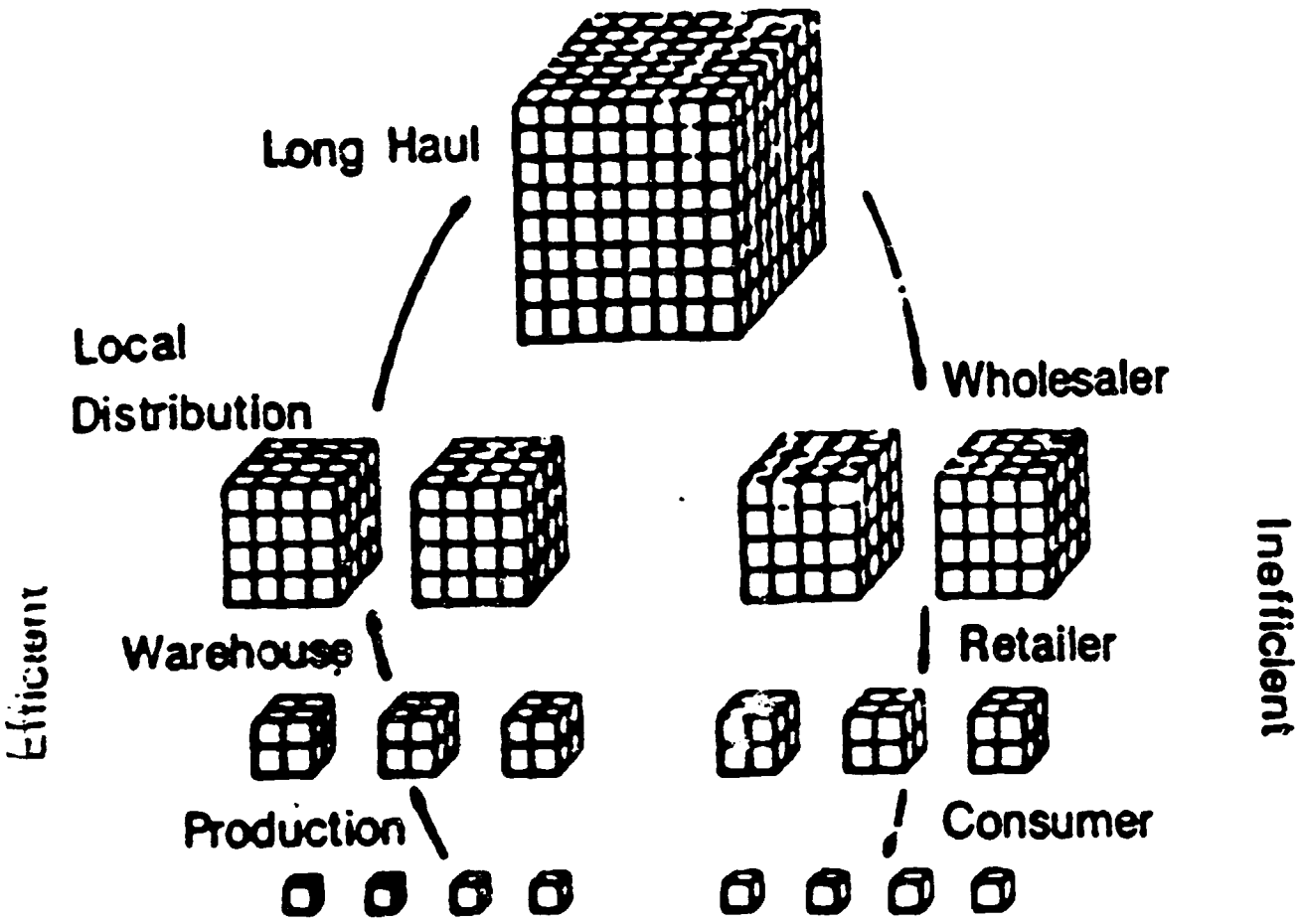
- Static Compression
- Dynamic Compression

TRANSPORTATION

- Vibration
    A. Broad Ranges Involved
    B. Resonance Develops
- Shocks
- Dynamic Compression

RAILCAR COUPLING

- Shock
- Compression (Dynamic)
    A. Impact Speeds
    B. Car Weight
    C. Coupler Design
    D. Load Type and Design
    E. Number of Cars



PACKAGE SYSTEM

- Primary Package
- Secondary Package
- Tertiary Package

Package = Material + Physical Design + Surface Design (Graphics)

The distribution system is a test.

PASS — Product available for sale.

FAIL — <u>ECONOMIC LOSS</u>

1. Loss of product and manufacturing time.
2. Unnecessary use of transportation
3. Loss of market opportunity.

Three levels of packaging for distribution.

1. Overpackaging
2. Normal packaging
3. Underpackaging

CONTAINERS

RIGID

- Glass bottles
- Metal cans
- Metal trays

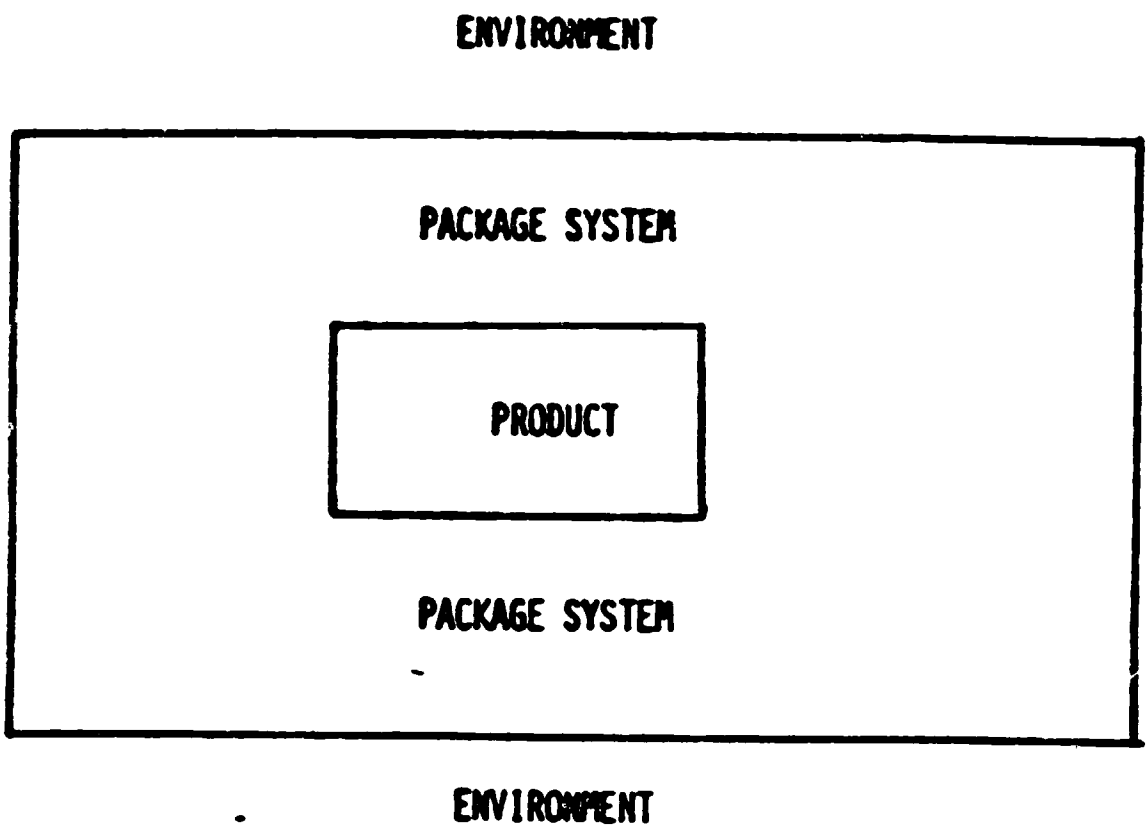
SEMI-RIGID

- Plastic bottles
- Plastic cups
- Plastic trays
- Composite cartons

FLEXIBLES

- Bags
- Pouches
- Wraps

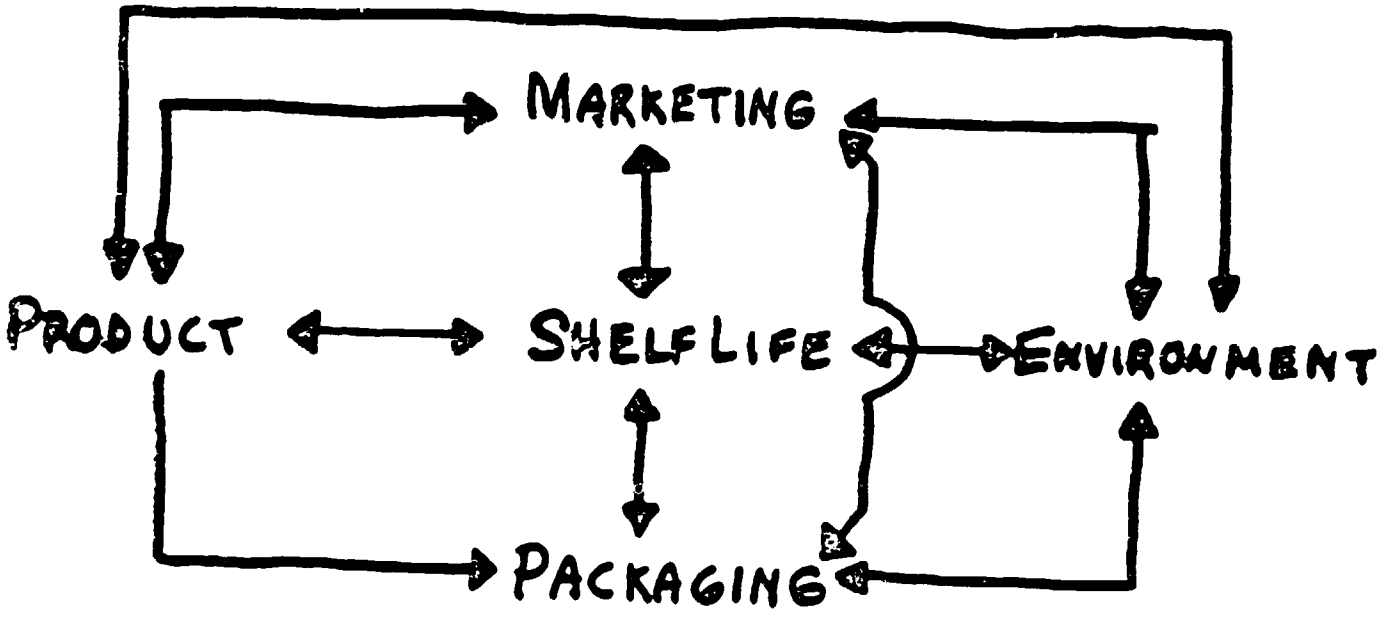
$$\text{PACKAGING REQUIREMENT} = f(\text{PRODUCT SUSCEPTIBILITY} + \text{ENVIRONMENTAL SEVERITY})$$


ENVIRONMENT
PACKAGE SYSTEM
PRODUCT
PACKAGE SYSTEM
ENVIRONMENT

SHELF LIFE (STORAGE LIFE)

THE LENGTH OF TIME THAT A CONTAINER, OR A MATERIAL IN A CONTAINER, WILL REMAIN IN A SALEABLE OR ACCEPTABLE CONDITION UNDER SPECIFIC CONDITIONS OF STORAGE.

SHELF LIFE DEPENDS ON MARKETING (DISTRIBUTION) REQUIREMENTS.



ENVIRONMENT

NATURAL vs. INDUCED

1. CLIMATICAL
   - -Humidity (H_2O)
   - -Oxygen, Carbon Dioxide
   - -Light
   - -Dust
   - -Temperature

2. BIOLOGICAL
   - -Human
   - -Animals, rodents, insects
   - -Microorganisms

3. MECHANICAL (PHYSICAL DISTRIBUTION)
   - -Shock
   - -Vibration
   - -Compression

RISKS TO HEALTH

From PEOPLE

- Tampering
- Sanitation

From MICROORGANISMS

- Insufficient processing
- Loss of package integrity

From PACKAGES

- Failure of TRP
- Physical injury
- Chemical contaminants

LOSS OF QUALITY

SHELF STABLE -- PERISHABLE PRODUCTS

- Loss of integrity
- Inadequate protection/shelf life desired

BARRIER

OXYGEN

Flavor change
Color
Potency

WATER

Absorption
Desorption / Loss

LIGHT

Color
Flavor

ADSORPTION OF FLAVOR/VITAMINS

LOSS OF VOLATILE FLAVOR COMPONENTS

MIGRATION

VIBRATION

TYPES OF DAMAGE

Flexing
Crushing
Impact

EFFECTED BY

Product Headspace
Product Consistency
Shipping Container Used
Method of Packing
Tightness of Pack

MEASUREMENT

Fixed Displacement Testing:
Repetitive Shock

Stacked Vibration Testing:
Resonance Search and Dwell

EVALUATION OF DISTRIBUTION DAMAGE

Know the distribution environment

Reproduce, in laboratory simulation, actual damage to package

Make adjustments as field data is gathered

TYPES OF FORCE CAUSING DAMAGE

Compression

Vertical Shock

Horizontal Shock

Vibration

TYPE OF DISTRIBUTION DAMAGE

Flexing

Pinholes

Abrasion

Seal Failure

Impact Damage

Compression Damage

Lecture 4 Wednesday 16 October 1985

Packaging Economics And Cost

I/- Basic Thesis

Emphasis is placed upon four key points. They are :

1. Performance is more important than cost.
2. That the market selling cost is completely independant and bears no relationship to the cost of manufacturing a product.
3. You must follow, market trends and constantly change your package to always maintain the most desirable package to attract consumers.
4. You must know exactly what factors your market requires and design the package attributes to suit these specific points exactly.

Market analysis involves selecting a particular segment of the population and manufacturing a product of which meets their desires.

Important marketing concepts are described.

Four basic consumer groups are described in terms of their food purchasing habbits.

Next we describe how to determine what characteristics a product needs to fulfill the consumers needs.

This is accomplished thru surveys, focus groups and government census data.

We recommend that packages be promoted and products be advertised based upon the one characteristic which differentiates it from its competitors.

Recommended changes to packages which benefit economics are listed.

Finally examples of significant world trends in packaging are mentioned since it is likely these will be felt in the North African market.

We have omitted using statistical tables showing numerical information from this lecture. If the user choses to add this information to demontrate how these general concepts apply to the local market the lecture will have stronger impact upon the audience. Statistical information is most useful in describing these economic concepts.

II/- The narration of the lecture moves from the written introduction to the overlays and concludes with written narration.

III/- All material for overhead display has been attached.
We strongly recommend the user obtain local survey information for use in presentation of this information to others.

George Wm Arndt, Jr.

Packaging Economics And Cost

Introduction

My first employer was a Scottsman.
We have a saying about Scottsmen in America. "They are the only people who take their money to Heaven when they die. Once they have it they never let go !"

My first employer gave me some good advice which I have never forgotten. He said :
"We are not in the food business to make food.
We are in the food business to make money !".
If he were here today he would say to you :
"We are not in the business to make packages.
We are in the business to make money !".

My first topic this morning will be a general overview of packaging economics. This will be presented without the usual tables of statistics. I will touch only on the major points.

1. The first and most important point is the relationship between package performance and package cost.
Performance is far more important than cost.
2. The second most important point was given to me by a Professor of Food Marketing.
"There is no relationship between manufacturing cost and selling price !".
- you say you must cover your costs.
- The consumer says : this is all I am willing to pay.
"Charge me less or I buy it elsewhere !"

3. The third important point :
"Look for an opportunity in the market an fulfill it !"
Survey to determine what the consumer is willing to purchase and produce only that item.
Determine what product attributes the custumer desires. Design the product to fulfill all of the custumers desires.

Caution : Do not exceed the customers'expectations.
This only increases your manufacturing costs.
The fourth point.

4. Know your market.
When the market changes this is a reflection of what attributes consumers will pay for to fulfill their needs.
Know how your product fulfills your customers'needs.

Begin Overlays OVERLAY 4-1

Market surveys have shown that people purchase food based on various socio-economic factors.
We recognize that packages make many products available that would otherwise not exist. Also that packaging can motivate a consumer to chose one brand in preference to another.

Our first task is to define the target market

Overlay 4 - 2 MARKET ANALYSIS

editorial

Performance vs. cost

Performance is the single most important measurement of your packaging's value. It directly affects your product's acceptance in the marketplace and should be the first barometer applied in gauging your packaging success.

In evaluating how your package performs, you should first review your packaging expectations: What chemical and physical barriers does your product require? Where is your product sold? What are your shelf life requirements? Who are your customers? Who is your competition? Does your package solve problems, respond to complaints or answer the needs of the distributors, brokers, wholesalers, retailers and agents who handle your package, as well as the needs of your ultimate customer?

Your list will vary. But, if your package is not performing up to your key expectations, you should examine the areas of failure and strive to correct them.

Once you're satisfied that your package is doing everything you've asked of it, your second consideration must be cost. *Cost should never be the primary consideration in evaluating a package. Performance should always be the first evaluation criterion.*

The cheapest package won't succeed if it doesn't work. On the other hand, you could be spending more than you have to for a functional package.

Striking the balance between function and cost is the key to cost-effective packaging performance. The performance/cost ratio of your packaging operation should be challenged on a continuing basis.

In examining the cost-effectiveness of your package performance, your goal might very well be the adoption of the least expensive package for the *jobs* you want it to do. Standing mute on the conference room table, your package might be open to cost cutting challenges. But, it's in the field that it faces its greatest challenges. If containment, product protection and identification are all you want, you can afford to question easy-opening options, promotional copy or sales-appealing graphics as frills. Whatever you want the package to do, each performance-enhancing expenditure should be justified. If it can't be justified, don't spend it!

You also need to consider your production facilities to determine if you're getting maximum utility out of your hardware. Idle machine time on one line can often be put to use on another line, provided production schedules and line layouts were engineered with such flexibility in mind.

The proximity of material and container suppliers has a direct bearing on cost, too, though a savings here can sometimes be more than offset in such less obvious ways as increased downtime, breakage and shipping charges.

Long before your customer ever sees your package, it must pass numerous performance tests — on your packaging line and throughout the distribution process. Failures anywhere along the line can condemn your package to a dark and dusty shelf position . . . or none at all.

In evaluating your packaging, therefore, it's good to remember that putting cost before performance is the fastest route to failure. Ignoring cost is a little slower . . . but it brings you to the same end.

—Ben Mynes

PACKAGING ECONOMICS

PACKAGE PERFORMANCE VS. PACKAGE COST

Performance is the single most important measurement of ~~your~~ your package's value. It directly affects your products acceptance in the marketplace and should be the first barometer applied in gauging your packaging success.

Packaging Expectations

COST - your second consideration.

Strike a balance between function and cost.

"In evaluating your packaging, therefore, it's good to remember that putting cost before performance is the fastest route to failure. Ignoring cost is a little slower... but it brings you to the same end."

Benjamin Miyares
Editor: Food and Drug Packaging.

4 IMPORTANT POINTS

1. PERFORMANCE vs. COST.

2. Production cost vs. selling cost.

3. Follow the market trends.

4. Know how your product fits the current market.

DEMOGRAPHICS

Population and age structure
Household composition
Fertility rates
Urban, suburban migration
Educational attainment
Working women
Singles
Households with two incomes
Changes in ethnic populations in your market area.

CONSUMER PSYCHOLOGY

Value of time
Demand for convenience
Family eating patterns
Attitudes towards brands
Attitudes toward variety
Demand for fresh or processed products

MARKET ANALYSIS

Market definition

What are the consumer's desires.
What attributes does my product have that fulfills the consumer's desires.
How well does my product compare with similar products available to the consumer.
What can I do to my product or package to:

1. Influence his impulse decision to purchase my product.
2. Fulfill the consumer's desires better than my competitor.

The Market Is Segmented

Based on:
- Demographics
- Psychology of ethnic groups
- Economic classes
- Social issues
- Ages of buying groups
- Lifestyles

TARGET YOUR MARKET

Economic Patterns

Income levels
Disposable Income
Inflation
Price/Quality relationship

Social Issues

HEALTH
Nutrition
safety
Changing roles of men and women
Stress and pressure

The Four Consumer Groups

Belongers
Achievers
Inner-directed
Need driven

NEED DRIVEN
CONSUMER LIFESTYLE SEGMENT

Need driven consumers have few economic resources and hence are driven more by need than by their own choices.

DEMOGRAPHICS

Income: extremely low and poverty level
Minorities
Unemployment is high, especially among the young.
Education: under 9 years (U.S.A.)
High proportion of women
many widows
many families headed by single women
Age: tend to be 50 years and older in the general population
- tend to be 30 years and older in the minority populations.

VALUES / LIFESTYLE

Dominated by sense of alienation.
Worry and mistrust for people with economic power and the government.
Strongly traditional (especially true of persons over age 50).
Live mostly in urban centers and isolated rural areas.

FOOD PURCHASING BEHAVIOR OF NEED-DRIVEN CONSUMERS

Private label (store brands) are preferred to national brands.
Lowest price is the most important factor in the decision to purchase.
Coupons are important.
Low income does not permit bulk buying.
Very little food is stored in the home.
Unable to take advantage of sales.
Many pay with funds provided by government welfare agencies.
Traditional ethnic food products and cooking styles with alot of spices are popular.
Popular products:
inexpensive meats and poultry
foods with more bulk value and lower nutritional value. Examples: bread, potatoes, spaghetti, noodles, rice, powdered milk, discounted vegetables and meat.
Shopping is done mainly at local stores.
Younger need-driven consumers are attracted to fast-food restaurants.

BELONGERS
CONSUMER LIFESTYLE SEGMENT

The central need is to blend into the group. It is important not to stand out. To belong and be accepted is a basic need. This group resists social changes.

DEMOGRAPHICS

Income: middle to low income levels.
Education is modest.
Age is typically over 50.
Almost 2/3 of this segment are women.
35% keep homes (do not work a job).
17% are retired and living at home.

VALUES / LIFESTYLE

Highly traditional
Very conservative
Most live in rural areas, some in small towns and villages.

It is unusual to find this group in suburban areas.

FOOD PURCHASING BEHAVIOR OF BELONGERS

Avoid experimentation with new foods and cooking methods.
Prefer "trustworthy" brands.
"The brand my mother used to buy."
Tend to be the consumers who maintain the mass market.
Family group meals are important.
Holiday cooking is very important.
Bland foods and condiments are preferred.
15% of food is eaten away from the home.
Shopping at neighborhood stores is most common. Prefer conventional shopping.
Seldom shops at far away stores.
During a recession this consumer is strongly motivated to purchase the lowest priced items only.
Stores which advertise low prices and offer coupons will attract this group.

INNER DIRECTED CONSUMERS

DEMOGRAPHICS

Affluent, their parents were successful achievers.
Age 32 years to 45 years.
Well educated.
40% hold technical or professional jobs.
Income is high - but not as high as achiever group.

LIFESTYLE

Active in sports to maintain good health.
Experiments in new social and cultural experiences. Like to travel.
Willing to try new activities simply because they have never done them before.
Socially concerned. Some have chosen lives of voluntary simplicity.
Some are interested in bringing gradual changes thru political activity.

Food Purchasing Behavior of Inner Directed Consumers

Interested in foods which are exotic, different and aesthetic.
Spend freely for the foods they want.
Spend great amounts of time in preparation of foods.
Freshness, appearance and flavor are important.
Are aware of health and nutrition.
Eat in restruants for new eating experiences.
A meal in the home with wine and candles is very popular.
Shop in specialty stores often.
Willing to pay the price for high quality products.

ACHIEVERS

CONSUMER LIFESTYLE SEGMENT

Enterprising, hard-working and hold values focused on materialistic achievement.

DEMOGRAPHICS

Middle age very successful.
Upper and high income levels.
College educated many with degrees from foriegn universities.
Occupation: managerial, professional, technical, successful sales.

Group 1 age 30-60, wealthy
Group 2 age 20-30 challenge present leadership, agressive, upwardly mobile.
Group 3 Single women who are career oriented.

VALUES / LIFESTYLE

motivated for success
spends money on "the good things of life."
willing to work hard for the best rewards.
competitive and self confident.
strongly interested in obtaining the newest technology.
LIVE IN THE SUBURBS.

FOOD PURCHASING BEHAVIOR OF ACHIEVERS

Prefer gourmet foods, top quality.
Convenience is more important than price.
Own freezers, microwave ovens and home computers.
Responds to advertising for "introductory price" of new kitchen devices.
Shops in specialty stores, fancy supermarkets.
Uses: Imported foods
fresh fish & high quality meats
frozen vegetables
ice cream and frozen baked goods
Entertaining with foods is popular.
Likes to take classes in cooking techniques.
Eats the majority of meals away from home.
Prefers the best hotels and restaurants.

II/- How to determine what characterictics a product needs to fulfill the consumer's needs.

1. Survey
   A. Basic questions : what, why, where, when & how much will you pay ?
   B. Use ladie's magazines to contain questionars.
   C. Government census statistics on (1) locations, (2) income (3) home values (4) ownership of automobiles.
   D. Personal interviews in stores using students, housewives.
   E. Subscribe thru trade groups to undertake studies thru IMEC.

2. Focus groups
   A. For a modest fee request the services of persons who have been identified as belonging to the target consumer group.
   Ask questions like :
   "Why do you like or dislike a particular product or convenience feature?"
   For example : One consumer of laundry detergent does not like using the cap to measure the product because product gets into the treads when the cap is placed back into the bottle.

3. Examine your competition and ask yourself what they have and you do not.

Show photographs or examples of conpetitors products to consumers ask them to rank by preference.

Once ranked then determine the factors which form the basis for preference.

Rank the the factors in order of importance.

Evaluate your product to see what factors it may lack or have in comparison to your conpetition.

Promote your product based on the outstanding factor which makes it better than the rest.

III/- Package changes which benefit economics

A. Value improvement for consumers

Convenience - prepared product
easy opening - portion control
longer shelf life (change structure of flexible films)
fits hand better
safety - child resistant caps
tamper evident feature
cans which dispense
larger containers.
Planned obsolesence.
Thomas Edison invented the light bulb.
His origional ligh bulbs are still working in his home which is now a museum.
How many light bulbs could you sell if they never burned out?

B. <u>Package savings based on performance</u>

Examine your package failures in the distribution system. If damage is very minimal your package could be changed to reduce material. You should always expect to have some minor package damage.

Test package designs to evaluate alternatives for the one with the lowest cost which passes abuse tests.

Aluminum can with double neck .

Lifeweight can with additional beads.

C. Energy savings

Cogeneration of steam in industrial process.
Use gravity conveyors in plants wherever possible.
Recycling.

D. Raw materials

A recommendation:
"For every purchased component or raw material the manufactuer should strive to maintain the flexibility to more from one material to another."
For example:

1) A canning line can,with modifications,run steel, aluminum, welded or drawn cans, composit cans or plastic cans. Plastic cans may be injection molded, blow molded or thermoformed
- all may use double seamed metal ends
2) 25 differnet composit papers and retortable pouches may be run on most form / fill / seal machines.
3) At least 4 specifications of cardboard will run on most cartoning equipment.

E. Seek alternate distribution systems
Back haul of raw materials, ship bright cans, label at warehouse near the market area just prior to sale.
Back haul of other products to your market area.

F. Increase production speeds thru :
1) partial refinement of raw materials before you receive them.
2) design of containers which permit higher speed.

3) positive control of containers in motion using timing screws, 3 cable conveyors.
eliminate:deadplates
turn tables
turning stars
use accumulating machines ahead of the labeler.
institute a preventative maintenance schedule for all equipment.
Equipment failure during production is the most expensive problem a manufacturing plant can have. People are paid to wait while the machines get fixed.

G. Use shrink wrapped trays to replace corrugated shipping containers

H. Use slip sheets instead of pallets

IV/- Examples of important economic trends in packaging

Glass — plastic bottles
composit paper containers
aluminium cans

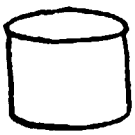
metalcans
elimination of the soldered side seam
high barrier retortable plastic cans

more frozen foods
wax cartons — plastic bag

alternate fiber sources for paper
sugar cane
bamboo
willow bushes
alfa

ask : What is the potential for the composit can in North Africa ?

plastic cap



Easy open top

Used for dry powders, high acid foods, and frozen concentrates.

Lecture 5 Wednesday 16 October 1985

Packaging Costs

I. Basic Thesis

The test follows closely a list of ELEMENTS OF PACKAGING COST. This list enables the user to include all possible costs in the estimate of package development, production and distribution We recognize that different cost accounting methods are preferred in different regions.
Consequently, this list is ment only to assist the user in avoiding the embarassing situation of overlooking one cost factor which is often the situation once the package has gone to market.

In grouping various cost factors into cost centers the user should conform to the requirements of the accounting system of the individual manufacturing facility, corporation, or government agency.

II. The narration follows the list very closely with some little variations. In presentation it is useful to provide each participant with a copy of the list. Then,as the list is displayed on the overlay,cover each main point in order.

III. The single overlay, as well as copies of the participants copies of ELEMENTS OF PACKAGING COSTS are attached.

George Wm Arndt, Jr.

Lecture 5 Wednesday Oct 16, 1985

PACKAGE COSTING

Each specific type of packaging has a begining, a time of use, and an end.

Each package must be continually examined by the packager to justify its life. If a package cannot provide the maximum of valve in relation to its cost if must be modified until if does.

Costs are incurred from the very conception of the packaging design until the final liquidation of the last inventories. Valve however, is received only during the active use period.

Please refer to the list Elements of Packaging Cost.

1. Development costs

There is almost no packages that escape development costs,

graphic design
setup
startup costs

Development costs are all expenses that lead up to and include the issuance of specifications for packaging materials.
Specifications are the back bone of the purchasing contract. Specifications will change continually throught the life of a successful package.

A. Identification of Package Criteria

Step i defines the requirements of the product.
This is a most important step.
Packaging requirements differ by the nature of the product.

Industrial products require only damage protection and goods identification on the package.

Consumer packages - appealing easy to open.
easy to dispose
must carry purchase incentives
Well known products have protective requirements built into the package.

New products - require laboratory testing to avoid a disastrous market introduction.

B. Concept Search

More than likely one kind of package will meet the criteria of the product with respect to damage and climatic resistance. Other factors become important
size, limiting cost, available packaging equipement, accepted market standards, important export standards

C. Design

Size, dictated by the package and the type of product contained,
The opening device is a matter of functional design.
Shape, similar to conpetitiors but distinguishable by consumer

Appearance, based upon target market.

Function, based upon attributes desired by the consumer.

Decoration, based upon target market.

Design costs - may be assigned to the staff design department, the supplier, or an industrial consultant.

D. Models

The model has the size and shape of the desired package but not necessarily its function. The designer uses the model for judgements on appearance. The model may be examined by consumer groups to judge its features.

E. Samples

Samples are test prototypes that function.
They are preferred over models in determining consumer reaction to the package design.

F. Sample Evaluation

Package samples are filled and sealed.
They are subjected to rough handling tests, climatic storage, and tested by consumer pannels.

The evaluation by consumer pannels include overall acceptance, ease of opening, understanding of instructions.

G. Costing and Specifications

The first place to start with costing is thru supplier bids. This requires accurate specifications. The specifications must be based upon performance attributes which ensure functional packages. The acceptance range specified should be broad enough to permit at least two potential suppliers to quality.
You should never have less than two suppliers for a package.
To quote a supplier requires specifications, expected volumes, and delivery schedule.

H. Test Market

Between sample testing and full scale production the manufacturer will desire to complete a test market survey. While expensive, consumer evaluations in the test pannel will reveal necessary changes.
However, unless a test market is undertaken the manufacturer is unable to determine the appropriate advertising or promotional program for market introduction.

The test market should be carefully targeted at your market group. It will be performed in an area removed from the major market in case the product or package is a failure.

Information provided by the test market

conditons of the market at the point of sale follow-up
interviews with selected buyers(volume turnover rates)
repeat sales potential
warehousing problems
shipping failures

J. Specification Refinement

Virtually all packages will require refinement following the test market.If the package appears to have no problems in the distribution system it is probably more expensive and heavier than necessary.

After specifications have been refined,they should be rebid and the estimated packaging and distribution costs recalculated.

K. Tooling for production

Lead limes are required to :

a) make bottle molds
b) printing plates
c) special q.c. equipment
d) if the container requires change parts to modify production equipment, these costs should be included here.

L. Quality control

Before production begins a sampling and inspection plan must be set up.

Critical dimensions and tolerances defect list
Sampling frequency
lot size
calibration of measuring equipment

M. Startup

Development costing should end on the day of startup. If the development job has been done well the only excess cost here will be to train packing line personnel.

2. One-Time Costs

These are defined as expenditures which do not have to be repeated during the active life of a packaging specification. Development costs are one-time costs as are production tooling and machinery installation.
This cost does not include replacement costs for parts on machinery that wear out during production.

3. Packaging Material Costs

There are six important areas of concern :

A. Basic Unit Price

is the cost per 1000 purchased containers.
Different containers are quoted by suppliers in different ways. The buyer must describe these terms carefully.

For example : galss jars are quoted at a price which includes the shipping container.
Plastic bottles are quoted without shipping containers.
Cans are sold with lids included in the price.
Plastic bottle caps are priced separtely.
Multilaminate rollslock is sold by the basis weight or gammage.

B. Special Packaging

Accepted trade practices have developed over the years. In instances where the packages requires unique packaging for inbound materials some additional costs must be expected.
For example
rollstock of normal rollzize or jumbo rolls.
Wrapping individual rolls may cost more.

C. Inbound freight

Trucks cost almost the same to rent whether they run emply or full. Empty bottles or cans are very expensive to transport. If cans can be nested and efficiency can be achieved the transportation cost reduces drammitically.

D. Packaging materials storage & handling

Usually handled in 3 ways.
1) The supplier stores against the packers' release for delivery
2) The packer buys outside storage
3) The packer stores in his own storehouse

Costs involve
money tied up in packaging material interest on the bankloan
cost of storage space
cost of labor to handle the materials.

Some suppliers take advantage of market conditions and store packaging material free as an incentive to get orders on charge a rate to encourage more rapid delivery.

E. Shrinkage on Packaging Material

You never ship all of the material you receive. Loss occurs from

1. Inspection
2. Startup testing (seales)
3. Jams, adjustment testing
4. Fall on floor
5. Testing during production
6. Retain samples

F. Sampling and inspection costs

A well organized quality control plan will have no duplication by the supplier and the packer.

Ideally the supplier will perform all tests and guarantee his product. The packer then has to check only for damage incurred in transportation.

In reality most packers audit incoming quality control if problems are found prior to use the supplier will replace or discount the packaging materials.

If the material is accepted and the containers fail it becomes the packers problem. When this occus it is wise to review the specification before starting a dispute with the supplier.

4) Packaging machinery costs other than one time :

machinery rental lease costs
maintenance and servicing
replacement parts and lubricants
air freight for needed repairparts
power and utilities
amortize as cost / unit package

5) Packaging Process Costs : Definition of cost centers changes from one country to another

Direct labor consist of
production employees and supervisors indirect labor
maintenance mechanics
quality control inspectors
Plant overhead
office help
building maintenance
taxes, power, heat
Incidental materials
glue, steam, gas

The way in which these cost figures may be analized, will be discussed under valve Analysis Optimization.

6) Distribution Costs

All expences concerned with physically moving finished packed goods from the packaging plant to the customer are distribution costs. They include :

storage and warehousing
special handing - for instance hand stacking a truck load without the use of pallets or less than load quantities.
Frozen shipments
special ware houses - customs
Decontamination - spices, fruits

7) Terminal inventories

All changes create an inventory of out dated materials. A new label may make an old label or carton absolute.

Changes should be handles so as to provide a smooth change own from the old carton to the new.
Ideally none will be discarded.

The problem occurs also at the market level. The consumer will purchase the new label and ignore the old. Some product may have to be collected from the store shelves. If the marketing department has initiated the change then the cost should be applied to the savings provided by the new label.

Conclusion

We have listed briefly all of the cost elements which are common to most packaging operations. It is helpful to keep alert for unexpected costs and we hope this list will assist you in your responsibilities regarding management of packaging operations and manufacture.

ELEMENTS OF PACKAGING COST

1. Development Costs
   A. Identification of Package Criteria
   B. Concept Search
   C. Design
   D. Models
   E. Sample Tooling and Samples
   F. Sample Evaluation - Technical and Customer Research
   G. Costing and Specifications
   H. Tooling and Materials for Test Market
   I. Test Market Pack and Evaluation
   J. Specification Refinement and Purchasing
   K. Tooling for Production
   L. Quality Control Program Implementation
   M. Startup

2. One-time Costs
   A. All of the above, principally *Tooling for Production*, which Includes
   B. Supplier Molds or Dies; Printing Plates, Dies, or Cylinders
   C. Packing-line Equipment or Change Parts
   D. Installation

3. Material Costs
   A. Basic Package Unit Price
   B. Special Packing for Inbound Shipment
   C. Inbound Freight
   D. Packaging Materials Storage and Handling
   E. Shrinkage of Packaging Materials from Damage, Loss Cost of Overages
   F. Sampling and Inspection Costs

4. Packing Machinery Costs, and other than One-Time
   A. Rentals or Leases
   B. Service and Maintenance
   C. Amortization per Unit Package
   D. Power and Utilities

5. Packing Process Costs
   A. Direct Labor
   B. Indirect Labor
   C. Overhead
   D. Incidental Materials

6. Distribution Costs
   A. Storage and Warehousing, including Special Handling and Materials
   B. Outbound Freight

7. Writeoff of Terminal Inventories

Lecture 6 Wednesday 16 October 1985

Value Analysis Optimization

I. Note : This lecture was prepared and not presented.
The method describes the technique for determination of standard production costs. The manager may perform these simple calculations using only a hand calculator. If the calculator has an automatic programming function, it will reduce calculation time in summaring figures to produce the graphs.
This system is simple. It tells the manager when each of his supervisors have performed in a manner which creates daily production costs which are above (+) or below (-) the standard costs.
Thru collection of statistical cost information for raw material which are poor, averrage or superior the method enables the manager to ignore the quality of raw material on the manufacturing process. The method is designed to identify those factors which make and lose money.

Given the economic facts in (+) and (-) terms the manager requires that the labor supervisor identify the reason for variance from the standard cost. The manager first focuses his efforts on reducing those causes of increased production cost. Next he focuses his efforts on methods to increase factors which reduce cost.

This method has proven useful in value analysis at two food plants. It leads to the development of worker and supervisor incentive systems. In both applications manufacturing labor costs were reduced.

II. No overlays have been prepared

III. The narration is attached.

George Wm Arndt, Jr.

IV. Collect cost information at each cost center for production.

A cost center is / production step
It is valuable to have / supervisor, responsible for each cost center although not essential.

A. Statistical treatment

Raw material quality	High A	normal B	low C
Process 1			
2			
3			
4			
Total			
average			
max			
min			
std.dv.			

B. Make the following graph for each cost center

C. You have now determined your standard cost for each step in the manufacturing process.
The first analysis / performed took 30 days if involved fish processing and packaging using 2 mechanical and 3 manual processing lines. The production area included 275 workers, 12 foremen, 1 supervisor + myself.

D. Each day of production information is added and the standard recalculated.

E. You now may compare the actual cost of each production step with the standard. The production cost is independent of the quality of the raw material.

F. To select the correct standard it will be necessary for an experienced quality control operator to determine if the raw material is quality A, B or C.

V. Value analysis now begins

A. We are intersted in variable costs.

Production labor

I have excluded supervision cost because all US and Canadian supervisors are customaraly paid at a fixed salary.

B. We now mav determine if the supervisor for the cost center of interest was abone or below the production standard.

If his cost is lower he is rewarded. If his cost is higher he is not rewarded. In either case the important information is provided by the supervisor. He must tell you what he thinks the reason must be for not being on the average.

List.

Reasons for Production below Standard cost	Reasons for Production abone Standard cost

The first changes you as the manager must make are to find techniques for eliminating high costs. You now know the reasons. They are :

1) Mechanical
   a. Maintenance
   b. Design
2) People
   a. Tired
   b. No intersted in working hard
   c. Concern for safety.

The first problem is solved with money. It is easy to get the money because the exportation involves increased profit. This is a good investment.

People are the problem that is hard to solve. Options

Psychological incentive

a) Share the savings brought by the new efficiency with the workers "Incentive system".
b) Share the savings with the supervisor as a "bonus system".
c) Psychological repression

Watch the worker carefully and make sure he does everything right.

Short term success long term failure.

Addage : "You can lead a horse to water but you cannot make him drink".

Conclusion

This simple system has been employed successfully in the implementation of incentive systems in North America.

It can be done using a hand calculator in 2 hours of calculations. Using a small home computer it is possible to compute standards and variance on 300 workers in a few seconds.

For those who wish to perform the calculation the function of the line on the graph is

$y = be^{-mx}$.

e = the natural log rythm
However, the method works equally well with $\log_{10}$.

$\frac{\text{cost}}{\text{Unit}} = y$

X =
number of units

APPENDIX II

METHOD OF CURVILINEAR REGRESSION FOR DERIVATION OF STANDARD COSTS AND VARIANCE IN A MANUFACTURING OPERATION

George Arndt

jb 1766

INTRODUCTION

This method of cost control has been designed to provide managers of manufacturing operations information on how to identify areas which contribute the most cost in the production process. By identifying these areas the manager may elect to make changes and determine the effect upon production cost. The method may be employed in large and small operations having manual or automatic production with variable qualities of raw material. The method first identifies a standard cost per unit then may be used to differentiate between observed and predicted values or between two group of observations. It may be used with tables for interpretation by managers without a math background, with a hand calculator, or using a personal computer.

Method Of Curvilinear Regression For Derivation Of Standard Costs And Variance In A Manufacturing Operation

Formula $y=be^{(m*x)}$

Slope $$m = \frac{\frac{(\Sigma x * \Sigma \ln y)}{n} - \Sigma(x \ln y)}{\frac{(\Sigma x)^2}{n} - \Sigma(x^2)}$$

Y-Intercept $$b = \frac{\left(\frac{\Sigma y}{n}\right)}{e^{\left(m * \left(\frac{\Sigma x}{n}\right)\right)}}$$

(x,y) paired data required
- x = units of production
- y = corresponding value for each unit of production
- n = the number of data points (x,y pairs)

Data Input Table

	x	(x^2)	y	(lny)	(xlny)
	0	≀	≀	≀	≀
	1	≀	≀	≀	≀
	2	≀	≀	≀	≀
	3	≀	≀	≀	≀
	4	≀	≀	≀	≀
	≀	≀	≀	≀	≀
	n	(x^2)	y	(lny)	(xlny)
Sums	Σx	$\Sigma(x^2)$	Σy	$\Sigma(\ln y)$	$\Sigma(x \ln y)$

Compute m and b values

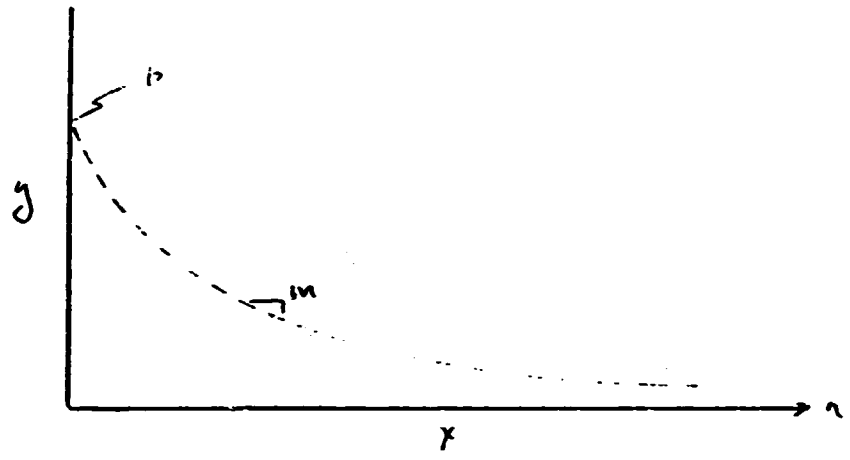
m = $(((\Sigma x * \Sigma \ln y)/n) - \Sigma(x \ln y))/(((\Sigma x)^2/n) - \Sigma(x^2)))$
b = $(\Sigma y/n)/(e \ @ \exp\ (m * (\Sigma x/n))))$
e = 2.7182818

Given concurrent list of x values, generate a list of corresponding y values.

y = (b * (e @ exp (m * x)))

x	y
≀	≀
≀	≀
≀	≀
n	≀

Plot on graph



Determination of variance.

Variance is the + or - difference between the standard cost (calculated) and the observed value from the data point.

observed y — standard or estimated value y'

The important point is that x observed and x' standard (calculated) are the same value.

Variance

x	y	y'	difference
1			+
2			-
3			-
4			+
5			-
			-
			-
n			
Σx	Σy	$\Sigma y'$	$\Sigma \pm$

Sum (± will be + or -)

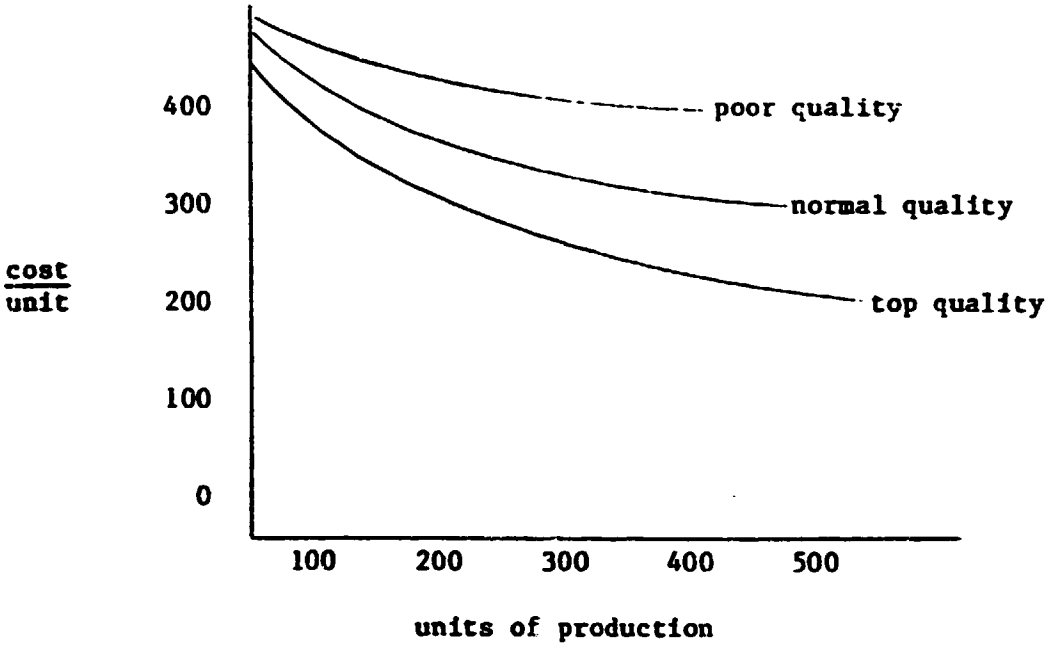
The total + or - sum will enable the user to determine if the cost of each unit is above or below the standard cost.

Collection of production cost information is required to analyze increase or decrease in production efficiency. Costs must be summarized by separate factors. These cost factors may be one of the following:

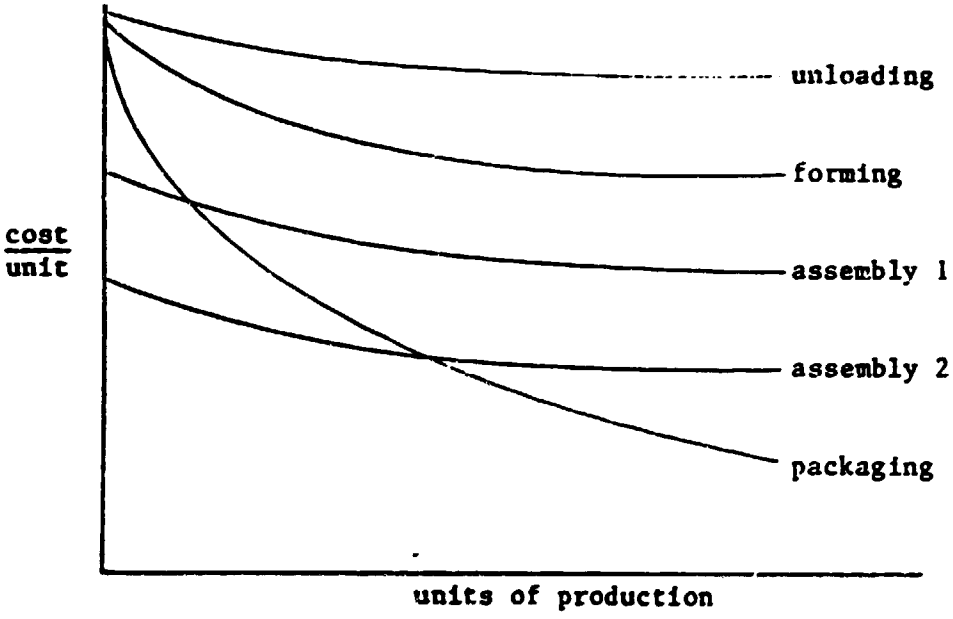
1. Different grades of raw materials.
2. Separate steps in the manufacturing proces.
3. Cost per worker/day.
4. Cost per unit of production.

Examples of the above are illustrated as follows:

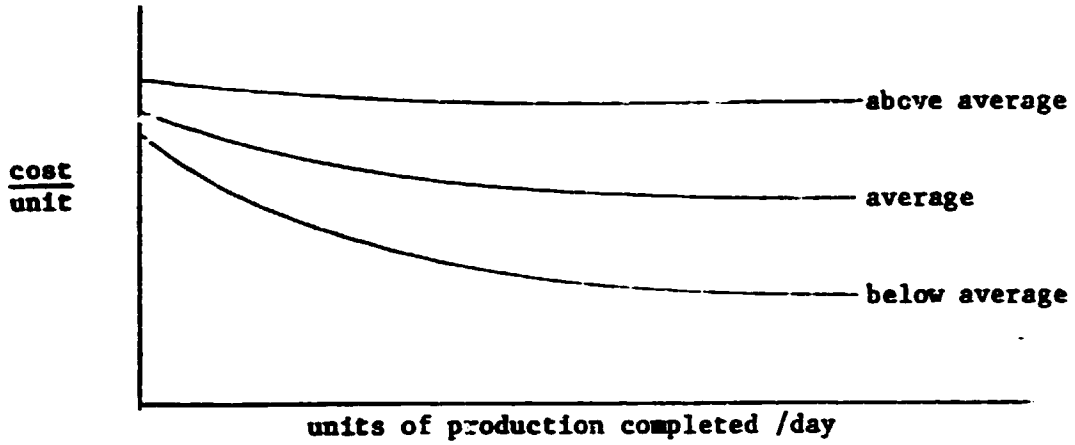
1. Different grades of raw materials.



2. Separate steps in the manufacturing process.

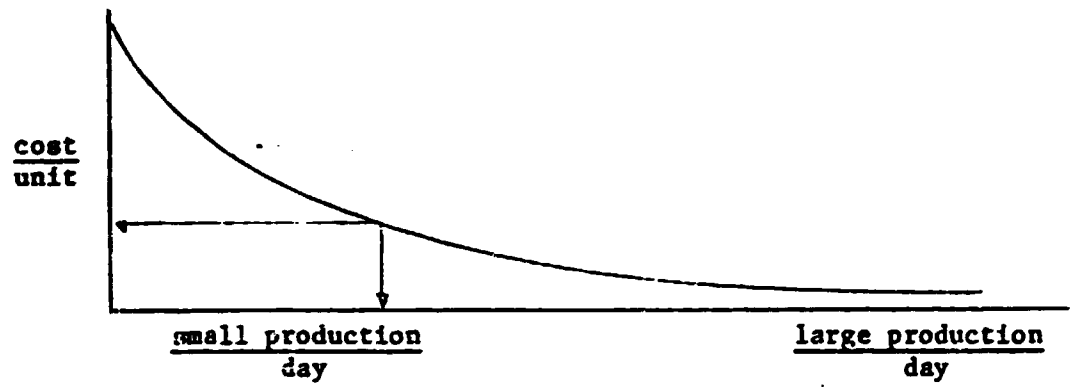


3. Cost per worker per day.



Graphical interpretation shows worker x performed slightly below average this day. This could be estimated $y=be^{(m * x)}$ by inserting the units of x produced this day. Variance could be seen as y observed from daily hours worked = value subtracted from y' - the estimated value which that worker would normally be expected to perform in that many hours worked.

4. Cost Per Unit of Production



Notice that to manufacture an item at any desired cost we may calculate the hours of production or size of the workforce necessary using the following formula.

$$x' = \frac{\ln y}{\ln b(m * e)}$$

$$x' = (\ln y \ / \ (\ln b * m * e))$$

The method also enables the user to estaimte values of x' for determination of variance on x observed. Thus we may estimate the number of manhours needed tc complete a step in a manufacturing process or the cost of any step in a manufacturing process.

Example Calculation Using Hand Calculator

x	y	(lny)	(xlny)	(x^2)
0	Na	Na	Na	Na
1	2.66	.978	.978	1
2	1.50	.405	.810	4
3	1.25	.223	.699	9
4	1.00	0	0	16
5	Na	Na	Na	Na
n=4				
Sums, Σ = 10	6.66	1.606	2.48	30

Na means "not available" data for this point.
Na is not counted in sums or for determining "n".
e = 2.7182818

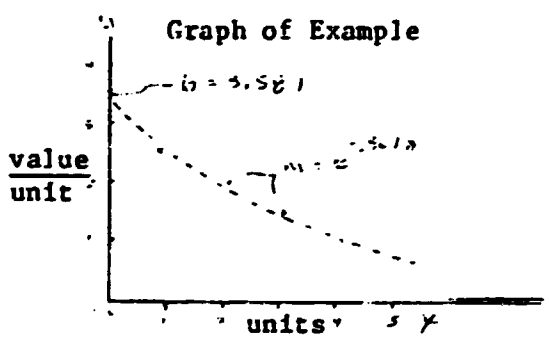
$$m = \frac{\frac{\Sigma x * \Sigma \ln y}{n} - (x \ln y)}{\frac{(\Sigma x)^2}{n} - \Sigma(x^2)} = \frac{\frac{10 * 1.606}{4} - 2.48}{\frac{(10)^2}{4} - 30} = \frac{4.015 - 2.48}{25 - 30} = -.307$$

$$b = \frac{\frac{\Sigma y}{n}}{e^{m\left(\frac{\Sigma x}{n}\right)}} = \frac{\frac{6.66}{4}}{2.718^{-.307\left(\frac{10}{4}\right)}} = \frac{1.665}{.464} = 3.587$$

given x, calculate $y = be^{mx} = 3.587 * 2.718^{-.307x}$

x	y'	y	variance
0	3.587	Na	Na
1	2.638	2.66	+.022
2	1.941	1.50	-.441
3	1.428	1.25	-.178
4	1.05	1.00	+.05
5	0.773	Na	Na
			Σ = -.591

Graph of Example



Conclusion

This simple method enables the user to perform estimates of standard costs and variance on limited data in a manufacturing operation.

Computer Applications

Given thousands of units produced using different crews and various qualities of raw materials develop standard costs and estimate variance to determine the performance of individual workers.

Steps To Summarize Data

1. Separate into groups by finished product.
2. Separate cost groups for each finished product into 3 or more qualities of raw materials.
3. Separate into 3 shifts or group all personnel together.
4. All data must be in the following form
   (x,y) paired observations
   x = number of units produced
   y = value for each unit produced
   x and y are corresponding values

Data Collection

All data must be coded at the time of observation. The coding of (x,y) observations is broken down into cells.

Determination of the number of coding cells.

		Example
a.	number of end products	7
b.	number of steps in the manufacturing process	9
c.	number of grades of raw material	3
d.	number of production shifts	3

number of cells = a * b * c * d
7 * 9 * 3 * 3 = 567 cells

Table For Collecting Data

x value units	y value value/unit	cell designation 1 thru 567

Computer will summarize 567 sets of data to determine standard costs and cost variance on each set. If desired, the computer will flash results of any cell which exceed + and - limits on variance. This will alert management to problems (+ cost/unit > standard) and identify potential efficiencies (- cost < standard).

Compute the following for each cost cell.

$m = (((\Sigma x * \Sigma \ln y)/n) - \Sigma(x \ln y))/(((\Sigma x)^2/n) - \Sigma(x^2)))$
$b = ((\Sigma y/n) / (e@exp(m * (\Sigma x/n))))$
$y' = b * (e@exp(m * x))$
$\Sigma(y'-y)$ = variance
if $(y'-y) >$ given value max, then ALERT
if $(y'-y) <$ given value min, then ALERT

By using this method, management may identify those areas which create added cost to the manufacturing operation and reduce these costs as the first step in optimization of production efficiency. Secondly, efficiencies may be identified by alerting management to their occurrence. An inspection of manufacturing conditions at this time will enable management to strive to reproduce these conditions. Third, knowing the production cost associated with standard or normal conditions management may wish to experiment by changing conditions to determine the effect upon production cost. This method makes rapid summary of data possible so that cause and effect may be studied within a short time. This provides concrete information to production control which enables them to adjust the manufacturing process to changing conditions during manufacturing while maintaining minimum production costs and optimum efficiency.