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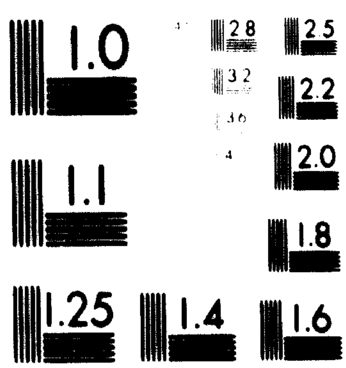

MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS

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PLASTIC FILMS FOR PACKAGING OF FOODS[a]

B. S. LUH[b]

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UNITED NATION INDUSTRIAL DEVELOPMENT ORGANIZATION (UNIDO)

PACKAGING PROJECT FOR PANAMA

PAN-154-A

C/O UNITED NATIONS DEVELOPMENT PROGRAM

APARTADO 6314
PANAMA 5, PANAMA

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[a] PRESENTED TO: CENTRO DE DESARROLLO Y PRODUCTIVIDAD INDUSTRIAL,
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APARTADO 7639, PANAMA 5, PANAMA

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PLASTIC FILMS FOR PACKAGING

OF FOODS

I. INTRODUCTION

II. TYPES OF PACKAGING MATERIALS

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I. INTRODUCTION

Packaging is the use of containers and containers plus decoration or labeling to protect, contain, identify, merchandise and facilitate use of products. All processed foods require packaging in some phase of production or distribution. It requires specialized skills, machinery and facilities to accomplish one or more of the following basic demands:

1. Protection of foods from environmental changes and deterioration.
2. Ease of dispensing, reclosure and storage.
3. Motivating customers to buy again.
4. Assure continuing sales at a satisfactory level of profit.

Professional handling of package development, procurement and production can contribute to lower unit costs, marketing strategy, and new markets.

The food packaging field is advancing into a complex and far more demanding role. There is good reason to believe that packaging will maintain its favorable rate of growth. The cost and yield of films for packaging of foods are presented in table 1.

II. TYPES OF PACKAGING MATERIALS

A. Paper

Paper is the most widely used packaging material. Over $6 billion worth of paper packaging products are used annually in the U.S. Advantages of paper containers are versatility, strength, printability, and low cost.

- a. Kraft-ordinary brown paper made with soda pulp.
- b. Pouch paper-bleached, highly refined, plasticized, supercalendered kraft paper.
- c. Greaseproof-pulp is made resistant to grease.
- d. Glassine-greaseproof paper that is supercalendered.
- e. Vegetable parchment-water leaf paper that has been soaked in a sulphuric acid bath. This is used for ice packed and wet products.
- f. Waxed paper- a wax fibre formation to make it porous and absorbant.
- g. Tissue paper-open fibre formation to make it porous and absorbent.

TABLE 1. COST AND YIELD OF FILMS FOR PACKAGING OF FOODS (HANLON,1971)

FILM	COST PER lb.($)	YIELD Sq.IN PER lb. 1 MIL	COST 1000 Sq.IN., 1 MIL	DENSITY gm/c.c.
ALUMINUM FOIL	0.64	10,250	0.055	2.70
CELLOPHANE	0.64	19,500	0.033	1.50
CELLULOSE ACETATE	0.96	22,000	0.050	1.40
NYLON	2.15	24,000	0.090	1.14
PAPER	0.23	17,000	0.015	0.45
POLYCARBONATE	2.07	23,100	0.090	1.20
POLYESTER	1.80	20,000	0.112	1.38
POLYETHYLENE (LOW DENSITY)	0.26	30,100	0.016	0.92
POLYETHYLENE (HIGH DENSITY)	0.36	29,200	0.021	0.96
POLYPROPYLENE	0.68	31.000	0.023	0.90
POLYVINYL CHLORIDE	0.55	20,750	0.034	1.28
RUBBER HYDRO CHLORIDE	0.95	25,000	0.033	1.10
SARAN	1.08	16,300	0.066	1.70
STYRENE	0.67	28,800	0.024	1.05

h. Paperboard-paper with a thickness of over 0.016 inches.

i. Cellophane-Paper pulp is dissolved in alkali solution and made viscose then extruded in sulphuric acid. Basic monomer is cellobiose.

B. Metal cans

The average per capita use of metal cans in the United States is 252 per year or about 850 per family, 75 percent of which are for food. Each day over 131 million cans are used for a total of approximately 52 billions per year in the U.S. The beer industry alone uses over 4 billion per year.

Coatings on the internal surface of the can are sometimes used in order to:

a. Provide corrosion resistance.

b. Protect the product from the container and the container from the product.

c. Protect and maintain flavor.

d. Facilitate fabrication.

e. Permit the use of more economical tin plate.

f. Improve appearance.

Natural and synthetic resins are used for coatings.

Aerosols

Over 2 billion pressurized containers (aerosols) are currently being used in the U.S. each year.

Aerosol types:

a. Single phase-consists of a propellant vapor and liquid product.

b. Two phase-consists of propellant vapor liquid propellant and liquid product. This is the conventional type.

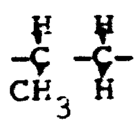
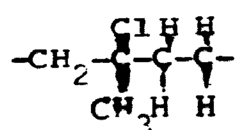
c. Three phase-liquid propellant occupies the bottom of the container with the product floating above the liquid propellant and a propellant vapor is at the top.

The principal propellants used for foods are nitrous oxide, carbon dioxide, and nitrogen. Fluorinated hydrocarbons are used for non food aerosols.

C. Plastics

Plastic films, bottles and foamed containers are rapidly increasing in their food product usage. Polyethylene is

TABLE 2. CHEMICAL STRUCTURES OF SOME SYNTHETIC POLYMERS

FILM	REPEAT UNIT		DESCRIPTION SYNONYM OR TRADE NAME
CELLOPHANE	$-(C_6H_{10}O_5)_2-$	GLUCOSE UNITS IN 1,4 BETA LINKAGE	(REGENERATED CELLULOSE)
CELLULOSE ACETATE	ROUGHLY 2.4 HYDROXYL GROUPS PER ANHYDROGLUCOSE UNIT ESTERIFIED		ACELE CELACRIMP ESTRON
NYLON OR POLYAMIDE	$-NH(CH_2)_5CO-$		POLYCAPROLACTAM NYLON 6; PERLON 1
	$-NH(CH_2)_{10}CO-$		POLYUNDERCANOLACTAM; NYLON 11; RILSAN
	$-NH(CH_2)_6$ NHCO $(CH_2)_4CO-$		POLYHEXAMETHYLENE ADIPAMIDE; NYLON 6.6
POLYESTER	$-OC-p-C_6H_4\cdot$ COO $(CH_2)_2O-$		POLYETHYLENE TEREPHTHALATE; TERYLENE; DACRON; LAVSAN
POLYETHYLENE	$-CH_2-CH_2-$		P.E.
POLYPROPYLENE			P.P.
POLYVINYLCHLORIDE	$-CH_2-CH$ $-CH(Cl)-$	HOMOPOLYMER AND COPOLYMERS	RHOVYL
RUBBER HYDROCHLORIDE			(POLYISOPRENE) NATURAL RUBBER

(Cont...)

TABLE 2 - Continued

FILM	REPEAT UNIT	DESCRIPTION SYNONYM OR TRADE NAME
SARAN	$-CH_2\ C\ Cl_2-$	SARAN WRAP (DOW CHEMICAL CO.); DARAN (DEWEY & ALMY);
STYRENE	$-CH_2\underset{C_6H_5}{\overset{H}{C}}-$	BIAX (CRANE PACKING CO.); BI-POLY-S (ATLANTIC REFINING CO.); DIETECT A-9 (DIELECT INC.); KARDEL (UNION CARBIDE CORP.); POLYFLEX 100 (MONSANTO CHEMICAL CO.); STYROFLEX (NATVAR CORP.); STYROLUX (WESTLAKE PLASTIC CO.); TRYCITE (DOW CHEMICAL CO.).

the leading polymer due to its versatility and low cost. "Structured" films are highlighting the packaging industry by building into the film the necessary protection, strength, permeability and machineability characteristics demanded by a product or a market. Laminations with other films, paper, and foils are commonplace. Advantages of plastic containers are strength, less breakability, transparency (not with all films), versatility in physical and chemical characteristics, economical and consumer convenience. The chemical structures of some synthetic polymers used in food packaging are shown in Table 2.

Plastic film types:

a. Polyethylene-high strength, sealable, low moisture transmission,medium gas transmission. Used as a general purpose film and for making bottles. It can be pigmented. It is very low in cost.

b. Cellulose acetate-used in packaging fruit and produce and as a window in folding boxes.

c. Fluorohalocarbon-Very expensive. Excellent chemical and thermal stability. Used by NASA for space foods.

d. Nylon- This moderately expensive films can withstand extreme cold and moderately hot conditions. It is extremely strong. It can be used for retort foods or cook in the pouch foods.

e. Pliofilm- This is a clear film made of rubber hydrochloride. This is used as a meat overwrap.

f. Polyester- This film is extremely strong and stable to heat and cold. It may be used for cook in the pouch packages.

g. Polypropylene- This is a clear, inexpensive film frequently used as a bread wrapper.

h. Polyvinylidene chloride-(Saran): Used for frozen foods.

i. Polystyrene- An inexpensive clear plastic used for fresh meats and produce. It is also used to make plastic foam packages.

j. Polyvinyl chloride (PVC)- Used to make clear plastic trays.

k. Polycarbonate-Used to package medical supplies.

l. Water soluble films-polyvinyl alcohol, methyl cellulose, polyethylene oxide.

m. Polyurethane-Used to make foam packages.

TABLE 3. CHARACTERISTICS OF PLASTIC FILMS FOR PACKAGING OF FOODS (HANLON, 1971)

TYPE OF FILM	WATER VAPOR TRANSMISSION [a]	GAS PERMEABILITY [b] O_2	N_2	CO_2	IN-USE TEMP. RANGE, ºF	HEAT SEAL TEMP. ºF	ELONGATION %
CELLOPHANE, (NITRO-CELLULOSE COATED)	0.3	1	1	13	24-300	225	20
CELLOPHANE (POLYMER COATED)	0.5	0.5	0.5	0.5	24-300	250	20
CELLULOSE ACETATE (10% PLASTICIZER)	150	35	40	1000	-15-140	350	40
NYLON	19	25	160	160	-100-200	---	100
POLYCARBONATE	11	300	50	1000	-150-200	410	75
POLYESTER (ORIENTED)	1.7	4	1	16	-80-230	275	100
POLYETHYLENE (LOW DENSITY)	1.3	550	180	2,900	-70-180	250	400
POLYETHYLENE (HIGH DENSITY)	0.3	600	70	4,500	-20-250	275	100
POLYPROPYLENE	0.7	240	60	800	0-275	350	300
POLYVINYL CHLORIDE, RIGID	4	150	65	970	-50-200	225	20
RUBBER HYDRO CHLORIDE	10	130	20	520	to 200	250	—
SARAN	0.2	14	12	4	0-200	280	60
STYRENE, ORIENTED	4	310	50	1,050	-80-175	250	10

[a] gm loss/24hr/100 sq. in./mil at 95ºF, 90% relative humidity

[b] cc/24hr/100sq.in./mil at 77ºF, 50% relative humidity; ASTM D 1434-63

D. Shipping containers

Wooden boxes, corrugated board boxes, fibre drums, textile bags and steel strapping are in common usage as shipping containers. Protecting the product through the distribution and merchandising channels is a formidable problem They must meet standards on the following basic protection functions.

a. Shock and vibration-Shock results from a throw, drop or impact. Corrugated board, plactic foam, fibres and air pillows are used to reduce these factors.

b. Moisture-Corrosion and deterioration frequently result from moisture contact. Moisture exclusion or netralization is accomplished by coatings, films, foils and tight construction.

c. Temperature extremes-Product damage due to brief exposure to excessively high or low temperatures can be prevented by insulated type containers. Foamed plastics, fiber glass, and shredded paper are common for establishing an inexpensive dead air space.

d. Pressure extremes-Bulging, denting, or seal rupture may occur during pressure changes. Pressure tolerance is generally established for each material and container. Both a change in altitude or a change in temperature can affect the product or package pressure.

e. Pilferage-Theft prevention is one of the more difficult packaging problems and is certainly an important one. Small high priced and readily marketable items are the most susceptible. Code marked cartons and sealed containers help prevent pilferage.

III. PHYSICAL PROPERTIES OF PACKAGING MATERIALS

The physical properties of some more common packaging films are summarized in Table 3. They differ in tensil strength, tear strength, heat seal temperature, water vapor and gas permeability. The food industry has to know the physical properties of the packaging materiasl in selecting the suitability of the materials for packaging of foods.

IV. TRANSPARENT FILM COMBINATIONS

The word combination indicates two or more layers of plastic materials that have been combined by laminating or by extruding, or by coating. The converting industry starts by sampling the prospective customer, receiving an order, and then producing the laminate. This results in custom-made materials for nearly every customer. It is necessary to first characterize the food to be packaged. The shelf-life of the product has to be specified. Then attemps can be made to combine plastic materials so that the demands for food protection are met. The economics of the packaging materials, the machines available for making and sealing the pouches, and the method of distribution are important factors to be considered.

Moisture protection.

In many cases this is the most important question-what protection from weight losses and wight gains is required by the product. There is cardinal rule which is easy to state but difficult to apply which states: "If absolute protection or near absolute protection is needed, then foil must be contained in the combination".

Let us pass over this point for the moment by saying that foil is not required and then we move on to whether the product is dry or moist, whether it is to be packaged under atmospheric conditions, vacuum packaged, gas packaged, gas sterilized, steam sterilized, radiated,aseptically packaged, or autoclaved.

The largest classification of course will be atmospheric packaging of dried products and under this classification we can consider moisture protection either by comparing this product to similar products of which we have a history or by running accelerated test in the laboratory under hot, humid conditions, 90% relative humidity at 90ºF. The types of cellophane films used in packaging of foods are shown in Table 4.

Many of the good films will have a MVT (moisture-vapor-transmission) rate of 0.6 to 1.0 grams per 100 sq in/24 hours. When combining two of these materials, the combined rate will be less than the rate of either one, but will not be the rate that you might expect by adding the two values and dividing by two.

When we combine a cellophane film that has a rate of 1.0 with a polyethylene film that has a rate of 0.9, the resuling combined film has a MVT rate of 0.65. We can obtain rates of 0.4 to 0.5 with two -ply materials and in some instances with three-ply materials and obtain MVT of 0.1 to 0.2 grams/ 100 sq in/24 hours.

Another known fact is that doubling the thickness of a monolithic film will not cut the rate in half. For example,

TABLE 4. SOME CELLOPHANE TYPES AND TYPICAL USES (HANLON, 1971)

TYPE	USE	PRODUCT	PROPERTY
LST	WRAPPING	PRODUCE	BREATHING
MSAT-36	WRAPPING	WET PRODUCTS	WATER-RESISTANT
MSAT-37	BAGS	FROZEN FOODS	WATER-RESISTANT
MST-44	GENERAL PURPOSE	GENERAL PURPOSE	GENERAL PURPOSE
MST-51	WRAPPING	BREAD	FLEXIBLE
MST-54	WRAPPING	BAKED GOODS	GREASE-RESISTANT
MST-58	WRAPPING	SMALL ITEMS	STRONG SEAL
MT-33	TWIST WRAPPING	CANDY	FLEXIBLE
T-79	BAGS	COOKIES	BARRIER
OF-16	WRAPPING	FRESH MEAT, UNCOATED SIDE IN	NON FOGGING
OX-511	WRAPPING	LIGHT WEIGHT PRODUCTS	MOISTURE- RESISTANT GREASE-RESISTANT
V-3	GENERAL PURPOSE	GENERAL PURPOSE	BARRIER, APPEARANCE
V-4	WRAPPING	GREASY PRODUCTS	GREASE-RESISTANT

one-mil polyethylene at a rate of 0.9, two mils at 0.6 and three mils at 0.45.

In general, the same materials that will keep a dry product dry when exposed to high humidities on the outside will keep a moisturized product moist when the packaged produc is exposed to dry conditions.

Vacuum packaging

There is no correlation between moisture permeability and gas permeability. For example, 2 mils of polyethylene has a very good moisture barrier property with a moisture rate of approximately 0.6 whereas the gas rate is extremely high or in the range of 300-400 c.c./100 sq in/24 hours. Gas permeability rates are determined by the nature of the polymers involved, and in general, saran coatings or saran films are the best. For gas packaging, combinations of K cellophane which is a saran coating on two sides of the basic cellulose film, M type mylar (which is a saran coated mylar), or K type nylon (which is a saran coated nylon), or two-side coated biaxially oriented polypropylenes are used.

When we refer to good gas barrier transparent films, we are indicating an oxygen diffusion rate of 1.0 c.c./100 sq in/24 hours or less. The list of films as given will fall into this classification. This rate of 1.0 is adequate to retain the color of processed meat or to prevent cheese from developing mold.

Gas Packaging

The same types of films that are used for vacuum packaging are used for gas packaging. The gases that are employed are inert gases such as nitrogen. By the gas being completely inert, then as far as the product is concerned, the inert gas is the equivalent of nothing. Those films that will hold a vacuum do so by preventing the gas from diffusing through the film from the outside in.

In the case of gas packaging, the same principle applies where the films prevent the oxygen in the air from entering the package. We are not too concerned in holding the gases in, although this is also done.

Sterilization

Steam sterilization is perhaps a misnomer as the more accurate term is autoclaving. This practice is involved with pharmaceutical supplies that are steam sterilized or autoclaved for hospitals under 15# steam pressure which is 254°F for a period of 39 minutes either when packaged or prior to use.

More sophisticated materials are used as this temperature is above the softening and flow point of many of the films. Typical constructions for autoclaving are mylar/polypropylene or mylar/foil/polypropylene as polypropylene is the only olefin that will withstand this high temperature.

The economics are a most important factor and should be considered from the concept of the packaging idea and as long as you use the material. Many factor influence cost. An example is shelf-life. If someone demands six months shelf-life when only three months is required, this may increase the cost of the packaging material as much as 25%. Other requirements can have the same effect. Once the package is in use, the over specifications are forgotten but the packaging cost continues month after month.

As selecting the exact packaging material is not an exact science, it is safer to slightly overprotect the product at first but the packaging requirements and packaging materials shoudl be reviewed periodically to be sure you are giving your product adequate protection at the least possible cost.

I have seen in San Francisco salted peanuts ---------- packaged in polyethylene bags. The product was rancid when opened. It would be good for the processors to know the shelf-life of the foods, and to select proper types of packaging materials to protect the foods in the package.

V. FOIL-LAMINATES

The use of metal foils as a component of packaging materials goes back over 50 years. I am sure some of you remember the great balls of tin foil we collected as children. This foil was a composite of lead and tin foil which became widely used in combination with paper as a wrap for chewing gum and tobacco products. It was used to provide protection against moisture gain in chewing -gum and maintenance of moisture content in tobacco products. This property of metallic foil, that is a positive barrier to moisture vapor, is still the most prevalent one for dictating its use for many packaging applications.

The development of the techniques for rolling aluminum to foil gauges provided a lighter wight and less expensive metal foil for packaging that effectively expanded its use. This was followed with the developmnt of inks and techniques for printing on aluminum foil which opened additional markets for what was being found to be a very versatile addition to the packagers catalogue. The use of metallic foils infers a laminated material (metal and plastic film).

There has been a continuous growth of the use of metallic foils, primarily aluminum, in domestic packaging.

We have already mentioned that aluminum foil is a positive barrier to mosture vapor. Most published data will show the MVT rate to be less than 0.01 grams per 24 hours per 100 sq inches at 100ºF 90-95% R.H. This is true. How much less is not known as the accuracy of the available test methods is not good in this range.

All of our test methods for moisture vapor transmission express permeability as a function of surface area. This is only valid for materials that have a uniform permability- Metal foils do not have a permeability fitting this definition, but unfortunately, we haven't found a better way to express this.

There are pinholes in aluminum foils. The average size of a pinhole is 0.000008 sq inch. If in a laminate this is covered with a film such as polyethylene wich has an MVT rate of 1 gram per 24 hours per 100 sq in., the total amount of moisture that can pass through is almost infinitesimal.

Aluminum foil also provides a positive barrier to gases. In flexible packaging of products requirig an inert atmosphere or in other words protection from oxygen, foil is dictated. It is also used, and will be used more in the future, in physically stronger specifications for vacuum packaging. In like manner, foil provides a positive barrier to oils, grease, and essential oils. These statements are all dependent on the metallic structure remaining intact as regards the structure itself. But to utilize these characteristics in a package requires that provision be made for sealing the material so that the seal will not compromise the properties desired. There is absolutely no reason to establish a package where the sidewalls have a zero moisture vapor transmission rate and the seal areas have large channels for access of moisture.

Aluminum foil is heat resistant. The melting point is approximately 1200ºF. Another property of foil that permits its use in packaging is the ease with which it can be combined with other materials.

Aluminum foil reflects over 95% of the radiant energy that impinges on its surface. This property hasn't caused any wild stampede of orders but possibly this, coupled with its high conductivity and low emissivity, will result in more widespread use. The internal temperature of the product in the top package of a stack in an open display type freezer can be as much as 7ºF difference in temperature between a stack of foil-wrapped cartons and waxed paper-wrapped cartons.

We can utilize these extraordinary properties to the best advantage.

First, let's start off with a very simple combination-aluminum foil laminated to a light tissue with wax, where the wax can be bled through the tissue to form a seal. Obviously, this structure does not possess any great strength, in fact, it is very fragile. It does not provide the same degree of protection as do more exotic laminates, but it is adequate for use as an overwrap for relatively small cartons of a light weight product or as a carton liner where protection is needed against moisture gain.

The fragility of this material imposes a responsibility on the part of everyone dealing with its utilization both in the converters and users plant. All idler rolls on laminators and slitters must be kept clean and free from defects which could rupture the foil. Stock handlers must exercise care in transporting rolls and packaging machines must be kept clean and in proper adjustment and heaters and thermostatic controls must be maintained in good working order.

This sets the stage for proper utilization of foil materials. The supplier of foil laminates can build a specification that will do the job in spite of poor handling procedures, but this results in higher material cost which can quickly become prohibitive.

Physical strength (tensile, tear, improved puncture resistance) can be built into a foil packaging material by combinign the foil with paper, cloth or a wide number of plastics. Heat sealability can be provided over a wide range of sealing conditions and strengths through selection of components. Slip or lack of same can be provided through the selection of coatings or through additives to the heat sealable coating if this is where it is needed. But these are the problems of the packaging engineers designing the materials.

Heat sealing.

This is the most prevalent method of closing a package in which aluminum foil is a component of the packaging material. If we set the machine to provide a certain sealing temperature under a given pressure, good seals should result. Machine speed is important to packaging operations. But we must remember that what we are trying to accomplish is the melting of a thermoplastic material and the wetting out of the surface to which it is to adhere or the fusion of two thermoplastic surfaces. It is necessary to provide sufficient heat to reduce the viscosity of the material at the interface to accomplish this. Where does the heat come from? Well, in most conventional sealing operations, from the outside of the material. This immediately brings in a heat transfer problem.

Paper-polyethylene-aluminum foil-polyethylene.
The heat must find a way through the paper (a pretty good insulator) through the polyethylene laminate (which, by the way, generally has the same melting range as the sealing polyethylene so it obviosuly melts) to the aluminum foil, and then through the sealing polyethylene.

Sealing Jaw
For aluminum foil materials a flat, non-serrated sealing jaw with a 1/4" radius on the face towards the inside of the package provides the best results. Damage can result from a serrated or knurled sealing jaw if too much pressure on the jaw was used on the samples.

Temperature-pressure-dwell time
These are the three inseparables when talking about heat sealing.

Sufficient heat must be provided to melt the thermoplastic material as mentioned. Sufficiente time must be provided to allow this heat to penetrate to the point that it can do its job and sufficient pressure must be present to provide intimate contact of the molten surfaces. Sometimes heat sealers that can achieve an adequate temperature may lack the ability to provide sufficient heat to maintain that temperature when production starts.

To do the best job of controlling these three conditions, it is necessary to know the properties of the heat scalable material. Polyethylene has a broad melting range. The change of viscocity with temperature is not great and it has generally good hot tack. With these characteristics we can tolerate a wider tolerance on heater temperatures and pressure fluctuation than with some other materials. Care must still be execised that too much pressure is not used as the molten polyethylene will flow away from the point of pressure thereby weakening the material.

Organic compunds that we label as thermoplastic have a melting range rather than a melting point. The range for polyethylene is broad but some of the materials pass from a solid to a liquid of very low viscosity over a temperature range of 20 to 30 ºF. If the use of these materials is dictated, packaging machinery control becomes critical.

The best seal is a continuous seal that is accomplished with the least physical stress on the components of the material. This includes the deteriorating effect of high sealing bar temperatures on the paper component of a specification where ever increasing temperatures are tried to increase machine speed. There were instances where paper has become so brittle that it cracked, which significantly weakened the pouch structure.

The method for determining the optimum combination of temperature, pressure, and dwell time for a particular operations is as follows:

1. On a laboratory heat sealer, seal the material in increments of 20ºF starting at the lowest temperature. A seal can be effected at 20 psi pressure and a dwell time consistent with your packaging machine.

2. Repeat above process at a temperature 25ºF above the starting point in 1 or at the temperature at which the best seal is acheived, varying the pressure from 5 psi to 40psi.

3. Evaluate the seals. Look for complete fusion of the heat seal medium and for any signs of flow of the resin outside of the area of the heat seal jaws. (Seal strength can be determined but remember that if the heat sealable material is fused the value you get is the tensile strength of the structure or the bond strength of one of the components).

If you do not have the facilities for making these determinations the supplier should supply the information.

4. Set the temperature on your sealing jaws at the optimum temperature found from the laboratory determination. This should be midway between the starting point and the point where heat bleed or flow outside the seal jaw area was noted in 1.

5. Reduce seal pressure until no heat seal occurs then gradually increase the pressure until a seal is acheived, consistent with the best conditions acheived in the laboratory study. Be sure to look for physical damage that might be caused by a burr or rough spot on the sealers.

This may sound like and unnecessarily complicated procedure, but it will make everyone in the operation aware of the conditions necessary to produce the best package and aware of what the best seal looks like.

3. Web Control.- If the material is not flat when the sealing jaw applies pressure, wrinkles occur. This can produce channels through the heat seal. Lack of adequate web tension control or too much product for the pouch are usually the offenders. Loss of tension control can frequently be traced to the coefficient of friction of the material or on some part of the machine. If a problem occurs in an

operation that has been running satisfactorily, a little polishing or possibly the application of some Teflon tape can work miracles.

4. Seal area contamination- This is a major problem with many types of products and one that requires immediate remedy. Some heat sealing materials can tolerate some types of contamination but even where they do it is undesirable. Powdered products of low particle density and liquids are the worst offenders and the most difficult to control.

In liquid fills the injection of the liquid through a small tube inserted into the pouch is desirable. Of course, even here there is a danger of a drop adhering to the end of the tube which will wipe on the heat seal area as the tube is withdrawn. If provision can be made to apply sufficient vacuum to the needle just prior to withdrawal, the drop can be drawn back into the system. If the liquid is totally volatile, such as alcohol, then preheating with hot air will dry the area prior to sealing. It can be easily seen that if the hot jaws close on a material with a liquid on the seal medium, the liquid will be vaporized and the vapor will prevent fusion of the interfaces.

Light powdered products, such as cake mixes are extremely difficult to handle. Filling much more gently than is normally provided on conventional filling equipment will be required to keep the stuff in the bottom of the pouch. This is a continuing problem with companies packaging these products.

Packing

The worst way to ship a pouch is the way most people ship them on end. The physical abuse that a pouch undergoes when all of the product is vibrated into one end which is a sealed end having a stiff seal on the bottom is drastic. For example, in one study the number of leakers in Nitrogen packaged pouches was reduced from 12% to less that 4% by placing the pouches flat in the shipper rather than on end.

It is well known that preventing motion of the pouches within a shipping case as much as possible, reduces shipping damage. As an addenda, the sharp corners produced by heat sealing often cause a lot of damage to adjacent pouches in a shipper. Care in packing the shippers can reduce this damage appreciably.

The properties of aluminum foil laminates and the coefficient of friction are important factors. It is necessary to have a careful analysis of a problem and to show the competing requirements that frequently complicate the choice of packaging materials.

Samples were submitted for evaluation on a vertical form and fill machine to produce a relatively small pouch. The report came back that the material was not strong enough. It tore when the sealing jaws moved down to advance the web. Fortunately, it was quickly recognized by the project engineer that to make the specification stronger would entail changing one of the components probably the paper, and that this would increase the stiffness and, consequently, the difficulty in pulling it over the former. A slip additive to the coating reducing the friction between the material and the former overcame the problem without the necessity of changing any other component. It illustrates the necessity for careful analysis of a problem and the danger of changing any packaging material characteristic wihtout considering all of the possible side effects that might accrue.

Carton overwrap

Here lap seals are employed rather than the face to face seals in pouches. The seal medium must be compatible with the opposite surface of the material, which seriosuly limits the choice of sealable materials. The carton or product rarely provides adequate or sufficiently uniform pressure to assure intimate contact as the wrapped product is transported through stationary sealing units.

The sealable coating is generally a wax or wax-resin blend which permits generally lower sealing temperatures, however, in many instances, lack of pressure to prevent scuffing of the printed surface requires sealer plate temperatures appreciably above the melting point of the wax. Heat- and scuff-resistant inks and coatings are generally used on the printed foil surface to minimize scuffing but even these are subject to being affected by too much heat. Of course, if scuffing does occur the sealing plates should be examined for rough spots or burrs and possibly coated with Teflon.

Waxes and many of the wax blends do not have hot-tack so it is generally necessary to provide a compression section on the machine to maintain contact of the surfaces during chilling. In machines with a short compression section or ones running at high speed it is desirable to provide refrigeration to aid in the setting of the seal.

It often is not possible to produce a complete seal in many overwrap applications because of the shape of the object and still adequate protection for the particular product can be attained.

It is appropriate to suggest a test for determining the intergrity of a package whether it is a carton overwrap or a pouch, but this test is not valid if your particular application does not require an hermetic seal.

A satisfactory test for the efficiency of a packaging operation which utilizes foil is as follows:

1. Equipment needed -
   a. Container for water
   b. Hypodermic needle
   c. Cork or gasket
   d. Source of compressed air
   e. Valves to provide uniform flow of air at a pressure of 3 psi

2. **Procedure-**
   a. Immerse the entire package below the surface of the water.
   b. Insert needle with air escaping through packaging material until gasket or cork contacts surface of material. (Care must be used on thin pouches that needle does not penetrate back wall inserting at an angle is usually required).
   c. Observe liquid for steady stream of bubles. If bubbles appear note carefully the source of the leak in the package.

If care is exercised in pinpointing the location of a package failure, corrections can usually be easily accomplished. To mention a few as guide (don't use it as all inclusive):

1. Carton overwraps

   a. Sidewall leakers-look for signs of scuffing of foil that might come from a burr or rough spot on the machine.

   b. Back or long seam leakers-can frequently result from inadequate contact with the sealing plate which may be caused by bowing of the carton due to too much pressure on the ends of the carton, or by lack of sufficient weight in the carton to hold it down. Correction can be in relief of the end pressure slightly or application of a hold down bar.

   c. End seal leakers-usually because of too little pressure but can also result from misalignment of material.

   d. Carton corners-Cartons have sharp corners-wrap may be too tight- of course, too loose makes a sloppy looking package, so use discretion. Misalignment of carton can also produce projections that puncture the wrap.

2. Pouches
   a. Sidewall leakers-look for signs of physical scuffing of the foil as for overwraps but don't overlook the possibility of a sharp product puncturing the sidewall.

   b. Seal leakers can be heater failure, warped sealing jaw, too little pressure, seal area contamination with product.

   c. Inside edge of seal area leakers - check for sharp edge on sealing jaws, rough edge or burrs or physical stress due to folding of seal.

Other methods of testing are used and provide similar results but I would like to add one comment relative to a widely used method. This is the immersion of the packages in a chamber and then pulling a vacuum on the head space. This method does create an internal pressure in the pouch and leaks are detected in the same manner. However I feel it has several disadvantages: 1. The internal pressure on the pouch is generally too great. It does not require an advance degree in physics to roughly calculate the stress the material is under when the external pressure is decreased to 760 mm of mercury. This may result in paying twice as much for a packaging material than is needed to protect the product just to pass the vacuum text. 2. Large holes are difficult to see because all of the air in the package escapes rapidly as the vacuum is drawn and no steady stream of bubbles is visible under the full vacuum. 3. With materials having paper exposed the air entrapped in the paper will frequently come out through a pinhole in the coating giving the appearance of a leak.

The Future of Packaging with Aluminum Foil.-
One future of the most widely used sealing mediums in foil laminations and in fact, in non-foil laminations is polyethylene. Polyethylene has lived up to most of the expectations, but it has a few drawbacks. In the low densities it lacks oil and grease resistance and has too low a softening point and lacks strength for some applications. Medium and high density polyethylenes present processing, adhesion and heat sealing problems.

Modifications of polyethylenes are coming thick and fast. The ionomers or ethylene-acrylic acid copolymers with cross linking metal ions- provide greater toughness and better grease and oil resistance with slightly lower sealing temperatures. Ethylene-vinyl acetate copolymers provide an additive for waxes that improve seal strength, oil resistance and provide block resistance. Polyethylene-polyisobutylene blends provide greatly improved toughness and higher temperature resistance, and others will come.

These materials are not going to replace polyethylene where it is now doing an adequate job. There are some borderline cases where the added cost will be justified. The big use of these materials is in opening the way for new products to be packaged in flexible materials.

Polypropylene is finding its wasy into laminations with foil in two ways and I predict that we will see a lot of it in the future. First it is being used in the form of a heat set biaxially oriented film reverse printed and laminated to the exterior of foil which is then coated with a heat seal as polyethylene. In this form it provides a material with greater dimensional stability when exposed to changes in humidity than the currently used cellophane and provides more flexibility and toughness. When talking about this form of polypropylene I like to illustrate the possibilities provided by lamination by describing a material for a dry powdered soft drink mix. It is composed of a high gloss coated printed paper laminated with extruded polyethylene biaxially oriented polypropylene which in turn is laminated with extruded polyethylene to aluminum foil which is coated with poylethylene.

The other form of polypropylene is as an extrusion coating for use as the heat seal medium where the particular properties of toughness and heat resistance are required.

Polyester films have already entered the market place as a component of laminations and will be used even more.

Nylon used to some extent in transparent laminations is beginning to be used in foil laminations where its unique properties can be utilized to best advantage. It can be heat sealed and will resist sterilizing temperatures. These laminations require high heat sealing temperatures, preferably with two heated jaws.

Polycarbonate has remained in the background so far mainly because of price. It has unique strength properties and will be used, but, I feel, to a limited extent for the immediate future.

Polyurethane has some "out of this world" properties that won't let it be ignored. For the immediate future, price and the extreme extrusion requirements are preventing immediate adoption for laminating particularly, but it will come. Polyurethane is tough and has unbelievable elongation.

Other resins now being studied include phenoxy, polyimide, polyphenylene oxide and modified polyphenylene oxide, polysulfones and polystyrenes.

Flexible packaging is one of the most exciting areas in our economy. The rapidity with which new developments are appearing and the replacement of established packaging tech n.iques which are taking place allows no room for complacency. Every new development is faced with becoming obsolete before it gets too far off the drawing board.

The fact that we can purchase products from the supermarket shelf with a high degree of confidence that they will produce the desired results when opened is a tribute to the packaging temm. This team includes all of those people who participate in identifying the degree of protection desired, who design the laminates to be used, who produce and handle the materials and those who apply it in the final packaging operation.

VI. SUMMARY

The basic packaging materials are paper, board, steel, aluminum, glass, wood and plastics. These are processed or fabricated into flexible, semi-rigid and rigid containers in traditional or fabricated into flexible, semi-rigid and rigid containers in traditional or conventional forms, wraps, bags, pouches, cartons, cans, bottles, drums,barrels, and tanks.

The objective of this report is to discuss the containers and plastic materials for the food industry with empahsis on package types. All packages involve some type of seal and many packages require a functional closure for opening, dispensing and reclosure.

Food packages require identification of contents and this generally means some type of direct imprint or applied printed label. The field of packaging design grows continuosly more important. The basic steps to successful packaging are a) piloting the program b) determining product needs c) selecting the target—the product, market, buying habits,retail considerations, and use factor d) selecting the package characteristics, closure, sealing, structural considerations, performance, checks and decoration e) design considerations—identity, and consumer acceptance f) production and handling—package line, design and structure, preproduction factors and packing and shipping g)Auditing the package—basic economics, legal considerations, records and final evaluation.

The types and characteristics of transparent films for packaging are discussed in terms of yield, tensile strength, tearing resistance, and properties. Typical base stocks of packaging papers are kraft, glassine, bleached paper and parchment papers. Converted packaging paper containers are coated with lacquer, wax,polyethylene, saran and hot melt for various food products.

Plastic films and laminates made of polyethylene, polypropylene, celluloec acetate, fluorahalocarbon, nylon, pliofilm, polyester, polyvinylidene, polystyrene, and polyvinyl chloride are used for food packaging. When laminated with aluminum foil, they offer extra protection to the food against light, oxygen and moisture.

The functional properties and selection of packaging materials for food products are discussed.

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