ANCILLARY MATERIALS FOR FOOD PACKAGING

In packaging, ancillaries cover a large group of products and play a vital role towards completeness of a package. Quantum and volume-wise, though ancillary materials have a smaller visible percentage of the total packages used, nevertheless, their absence or inadequacy may impair the performance of a package–functionally, aesthetically and statutorily. The ancillary materials along with the primary packaging materials provide product–package compatibility, product preservation and protection, containment, identification, consumer convenience and consumer protection. Some of the important ancillary materials which are discussed here include- adhesives, printing inks, labels, caps and closures and reinforcement materials such as tapes and straps.

In the case of packages, which come directly in contact with the food product, the safety aspects that apply to the primary package also apply to the ancillary materials. Typical examples are adhesives for laminates, printing inks for a food package/label, caps and closures for bottles and containers.

Adhesives

Adhesive bonding is the process of uniting materials with the aid of an adhesive, a substance capable of holding such materials together by surface attachment. Polymers are widely used as adhesives because of their versatility.

The primary function of adhesives is to join parts together. Adhesives do this by transmitting stress from one member to another in a manner that distributes the stress much more uniformly than can be achieved with conventional mechanical fasteners.

Classification of Adhesives

Adhesives are broadly classified into:

- Waterborne Adhesives
- Hot–melt Adhesives
- Solvent–borne Adhesives

- **Waterborne Adhesives:** This is the oldest, and still, by far, the largest volume class of adhesive used in packaging. These adhesives share the general advantages of ease and safety of handling, energy efficiency, low cost, and high strength. Waterborne adhesives can further be classified into two categories - natural and synthetic.

  Natural waterborne adhesives include starch, protein, animal glue, casein and natural rubber latex. The largest class of natural adhesive is based on starch.

  Synthetic waterborne adhesives are the most broadly used class of adhesives in general packaging. Almost all are resin emulsions, specifically polyvinyl acetate emulsions - stable suspensions of polyvinyl acetate particles in water.

- **Hot–melt Adhesives:** Hot-melt adhesives have been the fastest growing important class of adhesives in packaging for the last 25 years. Most of the volume goes into high-speed large-volume case and carton-sealing. Hot melts can be defined as 100% solids adhesive based on thermoplastic polymers that are applied when heated in the molten state and set to form a bond on cooling and solidification. Their chief attraction is the extremely rapid rate of bond formation, which can translate into high production rates on a packaging line.

  The backbone of any hot-melt is a thermoplastic polymer. Although almost any thermoplastic can be used, and most have been, the most widely used material by far is the co-polymer of Ethylene and Vinyl Acetate (EVA). These copolymers have an excellent balance of molten stability, adhesion and toughness over a broad temperature range, as well as compatibility with many modifiers.

- **Solvent – borne Adhesives:** Rapidly declining, of the three classes of adhesives used in packaging, solvent-borne adhesives find use in specialised applications where waterborne or hot-melt systems do not meet the technical requirements. Rubber-resin solutions are still used as pressure-sensitive adhesives for labels and tapes. However, factors of cost, safety, productivity and above all, compliance with clean-air law have led to a strong movement towards waterborne or hot-melt alternatives.

  Solvented polyurethane adhesives are widely used in flexible packaging for the lamination of plastic films. These multilayer film constructions find application in bags, pouches, wraps for snack food, meat and cheese packs and boil-in-bag food pouches.

Table 1 gives the important polymer based adhesives and their applications.

TABLE 1
Important Adhesives (Polymer Based) and their Applications

Adhesives	Applications
Acrylics	Pressure sensitive coating Heat Seal coating
Ethylene – vinyl acetate co-polymer hot melts	High speed packaging operations. Wrap around case sealing
Polyurethanes	Flexible laminates for food packaging – cover a large spectrum from heat resistant confectionery films to boil-in-bag / ovenable laminates
Polyvinyl acetate	Cold set corrugating lap-glue, case sealing, carton sealing, tube winding
Polyvinyl alcohol	Solid board lamination, tube winding
Styrene-Butadiene and Styrene-Isoprene block co-polymers	Label stock, tapes

Laminating Adhesives for Flexible Packaging of Processed Food

Flexible packaging materials are used extensively for packaging processed food and wide range of other products. These packaging materials are made from basic substrates such as plastic films, aluminium foil and various types of paper. "Dry Adhesive Lamination" is a process that is very commonly used to produce laminated flexible packaging.

Keeping in view the nature of dry lamination process, the types of substrates involved, and the end-use requirements, dry laminating adhesives must possess the following properties:

- The adhesive must retain tack after solvents are removed, to wet the secondary substrate and bond to it in the laminating nip.
- The adhesive must be flexible and retain elasticity even after it has cured. It should not become hard and brittle.
- The cured adhesive must possess the required level of thermal and chemical resistance.
- The cured adhesive must also be transparent and colourless.
- Laminated flexible packaging materials are generally used for packaging of food and pharmaceutical products. Therefore the adhesive must be odour free and must not contaminate the product or react with it in anyway. It must comply with all relevant government rules and regulations.

Although adhesive manufacturers evaluated several polymer systems during the early stages of development, solvent-borne adhesives based on polyester and polyurethane polymers very quickly became the standard for the flexible packaging industry. Polyester and polyurethane polymers are complex materials that demonstrate excellent adhesion to a very wide range of substrates and possess excellent cohesive strength when designed properly.

Laminating adhesives are classified according to their functional properties (i.e., bond strength, chemical resistance, heat resistance) as follows:

- General Purpose
- Medium Performance
- High Performance
- Ultra High Performance

General purpose adhesives are most economical and are used for low requirement, relatively simple end-uses. General purpose applications include packaging of snack food and non-aggressive dry products. The relatively more expensive medium, high and ultra high performance adhesives are used in laminates where higher thermal and/or chemical resistance is required. Typical applications include laminates for packaging liquids, aggressive products such as spices, pastes which are acidic and boil-in-bag and heat sterilisable laminates.

Adhesives for Labels

Glues and different adhesives for food labels have to be selected with proper care. The range of surfaces needing adhesives is altering, thereby stimulating adhesives formulators to produce

new and exciting adhesives. It is important that adhesives are fully tested, not only for the usual adhesion to the substrate but also for the penetration of constituents of the adhesive formulation through the substrate into the product.

- **Wet Glues:** Wet glue adhesive is defined as those labeling systems where the label is not pre-coated with adhesive, but the adhesive coating is 'wet' and is applied to the labeling machine immediately prior to the label being placed onto the substrate. The 'wetness' would usually be aqueous-based or hot melt applied, but there may still be some solvent-based adhesives that have not yet been replaced due to environmental pressures. These 'wet' aqueous adhesives are usually 'natural', in that they are based largely on modified animal or vegetable materials, e.g. casein, starches, dextrose or cellulose.

- **Sloventless Adhesives:** This is a technique originally designed for lamination, but which can also be used as a replacement for solvent or aqueous-based adhesive systems. The system is a two component polyether or polyester urethane system, applied at room temperature by smooth roller coating. This is useful for food application as no solvent is used.

- **Hot-melt Applied Adhesives:** Hot-melt adhesives are a well-established method of adhesion. A hot-melt adhesive is claimed to reduce the bloom and does not peel off PET, PVC or glass containers. An unusual development in the hot melt adhesive area is the introduction of an entire family of water dispersible adhesives. These are actually polyester-based hot-melt adhesives which, when re-pulped in alkaline or neutral environments are dissolved and dispersed.

- **Pressure-sensitive Adhesives:** Several developments are recorded in this field of adhesives. One company has developed a kind of adhesive, which can be used on high-quality roll label materials and is as effective below freezing point as at room temperature. Similarly, one other adhesive is a pressure sensitive adhesive suitable for freezer cabinet applications, providing a good bond to polyethylene film and carton board at temperatures as low as -30°C which is useful for frozen food and food stored at lower temperatures. Also, a specific adhesive for direct application to unpacked fruits and vegetables is on trial in some supermarkets.

Future Needs

As far as solvent-borne laminating adhesives are concerned, a complete range of products is already available in India. No constraints in terms of quality or quantity are envisaged in future. As newer applications develop, some upgradation may be required in the high and ultra high performance products. Judging by the developments that have occurred over the last ten years, the domestic adhesive manufacturers will be able to meet these demands.

The growing concern for environmental pollution, safety and health, and the passage of strict anti-pollution laws - especially in the advanced countries - are major factors influencing development in the entire packaging industry. The limitations on waste disposal by land filling are yielding to other options such as disposal by incineration and waste recycling. The strong trend towards recycling and elimination of waste will only get stronger as time passes. Energy use, along with air and water effluent will have to be minimised.

Environmental regulations already limit and may eventually eliminate VOC (Volatile Organic Compounds) emissions.

These developments have been exerting a strong influence on the research and development efforts of adhesive manufacturers. Several options are being examined including reduction in the use of solvents in solvent borne adhesives, waterborne adhesive systems, and solventless adhesive system. Complete elimination of solvents is still not possible, especially for high performance applications. This will require major technological breakthroughs and complete redesign and re-formulation of adhesive polymers. For low performance general purpose laminations "high solids" solvent-borne, water-borne and solvent-less (100% solids) adhesive systems are already available. Research and development efforts are focused on improving performance to cover a wider range of lamination requirements.

Interest in 100% solids technology is growing rapidly and converters all over the world are expanding their operations to include solventless lamination capacity. Solventless lamination started in India about seven years back. A few solventless laminating machines are already in operation and several more are expected to be added. Adhesive manufacturers all over the world and also in India look at solventless systems as the best solution to environmental concerns in the future and are deeply involved in developing polymer technology to extend the application range of solventless adhesives.

Printing Inks

Printing inks are coloured liquids or pastes, formulated to transfer and reproduce an image from a printing surface. They are used mainly to convey a message and provide protection; however, they also can give a decorative effect to the substrate to which they are applied. Printing inks are used on a wide range of papers, boards, plastic, glass and textiles surface in flat and, in some instances, preformed shapes.

Raw Materials in Ink

Pigments and dyestuffs together are probably the most important items in printing ink formulation, as they convey the visual identity of an ink and invariably contribute the major component. The vehicle acts as a carrier for the pigments and other modifiers in the ink. Resins, varnishes and oils are added to improve the printing performance. Solvents are normally used to disperse the liquid part of the printed ink, which is added to adjust the viscosity of the ink or control the drying speed of specific printing inks.

The other ink additives are plasticisers, driers, waxes, antioxidants, surfactants and wetting agents.

Inks Used for Food Packages

Food packaging inks have been classified into the following categories:

- **Inks for External Packaging:** This is defined as any packaging additional to an immediate food wrapping, and the printed matter has a barrier in the form of another wrapper between it and the food. The very low ink film weight and its remoteness from the food, makes any additional safe guard unnecessary. The materials used for the printing inks must however be non-toxic and non-injurious to health.

- **Inks for Immediate Food Wrapping:** This deals with wrapping material in direct contact with the food, such as butter wrapper, ice cream wrapper etc. The requirements of inks for such packaging are as follows:
  - It is essential that inks for such wrappers must be on outside of the wrapper, which itself must form a barrier between the food and the print. There should be no ink migration to the food. The reverse printing of the films must also be avoided unless there is a functional barrier between ink and the food stuff.
  - Printing inks used must be formulated on raw materials other than those known to be toxic and included in the list of excluded raw materials.
  - Care must be taken during printing of the immediate wrappers to avoid set-off and prevent any ink coming in direct contact with the food.
  - Where dye migration or bleed cannot be prevented, the ink should not contain dyes or other migratory colouring agents.
  - Although the ink film on the wrapping is extremely thin and is not in direct food contact and consequently the total quantity of ink involved is like-wise minutely small and the inks are formulated with deliberate exclusion of materials known or believed to be toxic, the printing ink raw materials could contain small quantities of undesirable impurities.

  It must be emphasized that printing inks are not food additives and are not to be used in direct contact with food.
- **Inks for Print in Direct Food Contact:** As already discussed, it is not feasible to formulate inks based on food additive grade raw materials therefore the printed surface should not be allowed to come into contact with food and printing inks are not recommended for direct food contact.
- **Varnishes for Printed Matter:** Varnishes applied to printed matter by any process do not necessarily constitute an effective barrier between printing ink and food for the prevention of contamination and any limitations on the use of printing inks for food stuffs packaging are equally applicable to varnishes.

Latest Trends

- **UV and Water based Inks and Coatings:** Increase in the production speed and the pressure for the ecological cleaner system has led to water based and radiation cure technology in place of conventional system. The main driving force for the change is the possibility of printing on a wide range of substrates which was not previously possible to be printed with conventional inks.

  The high gloss finishes, better chemical and solvent resistance, high rub and abrasion resistance, better print resolution, instant drying and low odour are some of the advantages of the radiation curing technology, which ultimately add value to the products.

  Instant drying allows the converter immediate cutting, creasing and gluing. Earlier with radiation curing system, it was not possible to get required properties such as barrier to oxygen, good adhesion and less shrinkage. The new chemistry based on the hybrid cure system has now overcome this problem. Other than folding cartons, plastic or paper bags

and wrapping papers are also printed and over coated with UV system for direct and indirect food contact.

- **Toluene Free Inks:** The flexo printing process is growing world-wide. The latest generation of flexo processes are coming into the market. Various ink technologies are now available covering all flexo segments like PE films, plastic films packaging, foils, etc. The ink manufacturers are constantly improving and adopting the flexo ink technology. One significant technology change, which is taking place, is the shift from toluene based inks to toluene free inks. The toluene free inks are based on alcohol/acetate solvent combination. The major reasons for this shift are:
  - Higher level of solvent retention in the print leading to potential residual odour, which is not the case with alcohol/acetate system.
  - Higher risks of migration of toxic impurities, which is avoided using alcohol/acetate system.
  - Unlike alcohol/acetate system, there is very limited ink chemistry possible with toluene and therefore, cannot be used in multi purpose ink series.
  - The prints with toluene based inks have limited brilliance and resistance to heat.
  - The occupational exposure limits for toluene is 50 ppm as compared to 400 ppm for ethyl acetate.

- **Universal Ink Concept:** Universal ink concept has been developed for flexible packaging using gravure and flexo processes. The highlights of Universal ink systems are:
  - Very low solvent retention in the print
  - Trouble free running at maximum speed e.g. 450 mts/min
  - Instant adhesion on substrates like co-extruded BOPP, OPA, PE, PET (plain, treated, primerised).

- **Thermochromic Inks:** There has been development of thermochromic inks in the context of time/temperature indicators, particularly in the food, storage and transportation sectors of the industry. A range of chemithermal flexographic inks that react to a range of measured doses of either light, heat or infrared radiation once laid down into label form have been developed. The reaction was from clear to black over specific ranges, i.e. up to 75°C, 90°C or 125°C.

- **Fresh Check System:** As 'freshness' and some of the recent food storage and handling problems have alerted the consumer to the poor indication of the degree of freshness of pre-packaged food, the way has been opened for the development of systems that indicate the degree of freshness.

  In USA, two companies have advanced this technology in recent times. Firstly, in the food labeling industry 'Fresh Check' system of printing a 'bull's-eye' onto the label, the centre of which fills as the product life elapses, is developed. Labels are pre-programmed to specific time-temperature gradients and are kept under dry ice until labeling onto the product occurs. Secondly, a range of printed labels designed for the storage and distribution sector are produced. These change from silver to black within one second when the target temperature is reached and are supplied for the ranges of 38-49°C and 65-125°C.

In India we use such kind of inks in case of irradiation of food. Before irradiation a dot on the label is of green colour but as it is exposed to irradiation it turns into red colour which indicates that this particular pack is irradiated.

Labels

The Oxford dictionary defines a label as "a slip of paper, card, liner, metal for attaching to an object and indicating its nature, owner, name, destination, etc".

Labeling is the manual or electromechanical process of attaching the 'label' to the correct particular product or packaging or service.

From the simple manual operations of sticking the paper label to the container with animal glue, the labeling technology has progressed significantly, offering a variety of labeling materials, adhesives and machinery, tailored to suit particular labeling equipment. Sometimes, the function of the label is done by the container/package itself which is printed with all the information which the label normally carries.

Functions of Labels

- To identify the product
- Provide ingredients
- Purpose/use of the products
- Providing aesthetic appeal
- Decoration as evidence
- Child safety
- Other information like maximum retail price (MRP), Batch No, Shelf-life/Best-before-date etc.

Information is required by all the links in the packaging chain, but the medium (i.e. the labels) used to carry that information represent only a minute part of the whole product. The quantum of information required has increased and is likely to do so again in the future; in particular, consumers, who influence the legislators, are demanding yet more information on products. Most parts of the production, storage and distribution systems are becoming more sophisticated in their use of barcodes and computers to track and record where goods are located, thereby requiring the design of specialist bar coding systems. Some or all of this information may have to be enshrined on the label. Increased information on the labels is influenced by:

- Health and Safety issues: More and detailed information is required on the product, from the point of view of human health, safety of the consumer and more comprehensive contents/ingredients listings.
- Better inventory control
- Much more environmental pressure, particularly on packaging waste
- National and international legislations
- Growing internationalisation of the label and labeling market leading to more languages being used.
- Increased problems with tampering, look-alikes and the counterfeiting of goods.

Types of Labels

- Non-adhesive Label Materials
  - Glue Applied: Wet glue
    Hot-melt glue
  - Shrink/stretch sleeve: Formed into tube and shrunk on with heat.
    Formed into tube and stretched over object.
  - Inmould: Placed in mould prior to injection or blow moulding
- Pre-adhesive Label Materials
  - Gummed – Activate with water
  - Heat Activated – Activate with heat.
  - Pressure Sensitive – Protective backing removed then applied with pressure.

Common Applications

Common applications of varieties of labels:

- Back Label – Used on back of containers.
- Band Label – Partially wrapped around the container (does not cover the entire container).
- Can Label – Used on cylindrically shaped tinplate container
- Die-cut Label – Label having special design
- Embossed Label – Label having portion raised giving a three dimensional effect
- End Label – Fixed at the end of carton or used for wrapper pack.
- Neck Label – Used for neck of bottle
- Over all wrap – Used for covering entire pack
- Spot Label – Used to cover a smaller portion of pack
- Tag – Generally fixed to the container with the help of string or wire
- Wrap around Label – Generally covers sides and ends of the pack except top/bottom.

Label Substrate/Materials

The two major label substrate materials are plastic films and paper. They are rivals in many areas of label production and application although since 1993 films have tended to make more headway into the primarily paper dominated label areas. However, the paper label using the wet-glue application system remains firmly entrenched in many industries as one of the quickest systems and certainly the cheapest, so there seem to be plenty of good reasons for keeping that particular type of labeling system in operation. Having said that, the increase in shrink/stretch labeling techniques is brought about only by the peculiar properties of plastic film. Each material has its place, advantages and disadvantages.

- **Filmic Materials:** Past few years have seen the use of filmic material in labels. Various plastic films and its combinations are used. PVC, BOPP, OPP, PP, PE and many other films are used. It is reported that a company in U.K. has introduced a novel way of reducing the

costs of high-quality filmic (PP) labels by as much as 60% (as is reported), thereby reducing the cost to near that of paper labels as there is no need for pre-laminated labelstock. A narrow web label press is modified with two unwinds. Filmic facestock is printed on the underside, the second unwind being from ultraviolet silicone-printed filmic label liner, which is adhesive coated. After bonding and die cutting, matrix waste remains bonded to the liner.

- **BOPP:** Biaxially Oriented Polypropylene (BOPP) is reported as being a popular replacement of label face material to PVC. This versatile film has been used by two roll fed labelstock manufacturers as the backing (carrier) layer for pressure-sensitive labels. This was used to eliminate the problem of paper dust (or lint). Secondly, it is reported that coatings are used on BOPP of 30µm thickness to replace the traditional glassine backing paper, giving the advantage of using half the weight of material. The surface smoothness allows the adhesive on the label to smoothen out, thereby giving it a better chance of wetting the adhered surface. It is forecasted that 30µm BOPP will become one of the most important filmic materials for pressure-sensitive labeling. BOPP is also the major material used for promotional labeling Roll-on Shrink-on (ROSO) technique. This is being introduced into Europe, having been successfully used in the USA.

- **OPP:** Oriented Polypropylene (OPP) is reported as replacing paper and aluminium foil in some instances in food packaging particularly in identified butter and ice-cream wrappers and used in a metallised form for coffee pouches.

- **PP and PE:** It is reported that the PE films in the range have improved their physical and mechanical properties, whilst the PP films are said to be of lower density, more moisture and chemical resistant and with greater tensile strength than the PE alternatives.

- **PVC:** PVC labels are used as shrink labels and shrink sleeves on the neck of the bottles for tamper evidence. These labels are put on many of the packaged drinking water, drinks, etc.

- **PO:** A recent introduction into the already very competitive pressure-sensitive film labeling market is a PO film that is carried on either a 67µm or 80µm glassine paper carrier with a range of both aqueous dispersion or solvent-based adhesives. It is thought that the combination of PO labels onto plastic containers should help alleviate the recycling problems of mixed plastics.

  Filmic materials used for labeling are said to be expanding their market at three times the rate of the paper label expansion.

Barcodes

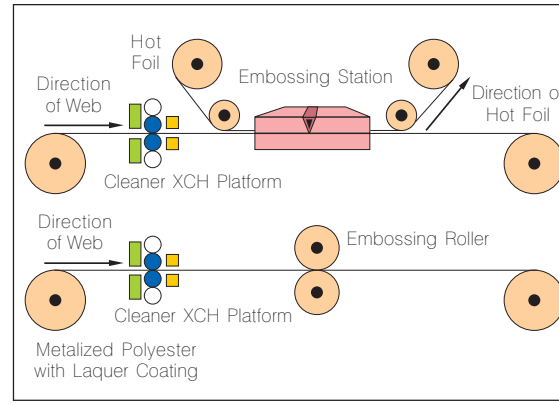
Barcodes have become an important part of the food labeling industry, so much so that it is becoming very difficult today to find retail or warehouse labels that do not have barcodes printed upon them. The whole idea behind barcode symbols relies upon them being capable of being read accurately at the correct point in the industrial/retail system. Barcodes make easy purchasing in super markets, inventory control and keeping records. They are printed using inkjet printers using UV ink.

Printing Processes

Printing is the soul of a label. Quality initiatives in the label printing industry are the improvements that have been noted in both the pre-press stages and actually on the printing machines themselves. Different techniques are used based on the priority, requirement, type of substrate and cost. Thermal transfer printing, inkjet printing, flexographic printing for the filmic materials, gravure printing, letterpress, screen, pad or tampon, waterless offset and digital printing are used for label printing. Novel decorating techniques are explained here.

- **Hot Foil Lamination:** A UK based company has announced a novel method of using this printing technique. This system uses screen printing with a heat-activated ink, with heated rollers when the foil and labelstock meet. It is claimed that the powerful adhesive acts exactly like conventional screen ink. This helps in making the pack more attractive. Refer Figure 1.

Figure 1: Hot Foil Stamping and Embossing



- **Metallising:** There does not seem to be much progress in this field except, perhaps, in the area of vacuum deposition of metals to the surface of label stock, where better control of the vacuum and rate of coating has produced cost savings in the process. Metallised labels are used in high grade or high rate food products.

Hologram

- **Holography:** The type of holography that is used in labels and labeling may be divided into two distinct sectors by function. There is a hologram used for security purposes and the hologram that is used purely as a marketing tool.

- **Sleeves:** Shrink sleeves have overtaken other means of providing tamper-evident food packages. Sleeving decoration is seen as maintaining perceived value differentials and enhancing pure design innovation on clear glass or PET containers. Now-a-days thermochromic inks can be used for tempera-ture colour changes and easy removal for promotional offers. These are tamper evident and require no adhesive. These are used for health drinks like malted milk food, juice bottles, carbonated beverage bottles, sauces, and many other products.

Shrink Sleeves

Security Devices

There are several basic ways in which labels are used as security devices:

- To prevent tampering e.g. tamper evident
- To prevent pilferage and theft from retail, e.g., radio frequency detectors for in-store security
- To be used as anti-counterfeiting devices, either designed to deter or designed to identify (e.g. overt security hologram-identified labels to reassure the customer that the article is genuine, or one of the several covert devices designed to give the manufacturer positive proof that the article is of their manufacturing).

Security Device

On-press label verification, online label verification, tamper evidence, anti counterfeiting etc help for security of the product.

For tamper evidence of food products various techniques are used:

- The use of 'fragile' materials that breach obviously when tampered with
- Weakened label materials (e.g. perforations)
- Laminated materials with differential tear zones
- Differential adhesives which may show 'VOID' if tampered with
- 'Reactive' labels that change colour if tampered with
- Labels with 'stripes' incorporated in their structure
- Air ingress into sealed packs which creates a colour change
- Overwrap the entire pack with a label or shrink or stretch film

Anti-counterfeiting worldwide is increasing. There are many ways of looking at anti-counterfeiting techniques.

- Overt or showing a complicated, difficult to reproduce device or design that can be clearly seen and is aimed at deflecting the counterfeiter away from the product.
- Covert or including secret marks or information known only to the manufacturer, usually used for identification in the storage, distribution and retail systems.
- Security inks are also used. A new ink has been developed for the inkjet printers. This has been used in a multiple coding system designed to prevent empty used wine or spirit bottles being refilled and resold. Some of the codes are printed invisibly across joints, thereby making it more difficult to match them up.
- Holograms are used as one of the anti-counterfeiting techniques.

Promotional Opportunities

Use of promotional devices in packaging is on the increase. The advent of the shrink sleeve gave the marketers one type of surface upon which to practise their methods, and others are the two-sided printed and replaceable labels.

- **Label Leaflets:** The basic concept of combining the basic labeling information with additional consumer information is expanding, e.g. on the pack of honey a leaflet is provided

on the cap which says about different usage and positive side of the honey. Second example is of pickles pack which used to provide a tag on the neck of the bottle that mentioned the type of the pickle in that pack and one recipe which could be made with that pickle.

- **Decoration:** A novel patented decoration technique, using gravure printing, has been developed in Europe. This is claimed to be an alternative to conventional aluminium coated labels. The process consists of printing with gravure offset, using a specialized ink containing very finely divided aluminium particles, which may also be coloured to give gold or metallised colour effects. The advantage over conventional techniques is that significantly less pollution is generated by the process, i.e. less inks and heavy metals and no solvents used. The technique is called AluPart and has been used as decoration on a beer brand.

- **Fragrance Labels:** These are made by special kind of process. An introduction into this area is the micro-encapsulation process. The label gives the fragrance, when stretched.

Future Developments

Developments are likely to take place in variety of aspects.

- **Laminated Labels:** Labels are developed with different types of laminates, which increases the shelf-life of label, attraction and other aspects.

- **Security Labeling:** In the short term, the closer integration of the embossed hologram with the label manufacturer/converter is becoming a reality. The newly-created photo-polymer holograms are starting to make an entry into the industry and are predicted to expand in the longer term. Usage of this kind of technique will help in tamper evidence.

- **Time/Temperature Labeling:** This type of labels will be used more and more for common food products in India.

Temperature Labelling

- **Sleeves:** Sleeves are always likely to be required where there is a need for both a large surface area of decoration and the need for tamper evidence, particularly on regular-shaped containers. There are likely to be developments of a hybrid sleeve that contains some adhesive, which could be activated by some external means.

- **Barcodes:** It appears that the barcode is here to stay. It has developed into data compression with 2D codes and it would not be surprising if this is continued and extended to 3D codes as well.

There is talk of a 'watermark' invisible barcode system that will help to solve the use of area on small labels more efficiently, since they would be underneath the printed decoration, be scannable but not affect the copy design. This might also be utilized as a covert security system. It also appears that the labeling of individual fresh fruit with 'snowflake' codes is likely to be taken up in the near future.

Barcode

Caps and Closures

Closure is a sealing or covering device affixed to or on a container for the purpose of retaining the contents and preventing contamination thereof. Cap is a cover type of closure with external threads to engage external threads of containers or may be held by friction, air pressure etc. against external parts of opening.

In today's aggressively competitive food packaging industry, at least three important demands are made of a closure:

- It must be absolutely reliable
- It must aesthetically enhance the product it contains
- It must be supplied at a competitive price

These three criteria are critical in the food market where the consequences of product contamination are often too monumental to think about. The innovations in caps and closures in all sectors have been considerable in recent years.

Closure Functions

A closure is an access-and-seal device attached to glass, plastic and metal containers. This includes tubes, vials, bottles, cans, jars, tumblers, jugs, pails, and drums. The closure works in conjunction with the container to fulfil various functions for food products as are mentioned below:

- **Positive Seal:** A packaged product is vulnerable to many forms of natural deterioration, including migration of water vapour, oxygen, carbon dioxide or contamination by microbes. The closure must provide an adequate seal until the contents are required for use. Usually this entails preventing escape of the contents and ingress of the external environment. Two closure methods provide containment and seal: friction-fitting closures - including snap-ons and thread-engagement closures - including plastic screw caps with continuous-thread or once at different interval. The degree of seal tightness, however, is dependent on the product packed, closure, container, and seal desired, the resiliency of liner, the flatness of the sealing surface and tightness or torque with which the closure is applied.

- **Access:** Contemporary closure design is shaped by the demands of pluralistic marketplace where strong consumer preferences for convenient access exist alongside legal mandates for access control. Many packages today are ergonomically designed systems capable of easy opening and dispensing and also affording critical access control. Closure technology has always sought to provide "a tight seal with easy access", but today's simultaneous demands for easy access and access control are the most polarised in the industry's history. In most instances it must be possible to open the container without difficulty and reseal it properly when only part of the contents is used at a time. Alternatively, of course, the closure may be provided with a dispensing device, such as a spout for oil container, which is operated without removal of the closure.

- **Control:** Concurrent to greater demand for convenience, often one-handed, access to a product, legal mandates and consumer preferences press for more access controls. These access controls are of two major types: tamper-evident and child-resistant.

  Regulated Tamper-Evident (TE) closures may be breakable caps of metal, plastic, or metal/plastic composites. In one variety, the closure itself is removable but a TE band remains with the neck of the bottle. In another, the TE band is torn off and discarded.

Best example is of packaged drinking water. Another system incorporates a vacuum detection button on the closure. Other TE systems include paper, metal foil, or plastic inner seals affixed to the mouth of the container. Child-resistant closures (CRCs) are designed to inhibit access by children under the age of five. This is frequently accomplished through access mechanism involving a combination of coordinated steps, which are beyond a child's level of conceptual or motor skills development. Of these closures, 95% are made of plastic: the remaining 5% combine with plastic.

- **Product - closure Compatibility:** The closure must not affect the contents of the container, nor be affected by them. It should be resistant to any climatic conditions likely to be encountered and it may need to withstand conditioning or processing treatment, such as pasteurization or sterilisation. The product/closure interaction is affected by the area of contact between the closure and the product and by the fact that many screw or snap-on closures may be fitted with internal wad or liner so that the closure material does not contact the contents. With narrow-necked bottles, the area of contact is very small in relation to the volume of the contents. Since migration is proportional to area of contact, the resultant hazard is small, with wide-mouth jars; of course, the area of contact can be quite appreciable.
- **Verbal and Visual Communications:** The closure is a focal point of the container. As such, it provides a highly visible position for communications, an integral aspect of today's packaging. Three communication forms include styling aesthetics, typography, and graphic symbols. Since the closure is handled and seen by the consumer every time the product is used, the audible, visual and tactile message (often subconscious) becomes very important to the packager.
- **Impact Resistance:** The closure may also have to comply with certain performance requirements. Impact strength may often be a factor, for example, especially where conditions are severe, either on the filling line or in the distribution system. The closure may also have to be resistant to cracking and creep in order to withstand excess torque during screwing-on (as with screw caps) or other internal forces. Thermosets, such as phenol formaldehyde or urea formaldehyde are generally brittle but usually have excellent resistance to creep. HDPE has good impact resistance and is fairly rigid. Its creep resistance is limited, and this affects torque retention adversely. Of the other plastics commonly used for closures, high-impact polystyrene has good impact resistance and creep resistance. Polypropylene homopolymer gives a good overall spread of properties.

Types of Closures

It is possible to place all closures into clean-cut categories where there is no overlap of functions. Yet despite these limitations, a classification can provide focus for understanding contemporary closure trends. As defined by their utility the four classes of contemporary closures are - containment, convenience, control and special purpose.

- **Containment Closure:** Though all closures provide containment, a containment closure is here defined as an on-place cap whose primary function is to provide containment and access on vast production scales. CT caps (for general-purpose sealing), crowns and roll-ons (for sealing of pressurised beverages), lug and press-on caps (for vacuum sealing of food) are within this class of containment closure.
- **Convenience Closure:** Closure development in recent years has been in response to consumer preferences for convenient access to the product. Convenience closures provide ready access

to liquids, powders, flakes, and granules for products that are poured, squeezed, sprinkled, sprayed or pumped from their containers.

Some of the convenience closures used for food packages are:

- **Fixed-spout Closures:** A spout is a tubular projection used to dispense liquid and solid materials. It may be fixed or movable, and capable of dispensing a product in a wide ribbon/a fine bead depending on size and configuration of the orifice. Fixed-spout caps incorporate a cylindrical or conical projection into the centre of a threaded or friction-fitting closure. Spouts on reusable containers are often sealed by a small sealer tip on the end of the spout. On some sealed spouts, dispensing control can be attained by cutting the spout at various heights, thereby providing different orifice sizes. A more contemporary form of fixed-spout closure is moulded with a smaller sealed spout on the top of the cap called "snip-tops". They are one of the most inexpensive forms of dispensing closures.

- **Movable-spout Closures:** Also referred to as turret, swivel or toggle types, the movable-spout concept features a hinged spout which can be flipped into operating position and reclosed with the thumb alone to provide one-handed access and reseal. Most movable spouts are two-piece constructions, though one-piece swivel spout design requiring one manufacturing operation has recently been introduced. Newer refinements of this type include the incorporation of a tear band across the spout to provide tamper evidence. Valve-spout closures, such as the "push-pull" closure, are opened and closed in a straight-line, vertical fashion. "Twist spouts" employ a tapered flange design and open and close by a twisting motion.

- **Plug-orifice Closures:** These closures first aided in the dispensing of personal-care and cosmetic products, and are now used in conjunction with multilayer high-barrier plastic bottles for convenient dispensing of food products. The hinged-top designs represent the wave of the future in food packaging. The closure consists of a dispensing orifice incorporated into a screw-on base closure and plug, hinged within the top of the closure or moulded into a flip-up hinged cap. In the polypropylene plastic versions, the plug and orifice provides a friction-fitting seal which produces an audible "snap" when engaged, an instance where a closure can communicate its sealed state by sound. The top of "snap-top hinged closure" swings open on two or three external hinges. The "disc closure" is another plug-orifice type, a two-piece design consisting of an orifice closure base and a plug fitment hinge to a round disc which is set into closure top. By pressing upon the access point, the disc fitment swings up upon its hinges, deactivating the plug seal from the orifice for one handed dispension. Some of these designs also produce audible "snap" on engagement and disengagement.

- **Tamper-evident Closures:** Tamper-evident caps have been in use for years, though earlier they were referred to as "pilferproof caps". Today these metal and plastic caps provide visual evidence of seal disruption and are used for over-the-counter (OTC) drugs, beverages and food products. The two kinds of TE closures are "breakaway" or "tear band" closures used for pressurised and general sealing applications. The closure user can also fulfil tamper-evident requirements through the use of innerseals, which cover the container mouth.

The two forms of tamper-evident caps are - mechanical breakaway and tear bands.

- **Mechanical Breakaway:** These are threaded caps with perforations along the lower part of the skirt which form a "break line" in the closure. When the closure is twisted for removal, the band, which is locked to the finish by crimping or rachets, separates from the closure along the break line.

  The cap is removed and the lower part of the skirt remains on the container neck. The breakaway cap can be efficiently applied, is highly visible, familiar to consumers and is durable enough to maintain its integrity throughout distribution. Metal closures of this type frequently crimp the band to the container neck for a friction hold. Variations in this type of TE closure include different band designs and methods of off-torque resistance.

- **Tear Bands:** These types, frequently called tear tabs, employ a locked band to prevent cap removal. Access is accomplished by completely removing the band from the container. Frequently protruding tab is easy for the consumer to grasp and commence tearing. Many non threaded TE closures utilise this type of closure, such as the press-on friction fit closures found on milk containers. The closure is removed by tearing off the lower skirt, which overrides a bead on the container finish. Most of the removable-band types are made of plastic, usually polyethylene.

Tear Bands

- **TE Vacuum Caps:** Marketing leverage, rather than legal mandate, accounts for the expansion of TE into food packaging. These measures are not referred to as "tamper-evident" in label or closure communications, but are placed in a more positive light, such as "Freshness Sealed" or "Safety Sealed". The two major types of TE vacuum closures are vacuum button and vacuum tear-band caps.

  A popular TE option for food products packaged in glass containers under vacuum is the "button-top closure". These include lug versions used for jellies, sauces and juices and the threaded-seal version popular with the baby-food industry. A safety button, or coin-sized embossment on the top of the cap, pops-up as the jar is opened and its vacuum is lost. Accompanying this is the "pop" which serves as audible evidence of an undisrupted seal. When capped the embossed button is held down by vacuum pressure, providing the consumer with visual evidence that the container has not been opened. Another type, the "vacuum tear-band closure", is a two-component closure used for the packaging of nuts and condiments. It consists of a metal vacuum lid inserted into plastic tear-band closure skirt. Protrusions moulded into the plastic collar provide friction-fitting resealability for the container.

- **Special-purpose Closure:** Special-purpose closures are those which are of specialized application or premium design. These include aesthetic closures, special-function closures, stoppers and overcaps.

  - Stoppers: The wine and champagne industry is the largest user of stoppers. Cork stoppers are standardised by size and grades, the latter according to

the degree of product vintage. Stoppers of natural rubber, synthetic silicone rubbers, and thermoplastic materials provide closure in some applications.

- Overcaps: The overcap is a secondary cap designed to protect the primary closure, dispenser, or fitment of a container. Metal or plastic overcap designs attach to the container by friction-fit or thread engagement, and are used to protect an aerosol and dispensing fitments.

- Wire Ties: This type of closure is one of the two closures, which have emerged as the standards of the baking industry. Different models are used to attach to different types of bread and buns. This type of automatic bag-closing equipment is limited to about 60 packages per minute.

Closure Materials

Closures are made of plastics, metal or glass.

- **Plastic Closures:** Moulded plastic closures are divided into two groups: thermoplastics (e.g. polyethylene, polypropylene and polystyrene) and thermosets (e.g. phenolic resins and urea components). Thermoplastic materials can be softened or recycled by heat; thermoset materials cannot be recycled once they are moulded.

  Thermoplastics

  In general, thermoplastic closures offer the packager light weight, versatility of design, good chemical resistance to a wide range of products, and economical resins and manufacturing processes. Their relative flexibility is essential to contemporary closure design with its emphasis on convenience and control devices. Thermoplastics provide good application and removal torque. They maintain a good seal and tend to resist back-off. Unlike thermosets, thermoplastics can be pigmented in full-colour spectrum in strong, fade-resistant intensities. Most thermoplastic closures are produced by injection moulding, although some are made by thermoforming. Polypropylene and Polyethylene account for about 90% of all thermoplastic closures.

  - Polypropylene: Polypropylene has unusual resistance to stress-cracking, an essential characteristic of hinged closures. In thin hinged sections, it has the remarkable property of strengthening with use. The homopolymer has limited impact resistance, but it can be modified for better performance. It has excellent resistance to acids, alkalies, oils and greases, and most solvents at normal temperature. It has the best heat resistance of all polyolefins, with a high melting point suitable for sterilised products, but it becomes brittle at low temperatures. Polypropylene has better printability than polyethylene but both are inferior to Polystyrene or thermosetting plastics in that respect. As a relatively rigid moulded material, it has outstanding emboss potential for closure communications.

  - Low Density Polyethylene: LDPE is resilient and flexible. It is relatively tasteless and odourless, although some organoleptic problems are more prevalent with LDPE than with Polypropylene. It provides outstanding moisture protection, but it is not a good gas barrier. LDPE's economy as a closure material is provided by low-cost resins and relatively short injection-moulding cycle times. Though it is considered to have good resistance to stress cracking, problems may occur in the presence of

certain chemicals. Communication embossments are good but limited by the softness of the material.

- High Density Polyethylene: Compared to LDPE, HDPE is stiffer, harder and more impermeable. It is tasteless, odourless and impact-resistant, but will stress-crack in the presence of some products unless it is specially formulated. Its heat resistance and barrier properties are superior to LDPE. HDPE resin is more expensive than LDPE, but it is still considered a relatively low-cost material. A particular drawback to HDPE closures is a potential for warpage and loss of torque.

- Polystyrene: Polystyrene is used for about 10% of the closures produced today. Polystyrene homopolymer is attacked by many chemicals, is very brittle, has relatively low heat resistance, and does not provide a good barrier against moisture or gases. Many of the disadvantages of polystyrene are overcome by rubber modification and/or copolymerization.

Thermosets

Phenolic and urea compounds have wide range of chemical compatibility and temperature tolerances. Some thermosets can sustain sub-zero temperature. Thermosets cannot provide the colour range or intensity of thermoplastics, but they accept vacuum metallising decoration in silver and gold with superior adhesion qualities. During the moulding process, thermosets undergo a permanent chemical change and cannot be reprocessed as thermoplastics can be. Thermoset closures are manufactured by compression moulding.

- Phenolics: Phenol-formaldehyde closures are hard and dense. They are the stiffest of all plastics, but are relatively brittle and low in impact strength. The properties of phenolics depend to a large extent upon the filler material used. Cotton and rag fibre additives increase the impact strength; asbestos and clay additives improve chemical resistance. Phenolics have excellent solvent resistance and heat resistance. Phenolics cost less than urea, and are easier to fabricate, but are limited in colour to black and brown unless decorated.

- Urea: Urea-formaldehyde is one of the oldest plastic packaging materials, first used in the early 1900s. The resin produces extremely hard, rigid closures with excellent dimensional stability, but is the most brittle. Urea compounds are odourless and tasteless, with good chemical resistance. They are not affected by organic solvents but are affected by alkalies and strong acids. They show good resistance to all types of oils and greases. They withstand high temperature without softening. Urea compounds are available in white and a wide range of colours, but with muted intensities compared to thermoplastics. Urea compounds, like phenolic resins, do not build up static electricity which leaves them free of dust. They are the most expensive of the plastic closure materials.

- **Metal:** Metal caps, the strongest of closures, are used today for general, vacuum and pressurized applications. Tinplate and tin-free steel are used in the production of continuous thread, and vacuum press-on closures, lugs, overcaps and crown caps. The largest market for steel closures is vacuum packaging. Aluminium closures are primarily continuous thread caps and roll-on designs.

- **Glass:** Glass closures are normally not used for food products.

Types of Plastic Closures

Fin-lok

Beverage closure with mechanical tamper evident band.

Application	Soft drinks, Liquor
Material	Polypropylene
Seal	Plastic Mold Lining, Packing Liner
Size	28, 36, 38mm
Filling	Flat, Hot-fill, CSD
Bottle	Glass bottle, PET bottle

NC-Flap

Two types of NC-Flap are available, one is One-piece linerless and the other has inner plug. Mechanical tamper evident band has flaps which engage with locking ring of the bottle finish.

Application	Soft drinks, Condiment
Material	Polypropylene
Seal	Linerless, Inner-plug
Size	28mm
Filling	Hot-fill
Bottle	PET bottle, Glass bottle

Uni-lok

One-piece linerless plastic beverage closure. It is designed for aseptic-filled beverages in PET bottles. It features high tamper evidence - ratchet band mechanism with dual threads.

Application	Water, Soft Drinks, Chemicals
Material	PP for Soft Drinks, PE for Chemicals
Seal	Linerless (for soft drinks) Packing liner for chemicals
Size	27 mm for Soft Drinks 25, 30, 40 mm for chemicals
Filling	Aseptic, Flat
Bottle	PET bottle, Plastic bottle

NC-lok

Ratchet type of Tamper Evident band.

Application	Soft drinks
Material	Polypropylene
Seal	Plastic mold lining
Size	28mm
Filling	Hot-fill

Pouch Spout Cap

Specially designed for food and beverage packed in pouches. The closure has tamper evident band and spout for drinking or pouring.

Application	Soft drinks, Condiments
Material	Polypropylene
Seal	Liner-less
Size	12, 21, 27mm
Filling	Hot-fill, Flat
Bottle	Pouch

Sports Push-Pull Cap

Developed for beverage in the active scene. Convenience to drink and security of sealing forms in the design.

Application	Soft drinks
Material	Polyethylene, Polypropylene
Seal	Inner plug
Size	28mm
Filling	Hot-fill
Bottle	PET bottle

AOV Cap

Heat shrink tamper evident band. Inner plug gives it convenient pouring with drain-back feature.

Application	Condiment
Material	Polyethylene
Seal	Linerless
Size	28mm
Filling	Hot-fill
Bottle	Glass bottle

Pull-Cap

Two piece tamper evident condiment cap. Tear off the pull-ring to break the seal. Upper body has thread and can reseal. Detachable type is also available.

Application	Liquid condiment
Material	Polyethylene
Seal	Linerless
Size	26, 32mm
Filling	Flat, Hot-fill
Bottle	Glass bottle, PET bottle

Smooth Hinge Cap

No slits on the top panel, thus make the package hygienic. The lid opens widely with adequate snapping. Various types and sizes of orifice are available.

Application	Desert toppings, Icing,
Material	Polypropylene
Seal	Linerless
Size	24, 25, 26, 27mm
Filling	Flat
Bottle	Plastic bottle

Smooth Pull-hinge Cap

One-piece condiment cap with snap open hinge and tear -off opening pouring mechanism. The closure is plugged on the bottle. This closure can be detached from the bottle.

Application	Liquid condiment
Material	Polyethylene
Seal	Linerless
Size	26, 32mm
Filling	Flat, Hot-fill
Bottle	Glass bottle, PET bottle

Side-score Cap

Tear-off the side score to break the seal and remove the closure from the bottle.

Application	Milk
Material	Polyethylene
Seal	Linerless
Size	37, 42mm
Filling	Chilled filling
Bottle	Glass bottle, Plastic bottle

Push-pull Cap

Pull up the top knob to open and push it down to close.

Application	Sports drink, Kitchen detergent
Material	Polyethylene, Polypropylene
Seal	Linerless
Size	25, 30mm
Filling	Flat
Bottle	PET bottle, Plastic bottle

Sealing Systems

Though often the smallest aspect of a package, the seal is responsible for keeping the entire concept intact. If the seal is not maintained by the closure, liner and container working together, the success of the product is at stake.

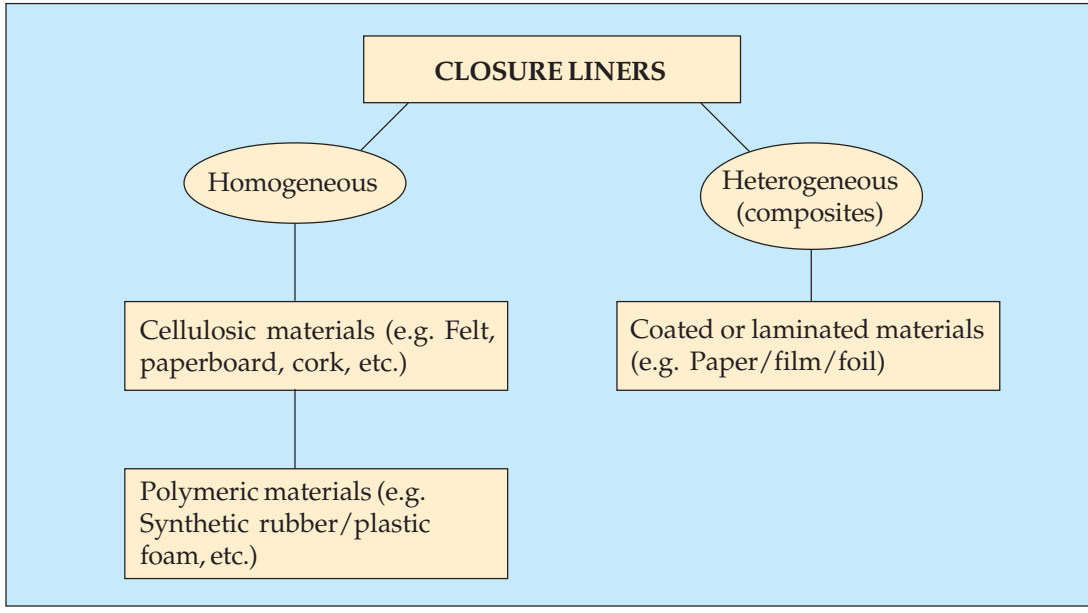
Liners

Today's lining material is either a single substance (usually paperboard or thermoplastic) or a composite material. Synthetic thermoplastic liners include foamed and solid plastics of varying densities. A composite lining material consists of a backing and a facing. The backing, usually made of cellulose or thermoplastic, is designed to provide the proper compressibility to affect the seal and proper resiliency force sealing. Facing materials, representing the side of a composite liner that comes into direct contact with the product are numerous, as are the variables of product chemistry which they must contend with. Generally, facing materials are thermoplastic-resin-coated papers, laminated papers of foil or film or multilayer types devised for special applications.

Actually, it is the liner, which plays the vital role in the success or effectiveness of a closure in particular, and package performance in general. According to their composition, liners can be broadly classified into two groups, namely homogeneous and heterogeneous. Refer figure 2.

As mentioned earlier, most closure liners contain two basic components - backing and facing. The backing provides compressibility, resiliency and re-sealability, and the facing provides mainly barrier protection and compatibility. In some liners, one component serves both functions, in some two-component liners are required.

Figure 2: Classification of Liners



Selection of Lining Material

The proper choice of a closure liner can often make the difference between the success and failure of a product. If the package integrity is not maintained due to improper selection of the closure liner, all other purposes are lost. Obtaining the proper sealing action is no simple matter and doing so at optimal cost requires a judicious evaluation of several variables.

- Product Compatibility
- Secure Macroseal
- Positive Microseal
- Application and Removal torque
- Other Considerations: Besides the above, freedom from odour and taste contamination, heat resistance characteristics, appearance, and above all, the economies are to be considered for selecting an appropriate closure liner.

Options for Closure Liners

The state-of-the-art in liner technology can best be described as 'crowded'. Available choices of liners currently number in the hundreds and new structures continue to appear. The salient features of some common liner materials are given below:

- Backing Material Options
  - Pulpboard: Widely used liner material. It costs less but compresses only 4 to 5% at a standard force (5lbs/sq inch or 0.775 kg/cm^2) with about 80% recovery.
  - Composite Corksheet: Manufactured from granulated cork binded with synthetic resin. It is more compressible, about 30% and recovers 90 to 95% of deflection. It is mostly used with a barrier film such as PVC to prevent permeability to gases and liquids. PVC faced cork liners, though widely used, have a tendency to shrink, thus falling out from the cap. Also, cork stock does not cut clean leading to dust. Other problems being delamination of PVC film due to poor adhesion between cork and PVC surface.
  - Rubber: For serum vials and similar biological product containers, rubber liners are often used to maintain hermetic seal after sterilization. Certain chemicals such as hydrocarbons, oils, esters, and ketones attack and eventually dissolve rubber.
  - Plastic Foams: These offer the exception to all backing material limitations. The resiliency and compressibility of plastic foams can be varied to give enormous diversity of properties.
- Facing Material Options
  - Paper Coated with Varnish or Plastic Resins: These were the first liners and continue to be important, but with the introduction of superior materials their usage is likely to be restricted. Though varnish paper offers good resistance to heat and chemicals, low water vapour transmission and glossy appearance, they tend to be brittle and require additional wax coating for both microseal and macroseal. As for thermoplastic

coatings on paper, the degree of performance is a shade lower as the coating is ordinarily thinner.

- Aluminium Foil: It offers excellent barrier properties but with aqueous products, acids and alkalies, it corrodes quickly. If used with a liquid product, it should be coated with suitable material.
- PVC Film: It is a good choice for resisting oil, grease, water or weak acids and alkalies. It should be avoided in use with organic solvents and essential oils. The water vapour transmission rate is marginal. It may be used with alcohol, provided it is confirmed that plasticisers are not extracted.
- Polyester: It is suitable for alcohols, most organic solvents, oil and grease. It should not be used with acids and alkalies. Water vapour transmission rate is marginal.
- Polyethylene: It stands up to solvents, strong acids and alkalies. Oil and grease resistance is adequate as is water vapour transmission rate. It is the most economically compatible facing material.

Innerseals

The innerseals afford TE protection by sealing the mouth of the container. Three common types of innerseals are inserted by closure manufacturers into the caps. A waxed-pulp backing and glassine innerseals are common within the food industry. After the filling operation, the container runs under a roller system which applies an adhesive to the lip of the container and then the cap is applied. Upon removal, the glassine adheres to the container while the pulp backing remains in the closure. Pressure-sensitive innerseals, generally foamed polystyrene, adhere to the lip upon application and require several hours to set. Heat-induction innerseals are plastic-coated aluminium foils, often adhered to a waxed pulp base liner.

Linerless Closures

Plastic linerless closures provide a positive seal in certain circumstances, foregoing the need for intermediary materials and secondary liner-insertion operations. To many packagers, the cost savings provided by the linerless closure can be considerable. The seal of a linerless closure is achieved by moulded embossments forming diaphragms, plugs, beads, valve seats, deflecting seal membranes or rings which press upon, grasp, or buttress the sealing surfaces of the container. Over a dozen types of linerless closures are in common use, each designed to provide a seal at one or more critical sealing surface, the inside edge of the land surface or the outside edge of the land surface. Some form of land seal in conjunction with a valve or flange represents one type of effective linerless closure design. The land is typically the most consistent sealing surface. A land-seal ring can bite into plastic container finishes or deflect on glass finishes. An inner buttress can correct ovality problems in plastic containers by forcing such off-round finishes back into proper shape.

Adhesive Tapes

An adhesive tape is composed of a backing element in a long strip upon which an adhesive is applied. Its function is to attach the carrier backing to some secondary surface. The attachment is made by activating the adhesive with solvent, heat or finger pressure.

Tapes are used for holding, bundling, sealing, protecting, reinforcing, colour identification and box closing.

Gummed tapes, stamps, etc are the most commonly known variety of solvent – activated tape, that is, the adhesive is activated by wetting with water. For certain industrial application, an organic solvent activated adhesive is used. A second type of adhesive tape is the thermoplastic or heat activated variety. In this construction, the adhesive is made sticky by the use of heat and pressure.

The most rapidly growing line of adhesive tapes is the pressure sensitive variety. This type of tape can be applied with hand pressure in the absence of solvent or heat and sticks aggressively to most common surfaces. Because of its extreme ease of application, it has gained wide acceptance.

Pressure Sensitive Tape

In such tapes, adhesives are composed of a rubbery type elastomer combined with a liquid or solid resin tackifier component. A mixture of resin may be used to provide a balance of properties.

Pressure sensitive tape is used for closing boxes, combining packages, attaching packaging lists, colour coding, pallet unitizing, adding carrying handles, splicing, providing ease of package opening, protecting labels, reinforcing critical package components, holding documents, besides a variety of other jobs.

There are hundreds of speciality tapes available for specific applications in packaging. The common theme is a backing material coated with an adhesive that adheres with a light touch without a need for activating solvent or heat.

- **Box-sealing Tape:** The largest use of pressure-sensitive tape in packaging is the closure of regular slotted containers. A plastic film is coated on one side with a pressure sensitive adhesive. The film may have a release treatment on one side to allow easy removal of the tape from the roll during dispensing. Some film backings also are treated or coated on the adhesive side to increase the bond of the adhesive to the backing.
- **Filament Tapes:** A second broad category of packaging tape is pressure sensitive filament tape, sometimes known as "strapping tape". Filament tape is typically made of a film backing (polyester or polypropylene) with reinforcing filaments embedded in the pressure-sensitive adhesive. The most common filament is fibre glass, which provides a high tensile strength with very little elongation. A few tapes have polyester or rayon filaments for extra impact or cut resistance. Tapes are also available with integral polymeric filaments. The adhesive requirements for filament tapes are as critical as those of box-sealing tapes. Care should be taken to choose a tape with a balance of tack and shear-holding power.

Film Tapes

Polymeric films have found numerous applications as tape and label backings. The properties inherent in polymeric films (impermeability, thinness, smooth surface, good dielectric properties and inertness) are reserved for many electrical, packaging and decorative applications.

Some properties of typical films are shown in Table 2.

TABLE 2
Properties of Typical Films

Film	Tensile Strength (kg/cm)	Elongation (%)	Thickness (mm)
Clear cellophane	5.7	19	0.07
Clear acetate	3.6	20	0.07
Etched acetate	3.6	25	0.08
Acetate fibre tape	8.6	3	0.15
Polyester transparent	4.5	110	0.05
Carton brown vinyl	6.3	40	0.07
Polypropylene clear	3.2	14	0.06
Transparent vinyl	3.6	16	0.07

Cellophane is the oldest transparent film tape. It was and still is widely used as an office and general purpose house-hold tape. Cellophane tape is being replaced by other film tapes. Matte cellulose acetate film tape replaced cellophane in some offices, paper mending and general purpose applications, despite the fact that cellulose acetate film is more expensive than cellophane. Cellophane is hygroscopic, becomes quite brittle when dry and is quite soft in humid atmosphere.

PVC films are widely used as tape backings. Plasticized vinyl film tapes are predominant in electrical insulation applications, while rigid vinyl films tapes are important for packaging and general purpose uses. Unplasticised vinyl films have occupied a dominant position among the packaging and general-purpose film tapes. Polyester film tapes are used in packaging applications where high tensile strength and high tear are important. Oriented PP tapes have replaced polyester tapes in some applications because of its lower price.

Strapping Materials

Strapping is generally the last but a key step in the packaging operation. Strappings are normally used for reinforcing, baling, palletising, unitising, bundling and tying. It is very useful in brace shipments of goods during transit.

Types of Strapping Materials

- Metallic
  - Round Wires
  - Steel Straps (Bands): Steel Strapping is used for unitising very heavy loads or bracing loads inside railcars, tractors and overseas containers. Steel strapping has the highest tensile strength and resistance to tension decay or creep and for all practical purposes does not elongate. In general, steel strapping is used where high strength and high retained tension are required. It is also suggested for high temperature applications.

- Non – metallic
  - Polyester: It has the lowest elongation in the working range and the least tension decay or "creep" of all plastic strappings. This makes it somewhat suitable for medium duty applications, particularly rigid and expanding loads. Polyester strapping generally exhibits good resistance to the effects of temperature and moisture.
  - Nylon: Nylon strapping has the highest elongation recovery of any strapping material which combined with a relatively low stretch gives the highest settling tolerance. In terms of break strength it is comparable to that of polyolefins and polyester strapping material. It has the best cold temperature performance of the plastic group, but is most susceptible to moisture degradation. It is commonly used to unitise shrinking loads of heavy items and loads that can withstand high initial tension.
  - Polyolefin: Polyolefin strap is used to describe strapping made from two closely related materials, polypropylene homopolymer and Polypropylene copolymer. While these materials have excellent resistance to moisture, they are least heat resistant of all the common strapping materials. Of the plastic strapping materials they are the most easily heat sealed or fusion joined. They tend to be more suitable for light to medium duty application like unitising, bundling and carton closure.
  - Rayon

General Uses

- Strap may be used to secure a handling base (skids, platforms, pallets, runners, spacers, etc.) to a unit to expedite handling or to secure other packaging materials (battens, stiffners, wrappings, etc) in position.
- Strap may be used for local securement or within the transport vehicle. It is applied under tension to restrain or control for movement of loading and thus accommodating in-transit shocks or irregular movements.
- Straps also provide security against accidental loss or theft of the contents.
- Different packages can be colour coded with strapping for easy identification in warehouses.
- Strap functions best when all resultant forces act directly parallel in line with the direction of the strap.

Reprocessed Strapping Material

As the name implies it is prepared by the waste materials collected from the road side, scraps coming out of various types of plastic articles, etc. It has low strength but because of its very low cost it is now-a-days used widely.

Conclusion

Ancillary materials – such as adhesives, inks, labels, caps and closures, etc. – along with primary packaging materials provide product package compatibility, product preservation, protection, containment, identification and consumer convenience.

Polymers are the backbone of all ancillary materials used for food packaging, whether it is thermoplastic or thermosetting depending upon the requirement. They provide excellent balance of stability as well as compatibility and can used over a broad temperature range.

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