Qualifications

Diploma in Beverage Packaging (Beer)

Unit 1.1 Packaging Theory and Materials

Packaging Theory

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DIPLOMA IN PACKAGING (BEER) - MODULE 1

UNIT 1.1: Packaging theory and materials

ELEMENT 1.1.1: Packaging Theory

ABSTRACT: This section describes the Development of Packaging from early packaging up to the modern day. It covers the birth of packaging and how it has rapidly developed over the last few decades in terms of what it is, the materials and how they have developed. An appreciation of the benefits and disadvantages of packaging as we know it today is included.

LEARNING OUTCOMES: On completion of this unit you will be able to:

1. Understand the history and development of packaging.
2. Comprehend key packaging materials, their uses and specifications.
3. Understand the basic environmental issues associated with packaging.

SYLLABUS.

1.1.1.1 History and development of packaging:

- Evolution of small pack packaging (glass, cans and plastics) and large pack packaging (casks and kegs)
- Development of packaging from primitive functionality to a sophisticated marketing tool

1.1.1.2 Packaging principles:

- Definitions and examples of primary, secondary and tertiary packaging
- Technical and marketing functions of packaging
- Identification and specification of key components
- Environmental concerns and effects of packaging (see also 3.1.1.5)

Element 1.1.1

Packaging Theory

1.2.1.1 – HISTORY AND DEVELOPMENT OF PACKAGING

What is Packaging?

Packaging today has almost become an art form. It contains, dispenses, communicates, sells, markets and transports goods. All products need to be packaged and there is everything from the sophisticated expensively dressed lightweight glass bottle to the cask.

Packaging is continuously in a state of flux and with the introduction of nanotechnology anything is possible. The estimated value of packaging materials and machinery used for packaging throughout the world is £270 billion, of which the European figure is an estimated £100 billion. Some 60 per cent of all packaging is used for food and drinks. It is a massive business. Beer packaging has not moved at the same pace as the rest of the food and beverage market. The move to plastic, for example, has been through expediency rather than desire. Brewers are conservative and the consumers are fickle. It is interesting that glass manufacture has decreased over the last few years for all sectors except brewing, where it has actually increased! See figure 1.

Packaging in Europe, the USA and Japan have become extremely sophisticated with the Japanese leading the way as the innovators. Packaging in developing countries is comparatively simple with returnable bottling lines and standard bottles. However, with globalisation and marketing influence these markets are introducing complexity which constantly hunts the packager who is trying to increase efficiencies under, what can be, difficult conditions

With all these new packaging ideas comes an environmental concern. The situation is exacerbated by the trend towards single use packaging. Packaging waste is very visible and it has become a major worldwide issue. Sadly many countries are not honest about their waste disposal and although it is said by Government organisations that packaging materials are being recycled, they often end up in a hole in the ground or are exported to another country for disposal! It is a constant embarrassment and there is a lot to be done in this area, especially with plastic.

It is noted that plastic is the environmentally unfriendly packaging material. However, packaging is moving to plastic more and more due to its lightness and flexibility. The key materials used for beverages are Plastics (44%), Glass (29%), Metal (15%), Paper and Board (8%), and others (4%). See figure 2. Looking at the worldwide usages, plastic and paper and board are the favourites with about 65% of the usage.

Life-cycle analysis (LCA) is a technique used as a method

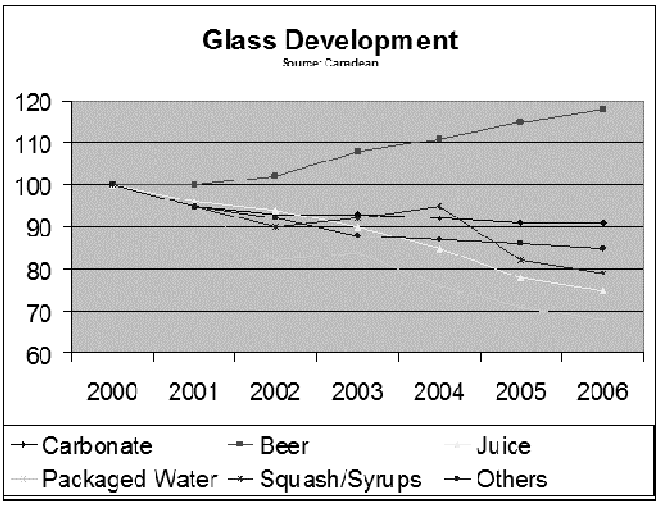

Figure 1 Glass Development

to measure the burden of packaging from cradle to grave i.e. from material extraction to its disposal, recycling or re-use. It also factors in the renewability of natural resources (such as trees for board) as well as the pollution effects.

With the outcry of packaging use going on at present, it is hoped that there will be more intelligent action rather than just words and veneer. For example, there is no reason why plastic, which is an oil derivative, cannot be recovered and perhaps the heat and energy derived from this used to benefit communities from whence it came. Surely this is better than burying it. Due to its inability to degrade, it will be there forever.

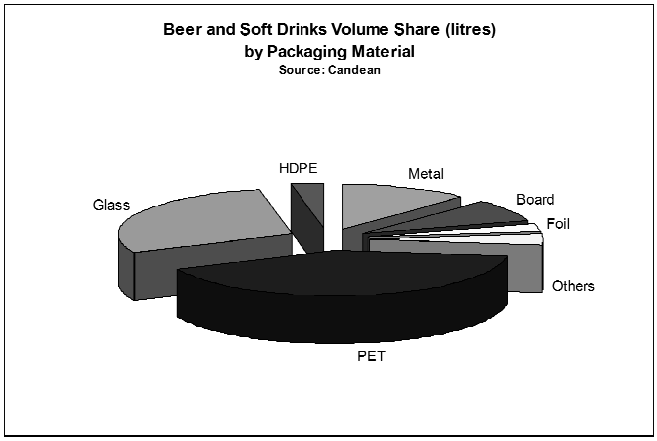

Figure 2 Beer and Soft Drinks Usage of Packaging Materials

A Potted History of the Main Materials

There is evidence of packaging going back to 5000 B.C. However in those days it was a purely practical issue – a means of protecting and conveying produce. There were sacks, baskets and bags made from materials plant and animal materials. Containers were also made from hollowed out logs and clay from the riverbanks could be shaped and dried in the sun and then later by fire.

Glass

Between 4000 and 3000 B.C., depending on the source, there is evidence of glass was first discovered when Phoenician sailors who used salt, nitrate or soda blocks (depends what you read!) to shelter their fires on the beach. They then found the bits of glass in the ashes. Hollowed out containers were evident in Mesopotamia and Egypt around 1500 B.C. These were formed by building up a core on a rod using dung and clay, or compacted sand, and then molten glass was then built up on this core and shaped on a stone or by shaped tools.

A major breakthrough in glassmaking was the discovery of glassblowing sometime between 27 BC and AD 14, attributed to Syrian craftsmen from the Sidon-Babylon area. The long thin metal tube used in the blowing process has changed very little since then. In the last century BC, the ancient Romans then began blowing glass inside moulds, greatly increasing the variety of shapes possible for hollow glass items.

Paper

The invention of paper and paper-based products was generated from man's necessity to communicate with one another and to transport goods. It was the early Egyptians who discovered that the papyrus reed could be used to create a writing surface, whilst in Europe, calf and goat skins were washed, stretched and rubbed smooth with a stone to produce a parchment writing surface. Between 100 and 200 A.D. Chinese papermakers began to pound together the inner bark of mulberry trees with water to produce a pulp. When the water was drained away, the remaining cellulose fibres were poured into a mould and left to dry in the sun before being used as 'paper'. By the 13th century, this method of papermaking had made its way to Spain but it would take a further 300 years to reach England and other parts of Europe.

The introduction of the printing press in the 15th century enabled mass production of books for the first time and created a demand for emerging paper mills that would produce a less costly alternative to parchment. A manufacturing breakthrough was made in France in the 17th century where a moving machine belt replaced traditional paper moulds and enabled a production process to produce paper on a continual basis.

In 1856, corrugated was patented in England and used as a fluted hat lining paper. Some 15 years later, a patent was obtained in America to use corrugated paper for wrapping fragile products such as bottles. Later, in 1874 and also in the United States, the concept of adding a liner to one side of the corrugated paper to strengthen it was patented. Production machinery gradually developed and improved and the first corrugating machines appeared at the beginning of the 1900s running at speeds of about 6 metres/min.

The carton designed for the purpose of transporting goods was known as the regular slotted case abbreviated to RSC.

The first automatic machine started production in 1914. Rising population levels and economic prosperity generated increasing demand for goods. The movement of products from one place to another meant that the need for protective packaging rose significantly.

Cans

The can's history began in 1795 when the French government offered a prize of 12,000 francs to anyone who could invent a method of preserving food. Napoleon's troops were being decimated more by hunger and scurvy than by combat. As his soldiers resorted to foraging for food on their own, Napoleon famously noted that an army "travels on its stomach". Military prowess and colonial expansion required that a way of keeping food unspoiled over distance and time be discovered.

A Parisian named Nicholas Appert came up with the idea. A jack of all trades, Appert used his experience as a former candy maker, vintner, chef, brewer and pickle maker to perfect his technique. After experimenting for 15 years, Appert successfully preserved food by partially cooking it, sealing it in bottles with cork stoppers and immersing the bottles in boiling water. His theory of canning was all his own—Pasteur's discoveries regarding bacteria were still almost a half-century away. But Appert assumed that, as with wine, exposure to air spoiled food. So food in an airtight container, with the air expelled through the boiling process, would stay fresh. It worked.

Samples of Appert's preserved food were sent to sea with Napoleon's troops for a little over four months. Partridges, vegetables, and gravy were among 18 different items sealed in glass containers. All retained their freshness. "Not a single substance had undergone the least change at sea," Appert wrote of the trial. He was awarded the prize in 1810 by the Emperor himself. One of the conditions of the prize was that he disclosed in 200 copies all the details and description of his invention. Appert did that in a book called The Art of Preserving Animal and Vegetable Substances for Many Years.

That same year, an Englishman named Peter Durand was granted a patent from King George III for the idea of preserving food in "vessels of glass, pottery, tin or other metals or fit materials". Durand intended to surpass Appert and fashion containers out of tinplate. Made of iron coated with tin to prevent rusting and corrosion, tinplate could be sealed and made airtight but was not breakable like glass. A cylindrical canister and soldered lid would be much easier to handle than a fragile bottle with an unreliable cork.

Two other Englishmen, Bryan Donkin and John Hall, used Durand's patent and, after more than a year of experimentation, set up the first commercial canning factory using tinplate cans in Bermondsey, England in 1812. If the French military was to travel farther and longer on their provisions, then the British needed to be able to do so as well. By 1813, Donkin's tins of preserved food were supplying the British army and navy. The Royal Navy used as many as 24,000 large cans—nearly 40,000 pounds—on

its ships each year by 1818. The nutritious canned vegetables were a great relief to sailors who previously had relied on live cargo or salted meat and were often plagued by debilitating scurvy. It was believed that the salt caused the condition, when it was actually because the salt-cured foods lost most of their vitamins and nutrients in the preservation process.

A much sturdier container than that used for food products was required to withstand the 80 to 90 psi pressure of pasteurization, In contrast to the 25 to 30 psi used in food processing.

The major problem the early researchers were confronted with, however, was not strength, but the can's liner. Several years and most of the early research funds were spent to solve this difficult problem. Beer has a strong affinity for metal, causing unacceptable haze and metallic flavours. The brewers called the condition "metal turbidity".

The American Can Company produced the flat or punch top can in 1934. The lining was made from a Union Carbide product called "Vinylite", a plastic product which was trademarked "keglined" on September 25, 1934.
Unlike the bottle, the can could be made in many shapes and designs, and the brewers liked the ability to use the whole can's surface to promote brand recognition.

While the punch top can lent itself to rapid filling, the equipment required was expensive. The Continental Can Company recognizing this limitation to the punch top can developed a new shape they called a "cap sealed" or cone top can. See figure 3. This new can, similar in shape to a bottle, could be used with existing bottle filling lines.

Continental found a waxy compound which they sprayed on to form the can liner. Their early advertising stated that "the liner is applied after the can is made, further ensuring a complete seal between the metal and the beer".

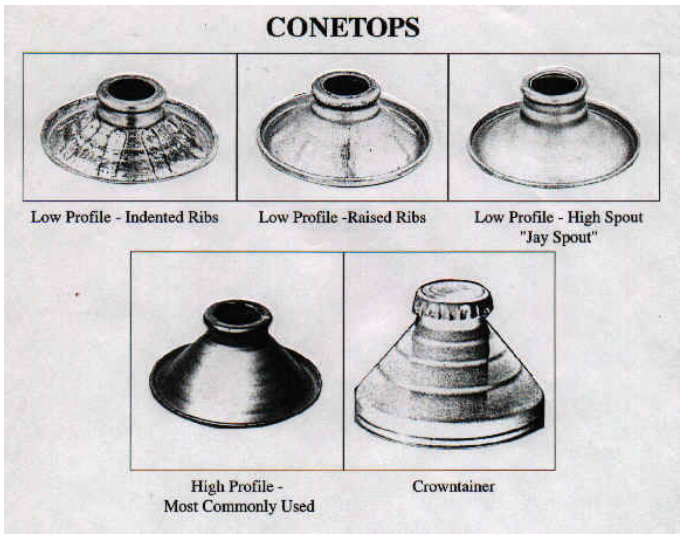

Figure 3 Different Cone Tops

The first brewery in the British Isles to sell beer in cans was a small Welsh brewery in December 1935.

The story is much the same on both sides of the Atlantic. No big brewer would take the risk in putting their beer in a can.

In 1931 near the end of Prohibition American Can started to develop the can for beer. After two years of research they were ready to try their can in the market, and not finding any takers, approached a small brewery called the Gottfried Krueger Brewery in Newark New Jersey. After 13 years of Prohibition and the death of their founder, followed by a strike they were in a vulnerable position. American Can offered to put in the equipment free which need only be paid for if the venture was a success.

Initial trials were deemed successful and the first beer, Krueger's Finest Beer, went on sale in January 1935. By the end of 1935, 37 breweries were producing beer in can!

In Britain, Metal Box Co had seen the developments across the Atlantic and began looking for a British brewery that would be willing to package its beer in cans. Unfortunately, many of the breweries did not believe that canned beer was a viable.

In 1934 Sanders Watney went on record in a published article saying 'I am not convinced that there would be any demand in this country for beer in cans. I cannot conceive the idea of a can ever replacing the half pint, pint or quart bottle. The canning habit is certainly growing, but I do not think it will spread to drinks'

A small independent, Felinfoel Brewery Co of Llanelli, Wales, took up the challenge to be the first brewery outside of the USA to sell its beer in a can. The cans were 'conetops' see figure 4, supplied by Metal Box, and looked similar to a can of metal polish and were sealed with a crown cork. This allowed them to be filled on a standard bottling line. Two sizes were produced, 10oz for the domestic market and 12oz for export.

Figure 4 Cone topped can

During the following year, other breweries began to show an interest, especially those involved in the exporting of beer. John Jeffreys of Edinburgh produced Scotland's first beer can, Jeffreys' Padlock Brand lager in both 10 and 12oz sizes. This was soon followed by Barclay, Perkins; Hammertons; Wm. McEwans; Simonds and J. & R. Tennent.

Figure 5 Various cans

The next progression was to the flat topped can which was opened with a beer can opener see figure 5 which punched a triangular hole on adjacent sides of the can. One large hole for drinking from; the other, a small hole to allow the air to displace the beer.

The next phase was in the introduction of aluminium ends for the three piece cans and the invention of the ring pull or as we know it, the tear off tab (TOT) in 1959. It was first used in 1963 and the first all aluminium two piece can in 1964.

Although the ring pull was a break through these tabs, when removed, were cause for concern as they created litter and were a danger to animals, especially cattle, horses and deer that may accidentally eat them with the grass. As a result the stay on tab (SOT) was invented and was in use in 1975.

Most activity now is around light-weighting of cans.

Plastics

The word plastic means the ability of a substance to be moulded from any substance such as wax, clay, tar, shellac, straw pulp etc. The Oxford Dictionary definition today gives it as 'a synthetic material made from a wide range of polymers which can be moulded into shape while soft and then set into a rigid or slightly elastic form'.

The first synthetic material was called celluloid was discovered by an American, John Wesley Hyatt, in 1868. His incentive was to invent a material that could replace ivory which was used to make billiard balls. The process involved the mixing pyroxylin, made from cotton (one of nature's polymerics), and nitric acid, with camphor. Celluloid was later used by George Eastman to make the first photographic film for the first motion film in 1882. It is still used today!

Some time passed before in 1909, Dr. Lee Hendrik Baekeland, was able to produce a controllable reaction between phenol and formaldehyde. This involved using a catalyst, hexamethylenetetramine, and the use of pressure to suppress the foam during the reaction. The resultant material was known as Bakelite after its inventor. This material and others based on formaldehyde were difficult to form and were brittle. Earlier electric plugs were often made from this material and broke easily – it was not unusual to see wires laid bare or a heavily taped plug! This was the first synthetic plastic.

In the 1920s a number of plastics followed, for example, cellulose nitrate, urea-formaldehyde and polyvinyl chloride (PVC) in 1927.

The next big development came in December 1935 when the Imperial Chemical Industries (ICI) reacted ethylene under high pressure with a chance addition of some oxygen in their laboratories. This produced a material known as polyethylene (PE). During World War II this material was used in large quantities to insulate communications wire. At the end of the war demand dropped and so new markets were looked for. This was when this plastic was found to have ideal properties for use in the packaging industry. See Unit 1.3 for further information.

During the 1950s a large number of different polymers were developed, amongst them polypropylene.
A simple synthetic plastic is formed when a number of repeating units come together to form a large molecule from the often referred to as a polymer. This is formed from the Greek words 'poly' meaning many and 'meros' meaning parts. The unit is known as a monomer where 'mono' means one.

The term 'copolymerisation' is also used. In this instance two or more different monomers are polymerised.
More information is readily available on the web or in the recommended reading material.

Packaging General

In 1746 the first packaged branded product was launched, in England. Dr Robert James sold his "Fever-Powder" in a box. A few years later, Yardley of London began selling its famous lavender water in glass bottles, and Crosse & Blackwell began selling olive oil and mustard in jars. A. F. Pears, also in England, launched what was to become one of the most consistently prosperous industries in the world when he established the first packaged soap company.

Through the late 18th and into the 19th century decorative packaging was restricted to 'upmarket' packs. The real changes took place in the 20th century around the 1960s when fast foods made their appearance. New materials, such as polyethylene came onto the market and peoples shopping habits started to change. The small shop grew into the general store which in turn expanded into supermarkets with national distribution. This lead to the rapid development of packaging materials that were not only for decoration but also had to stand up to the rigors of the transport system. Further, products were in competition on the shelf – there was no friendly shopkeeper to advise the customer on what to buy.

During the 1960s and 70s refrigeration and microwave cooking have had a significant effect on packaging. Cartons with varnish that prevents sticking when placed in a deep-

freeze, and packs that will withstand both conventional and microwave ovens were developed to suit modern eating habits. Plastics have played a significant part. Plastic films can provide barriers to air, containers can be moulded in a myriad of shapes, and plastic textiles can be woven to give strength and security for, say, bulk bags of fertilizer.

Inevitably with all the packaging came legislation. Packaging is visible and there was a growing concern for the environment. Tamper-evident (was known as 'tamper-proof' but it is recognised that that is hardly ever possible) packaging was developed. Also child-resistant closures which often precluded the elderly from opening their medicines as well!

Packaging today is a major industry which has really only seen major development over the last half century.

1.1.1.2 PACKAGING PRINCIPLES

The Definition of Primary, Secondary and Tertiary Packaging

Primary

The product cannot be sold without these materials. They contain the product and meet legislation e.g. bottle, crown and label or can and can end with product and best before information. The keg or cask is a primary package. The labelling is still important – this is usually a paper label, but can also be in ink.

Examples:
Bottles (Glass, Aluminium & PET), Cans (Aluminium & Steel), Crowns (Tin Free Steel, Tinned or Stainless Steel) Roll on Closures (ROC), Labels or Sleeves (Paper, OPP - Oriented Polypropylene, PVC - Polyvinyl Chloride, PET - Polyethylene Terephthalate, PETG - Terephthalate Glycol) , Glue (Hot Resin, Casein, Dextrin), Kegs, Spears and Casks

Secondary

This effectively is the material that collates of the primary package in some form i.e. a second layer of packaging. This turns the primary package into a saleable or marketable unit. There is no secondary packaging for kegs or casks – although it can be argued that the secondary packaging is the dispenser in the on-licence premises.

Examples:
Board (Carton, Tray, Layer Board, Kraft & Corrugated, Sleeve Wrap & Multipacks (Board & Film), FEC (Board & Film), Hi-Cone, Crates

Tertiary

This relates to the remainder of the packaging. Its purpose is to protect the finished product, and allow it to be transported safely, and without damage, to its final destination.

Examples:
Pallets, Locator Boards, Stretch & Shrink Film, Tray/Shrink (If it is covering Secondary)

There are two main functions of packaging, these are:

- Technical Functions
- Marketing Functions

Technical Functions

- Containment
  - Holds contents without leakage
- Protection
  - Productor Package does not hurt the consumer
- Preservation
  - Product will keep for the period described as the shelf life of the product which be up to the best before date and is not responsible for imparting flavours
- Measurement
  - Holds the legally declared quantity
- Dispensing
  - Dispenses easily
- Storage
  - Will travel and store successfully
- Legal Compliance
  - Meets Weights and Measures and Customs and Excise Legislation. Also Due Diligence
- Lowest Cost
  - Budgets must be met or bettered

Marketing Functions

- Communication
  - Product name and anything else about the product
- Display
  - Looks good on the shelf. Neat, tidy and well packaged
- Information
  - Contents, ABV, Best Before, Batch Number and any other relevant information which will normally be a legal requirement
- Promotion
  - Packaging is often used to promote a product – a peelable label for example
- Selling
  - Final packaging will sell the product

The Technical and Marketing Functions will differ on bulk pack mainly on the marketing points, as this will be done at the point of dispense. The technical functions are only slightly different in that the dispensing takes place at the on-licence. However it is important that the valve arrangement is functioning properly and gives a hygienic and hermetic union with the tapping head.

Functions as Specifications See Under 'Quality and Hygiene' for further details on Specifications

Packaging functions are not always clearly understood. They must cover to three major criteria:

- Meet marketing expectations
- Perform on the packaging line and during stacking
- Be adequate enough to protect the unit of sale up the shelf

Due to the number of stock keeping units (SKUs) that most packaging plants have to contend with it is important that specifications are clear, unambiguous and are signed off by the supplier. One way of doing this is divide the specification into three parts as follows:

First
This is an overall policy statement. It will normally relate to a restriction in chemical treatment or the use of compounds which could affect the product. This will also include the requirement for tests should the supplier wish to use a different form of treatment; for example, the use of a different lacquer inside a beverage can. It may also include an environmentally based statement that requires a percentage (usually maximum) of the supplied material to be recycled or not, as the case may be.

Second
This will cover all components that come under a common heading, such as bottles, cans, trays, cartons, film etc. This will include the general description, technical requirements, quality and environment specific to the component.

Third
This will be specific to the actual component, giving dimensions, type of material, barcodes, artwork and so on. This is agreed with the supplier and with other parties, such as marketing, sales and manufacturing. As components are added or changed there is a minimum quantity of documentation involved – whether it is computer based or in a file. Each component is given a code – preferably alphanumeric; however, if you have SAP, it has to be numeric.

For bulk packaging - marketing expectations are more the specification of the beer than anything else. However size or shape could be an issue and this expectation needs to be covered.

Performing on the packaging line and in the warehouse is important. For example, if kegs slip when stacked, the valve is proud of the level of the chime (handle) or if kegs damage too easily these issues will give handling problems. It is also important that the kegs can be easily handled up to the point of use.

In order to assist in monitoring the performance of kegs, they can be fitted with a transponder. This is an active RFID (Radio Frequency Identification) which allows information such as metal (SS or Al), tag weight, brim capacity, number of trips, last service, last use to be stored.

Legal Impact

Regulations vary from country to country. Key legislation regarding the pack for the UK requires – this is not a complete list – just the main elements:

- Product Identification
- Declaration of contents
- ABV (Alcohol by Volume)
- Best Before Date and Batch Number.
  - The BB date is sufficient if it is restricted to the 24 hour period when it was produced i.e. the full date, not just the month and the year
- Name and address of manufacturer and source should that be different
- Allergen Information
  - Presently this requires information on cereals used in brewing i.e. Barley, Wheat, Oats, Rye
  - SO2 if more than 10ppm has been added
- Alcohol Warning – not yet legislation but under discussion
  - Number of units (Max 2-3 Women 3-4 Men)
  - Comment on 'Responsible Drinking'
  - Warning for pregnant women
  - Reference to Dept of Health web site

Environmental Effects

The environmental lobby find packaging an easy target as it is visible. It is not actually the worst offender as the following figures illustrate:

Sources of Waste

House Holds	39%
Commerce/Industry	36%
Amenity Sites	15%
Shops/Offices	9%
Others	1%

House Hold Mix

Kitchen Waste	30%
Newspapers/Magazines	20%
Paper & Board	10%
Glass	9%
Metals	8%
Plastic	6.5% (Films 4%)
Textiles	3%
Others	13.5%

Source PIFA (Packaging and Industrial Films Association)

The legislation in the form of laws and mandates that has been introduced to reduce packaging waste is extraordinary and covers every area:

- Recycling

- Material Reduction
- Bans or restrictions on selected pack types
- Bans or restrictions on materials (heavy metals, PVC)
- Bans on materials accepted for landfill
- Green labelling requirements/prohibitions
- Purchasing preference mandates
- Tax incentives/penalties
- Deposit laws
- Refillable container laws and mandates
- Recycled content requirements
- Comprehensive 'take back' laws (e.g. Green Dot)
- Weight –based household rubbish removal fees
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Legislation is found in the Packaging Waste Directive in the Countries of the European Community Directive 94/62/EC., adopted 1994.

UK laws related to this are 'The Producer Responsibility Obligations (Packaging Waste) Regulations 1997' and 'The Packaging (Essential Requirements) Regulations 1998.

Producer Responsibility is about packaging targets for recovery and recycling. Obligations are divided up by sector – Manufacturers; Converters; Packer/Fillers; Retailers and proof of compliance is based on the production of a 'Packaging Recovery Note' or PRN. PRNs can only be issued by accredited re-processors approved by the EA (Environmental Agency). Each material and sector are given targets – the materials are divided up as Paper/board; Glass; Plastics; Metals; Wood.

Essential Requirements say that no person responsible for packing or filling products or importing packed or filled packaging into the UK may place packaging on the market unless it fulfils the Essential Requirements, which includes Heavy Metal Limits. The Essential Requirements are:

- Packaging must be minimal subject to safety, hygiene and acceptance for the packed product and for the consumer
- Noxious or hazardous substances in packaging must be minimised in emissions, ash or leachate from incineration or landfill
- Packaging must be recoverable through at least one of:
    - Material Recycling
    - Incineration with energy recovery
    - Composting or Biodegradation
    - Packaging maybe reusable

The Regulations require that a responsible person within the company maintain technical documentation for 4 years

The Heavy Metal Limits apply to the total of Cadmium, Lead, Mercury and Hexavalent Chromium in the packaging, and refers to the sum of these in each readily separable package component. The total level must be less than 100ppm.

The guiding principles for packaging and the environment are the 4 'R's:

Reduce	Minimum packaging
Reuse	If practical and environmentally acceptable; e.g. layer pads, pallets, bottles etc
Recycle	Paper, some plastics, metal, and glass
Recover	Energy recovery through incineration for example

Environmental Effects

The keg is the perfect pack, it is re-useable and recyclable (some may say, due to the high losses in trade, too recyclable). There is no waste with the exception of the label. In cases where ink is used, this is not even an issue.
Kegs are transported on re-useable pallets or locator boards.