EUROPEAN ALUMINIUM ASSOCIATION

Aluminium in packaging

Contents

Executive summary

This report highlights the following key points regarding the advantages of aluminium used in packaging applications :

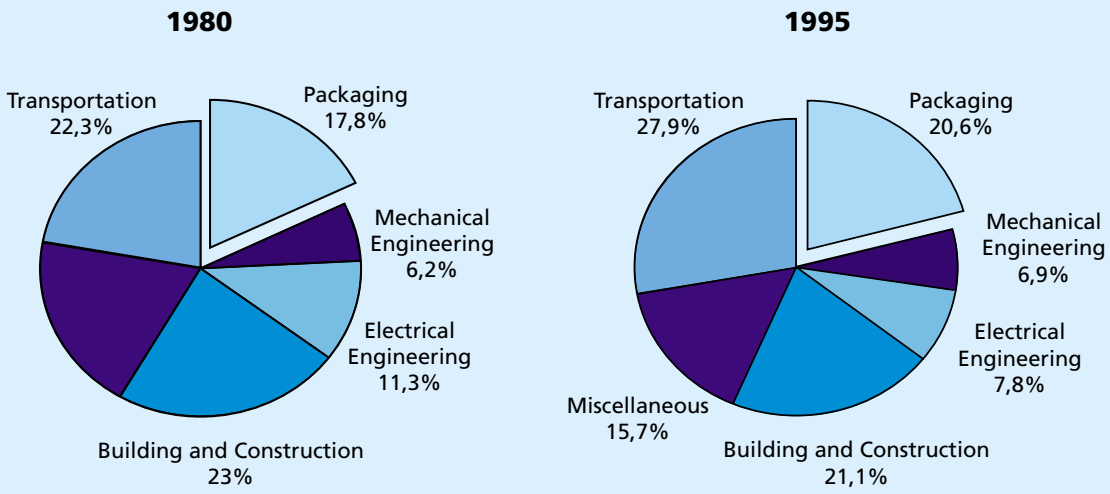
- Aluminium packaging provides an impermeable barrier to protect food, beverage, pharmaceuticals and cosmetics and minimises wastage.
- Good formability and machinability plus a wide range of thicknesses and finishes make it suitable for use in a variety of applications.
- Aluminium packaging is highly corrosion-resistant and for most fillings chemically neutral. It is hygienic, non-toxic and non-tainting.
- High strength-to-weight ratio offers the maximum protection for the minimum additional packaging material weight.
- In order to offer the same packaging advantages for the same application less aluminium by weight is required for the same functionality in comparison to competitive materials.
- The thicknesses required for packaging applications have been reduced on average by 30 per cent over the past ten years.
- The light weight of aluminium packaging reduces transportation costs.
- Aluminium conducts heat and thus minimises the energy used in re-heating or cooling the packaged product.
- Aluminium is produced from abundant raw material resources and recycled aluminium.
- The high economic value of used aluminium products produces an incentive that results in a high level of recovery and recycling.
- Recycling saves in the order of 95 per cent of the energy required to produce primary metal.
- When incinerated, the high calorific value of aluminium foil provides a valuable fuel substitute.

1. Introduction

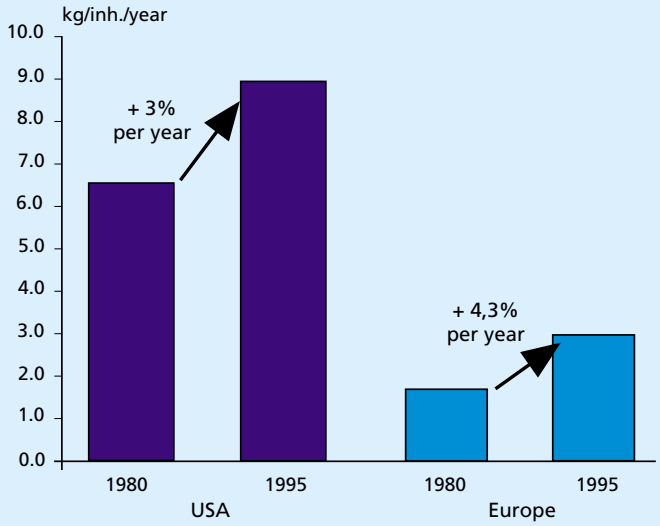
Mankind has relied on packaging since civilisation began. Even 3,500 years ago, the Egyptians were storing and transporting ointments, oils and wines in glass and earthenware containers. Over the past century, packaging has increasingly become an essential part of modern life.
Nowadays, in every country of the world packaging is used. However, still in many cases, particularly in Third World countries, there is often not sufficient or inefficient packaging. According to statements made by the World Health Organisation, an average 30 per cent of the food in developing countries perishes.

Packaging today responds to consumers' demands for choice and convenience as well as changed production and distribution conditions and systems. By safeguarding product quality, packaging allows products to be transported and distributed locally, regionally and even globally, thereby making valuable food resources available to a wider population. Thanks to packaging, almost every type of fruit and vegetable is available all year round, whether it is locally-grown or imported. In modern households, people increasingly turn to the use of fully-prepared meals, canned and frozen foods, in a wide variety of portion sizes, to save time in cooking and preparing meals. Packaging makes this possible.

Aluminium in packaging : a constant progression worldwide
(USA + JAPAN + EUROPE)



Aluminium in packaging : future potential for Europe



This paper looks at the properties and advantages that make aluminium an effective and appropriate material for a very wide range of packaging applications. It also examines the issues occasionally raised with regard to aluminium packaging, including its use of resources and waste resulting from its production, processing, and recycling.

2. Market and applications

Whatever the application, aluminium is a highly-effective and visually attractive packaging material. Aluminium is used in many forms in packaging including cans, aerosols, tubes, dishes, lids, wraps and labels. It can contain, protect, decorate or even dispense products as diverse as soft drinks and soaps, pet foods and snack foods, tobacco and toiletries, chocolates and chilled foods, tablets and take-away meals - even tennis balls and welding rods.

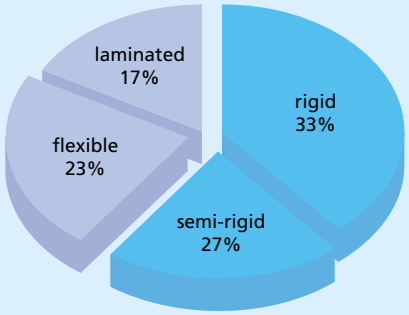
In packaging, aluminium via its unique combination of properties contributes to the efficient fabrication, storage, distribution, retailing and usage of many products. In addition, it can be combined with other materials to produce composite laminate systems. It can be lacquered, painted and printed.

There is a wide variety of aluminium packaging applications within industry which will not all be dealt with here.
For a variety of applications in industry, aluminium cans, tubes, bottles or pouches are ideal packaging, for example moisture-sensitive welding rods, dried seeds, micro-chips and machines wrapped for long-distance shipment.

For agriculture and trade many critical or sensitive items such as chemicals, pharmaceuticals, sealing compounds, adhesives or oils are packaged in aluminium. The perfect protection from light, moisture, oxygen or germs without altering odour, taste or colour of the contents provided by aluminium packaging is of fundamental importance for such applications. Users of these products also appreciate the safe handling and the long storage capability without loss of quality.

This paper focusses on aluminium end-consumer packaging. Traditionally one differentiates between aluminium foil, semi-rigid and rigid containers. In the context of this paper two examples have been chosen: aluminium foil for flexible packaging and the aluminium beverage can for rigid packaging.

Aluminium in packaging : a wide range of applications



- ***about 1 million tonnes of rolled aluminium is used for aluminium packaging products***
- ***40% flexible packaging (foils)***
- ***60% rigid and semi-rigid packaging (cans, containers, trays, etc.)***

EUROPE 1995

Table: Summary of aluminium packaging applications:

Food
milk products (e.g. yoghurt, curd cheese, butter, cheese, sterilised milk), sweets (e.g. chocolate bars, boxes of chocolates, ice cream, chewing gum), coffee, tea, baby food, dried foods (e.g. soups, cereals, potato purée)

Beverages
beer, soft drinks, juices, milk, etc.

Ready made meals

Pet food

Tobacco

Pharmaceuticals
tablets, ointments, transdermal systems...

Cosmetics
toothpaste tubes, refreshing tissues, shampoo...

Industrial goods
glues, ink cartridges, chemicals...

2.1 Flexible aluminium packaging

Aluminium foil for packaging is available in thicknesses from 6 to 200 microns (i.e. 0.006 to 0.2 mm). It offers a unique combination of properties which facilitate the production, storage, distribution, retailing and use of many consumer and industrial products.

Aluminium packaging serves a large variety of products

According to recent estimates, approximately 400,000 t of aluminium foil are used in Europe every year for packaging.
While 400,000 t might seem a considerable amount, it is worth noting that aluminium packaging products only account for less than 2% of all used packaging materials, as only small amounts are required to provide an all-important barrier element to a packaging system.

Aluminium foil helps to preserve food for long periods thus minimising wastage. The material's versatility allows it to be adapted and tailored to suit the many shaping, filling and decorating techniques available to today's packaging technologists and designers.

At the packaging manufacturing stage, aluminium offers good formability. In addition, its surface can be printed or laminated and coated with a wide range of papers and polymers. Having a high strength-to-weight ratio, it meets the packaging designer's structural performance specifications while adding little weight to the products it protects.

Aluminium flexible packaging is used to contain, protect and decorate products as diverse as soups, snack foods, tobacco and toiletries, chocolates and chilled foods, dairy products, yellow fats and tablets. Today's consumers

take for granted the advantages offered by laminated foil cartons used for milk, juices and even wine, as well as foil-lined composite cans, widely used in the packaging of powdered drink products.

Aluminium foil has also earned a special place in the protection and presentation of pharmaceutical and dietetic tablets and capsules. Push-through blister packaging, for example, provides barrier properties while also being user-friendly. The formability of aluminium means it can be used to produce cold-formed foil blister packs used to protect moisture-sensitive or light-sensitive materials.

Aluminium foil is also today's preferred material for the easy-to-open closures of some bottles, jars and a range of other containers. Induction heat-sealed lids are used with products ranging from sauce bottles through to pharmaceuticals, ink cartridges and motor oil containers.

2.2 Semi-rigid containers

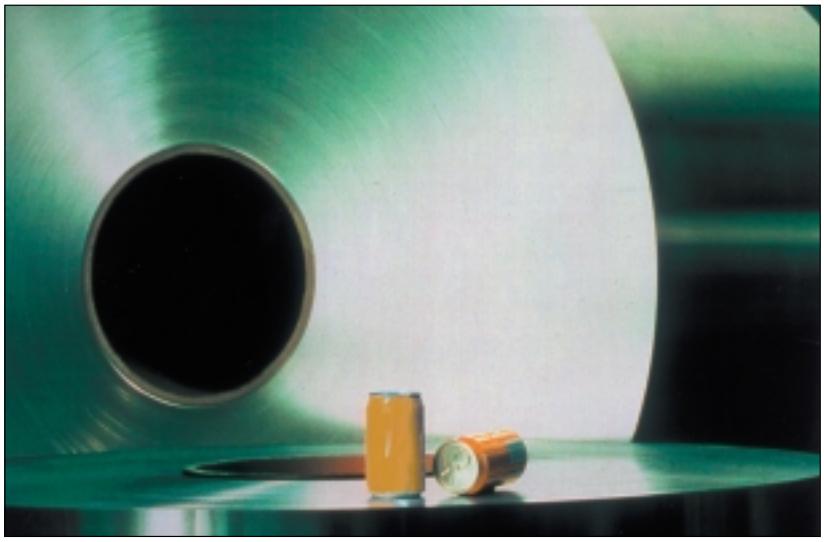
Aluminium semi-rigid containers :
easy to heat or cool,
easy to recycle

Wrinkle-walled or smooth-walled containers are among today's common applications for aluminium foil. While made from thin strip gauges of rolled aluminium, these containers nonetheless provide a form of semi-rigid packaging. Due to their versatility when it comes to the filling process and the distribution they are most commonly used to package items such as take-away foods, ready-to-bake desserts, pre-prepared chilled meals, frozen foods, baked cakes and tarts, pet food, meat and jam, paté, individual milk portions, etc.

They are favoured by the food processing industry as they can be used as a vehicle for the product during manufacture and be lidded simply and effectively. Their heat conductivity is excellent and at home, the food can also be warmed, steamed, baked or grilled directly in the aluminium package which does not lose any of its protective properties.
These same advantages together with its lightweight make aluminium containers also a preferred material for airline catering applications.

Less familiar to the average consumer is the use of these containers as receptacles for the sterilisation of surgical instruments in hospitals, as "grow-pots" for seeds and as fireproof containers for pre-packed barbecues.

2.3 Rigid aluminium containers



For the aluminium rigid containers there are a variety of application in the drinks, food, pharmaceutical and chemical product industries. As the aluminium beverage can represents by far the biggest market for aluminium rigid packaging it will serve here as an example .

Since its introduction in 1960, the annual worldwide consumption of the aluminium two-piece beverage can has grown to 145 billion cans in 1995, which amounts to 85 per cent of the total beverage can market. Thus six out of every seven beverage cans are now manufactured completely from aluminium.

In the European market, production moved from around 15 billion cans in 1987 to 32 billion cans in 1995, while aluminium's share over the same period grew from 38 to 55 per cent.

The rapid increase in the popularity of aluminium cans is accounted for by the advantages they offer to can makers, fillers, retailers and consumers.

Aluminium producers and can makers work closely together to produce containers that are strong but lightweight and dimensionally stable. This meets the needs of fillers, who have been encouraged by the continual expansion of the carbonated drinks market to move towards high-speed filling technologies which place increased emphasis on the can's mechanical performance.

Fillers also need materials which will not corrode or contaminate the contents and which can safely be used to pack such sensitive products as mineral water and wine. In addition, they want a good base for carrying metallic, transparent and solid colour designs.

Moving on to the retailer, the light weight of aluminium beverage cans results in easier and more cost-effective handling and transport. They are strong, shatter-proof and stackable, optimising the use of truck load and shelf space.

At consumer level, aluminium beverage cans offer convenience and quality, and due to their light weight and range of sizes aluminium cans provide ideal containers. The tamper-evident closure guarantees that the flavour and quality remain locked in the container, and the fact that cans are shatter-proof also makes them safer. Also, the advent of "multi-packs", made possible by the size and light weight of aluminium containers, offers the consumer better value for money, together with promotional opportunities for fillers and retailers.

Finally, aluminium beverage cans are totally-recyclable containers and have effective recycling programmes in place.

3. Properties and advantages

3.1 Barrier properties

Aluminium packaging offers a high level of corrosion resistance to a wide range of products. It provides optimal protection properties by offering an impermeable metal barrier to light, ultra-violet rays, water vapour, oils and fats, oxygen and micro-organisms.

When used to package sensitive products such as pharmaceuticals or food, aluminium is hygienic, non-toxic, non-tainting and retaining the product's flavour. The aluminium barrier also plays the essential role of keeping the contents fresh and protecting them from external influences, thereby guaranteeing a long shelf-life.

In addition to their general protective properties, the thin barrier provided by aluminium foil lids used, for example, on dairy products eliminates the danger of the light-sensitive fats they contain turning rancid when exposed to bright fluorescent chill cabinet lights. Scientific studies conducted by the Fraunhofer Institute for Food Technology and Packaging, in Munich, on a variety of food products, have clearly demonstrated the importance of these barrier properties. For example, white chocolate wrapped in transparent packaging develops a strong rancid taste, making it inedible after only six weeks exposure to light of about 500 lux intensity (the light level encountered in the average cold storage counter).

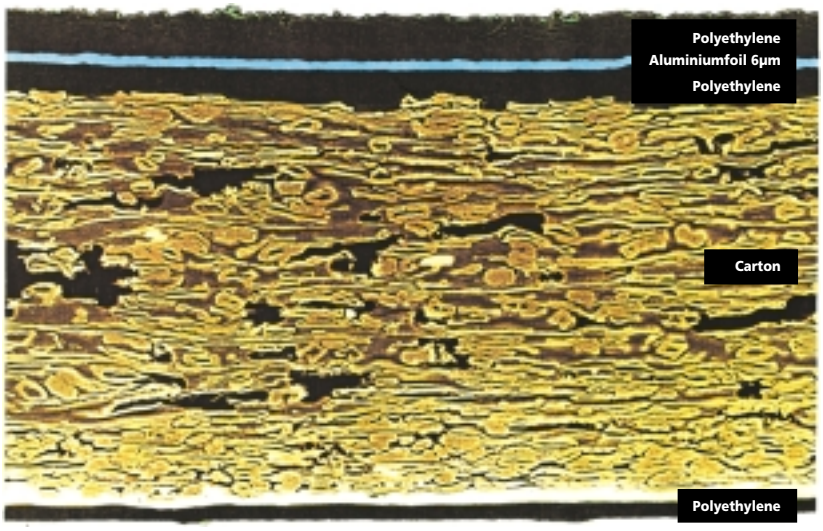
By contrast, aluminium-wrapped chocolate products offer shelf-lives of up to one year. In the same study, similar effects were noted when muesli cereal products packaged in sealed aluminium laminate pouches were compared with pouches

closed by clips or folds. The lack of an oxygen barrier in the clipped or folded pouches resulted in the product becoming rancid after only a few weeks.

For another example, the coffee foil, the Fraunhofer Institute has published a study in January 1996 which concludes that the aluminium foil has the tightest barrier in comparison to other packaging options.

3.2 Light weight

The content ratio is one major advantage of the aluminium package.
The intrinsic performance benefits of aluminium, combined with the continued efforts of the packaging industry to reduce material input, result in some significant cost benefits. Given the high strength-to-weight ratio of this material, often less of it is needed compared to alternative materials to meet the same performance specifications. For example, a 4.8g flexible fruit juice pouch with aluminium is 33 times lighter than a traditional bottle containing the same volume of juice.
For a one litre aseptic carton used to package milk, fruit juice and other beverages only 1.5g of aluminium is used.



Cross section of a typical aseptic brick pack

Where laminates are involved, even the smallest aluminium thickness of 0.006 mm is sometimes enough to provide the required barrier properties and therefore meets the objective of "as much packaging as necessary, but as little packaging as possible". In foil applications therefore, as in other semi-rigid and rigid packaging applications, custom-made packaging often clearly reduces material input by uniting the positive properties of different materials, thus providing the maximum packaging benefits from the minimum material investment. This saves both raw materials costs and energy resources.

As an overall consequence of the light weight, aluminium packaging results in reduced transport costs.
For example, when a truck is loaded with milk in aseptic cartons, from 86 to 95 per cent of the total load is milk, while from 5 to 14 per cent is packaging. When the same truck is loaded with milk in traditional packaging, the amount of the total load taken up by packaging rises to 40 per cent.

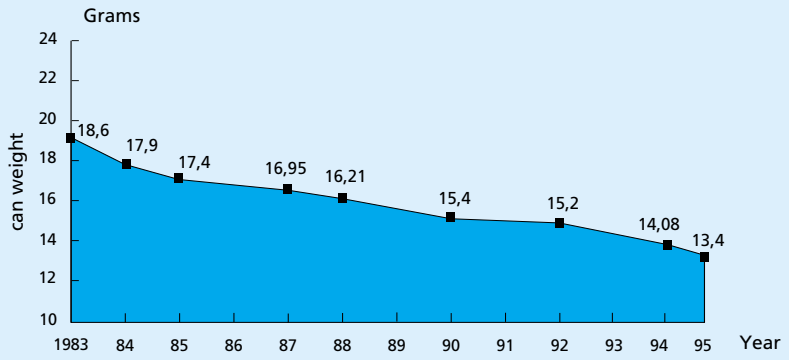
Equally, beverages transported in aluminium cans save more than 50% of the required truck loads in comparison to the traditional bottle.

3.3 Less material-source reduction and prevention

At 8%, aluminium is the third most abundant element in the earth's crust, after silicon and oxygen. At current levels of consumption, today's known reserves of aluminium bauxite will last another 300 years. In addition to this abundant supply of raw material, a substantial and growing amount of the demand for aluminium is now being met by remelted aluminium (see separate chapter on this subject).

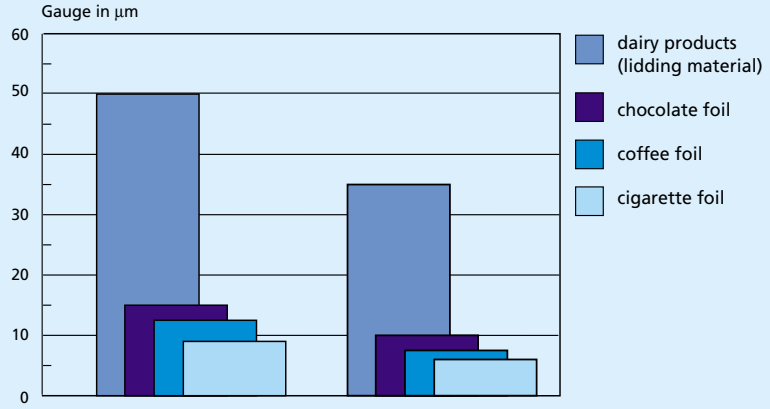
However, in order to save raw material resources and to prevent the use of superfluous material, the industry constantly tries to further reduce the amount of aluminium needed for the fabrication of packaging products. Therefore, the industry is dedicated to down-gauging the materials required for packages, while maintaining the same barrier and rigidity properties, by optimising package design. As a result, during the last ten years the average thickness of material used in aluminium packaging applications has been reduced by around 30 per cent.

Weight reductions of the 0.33l aluminium beverage can



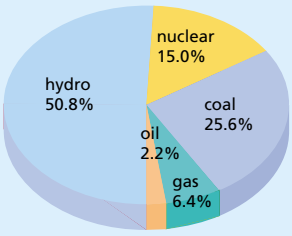
For example, only 1.5 g of aluminium foil is used in a laminated package of the aseptic brick type, accounting for 5 per cent of the total packaging weight. In the same way the quantity of aluminium applied in yoghurt lids and chocolate foil or other semi-rigid and rigid containers has been reduced by 30%.

Gauge reduction of aluminium packaging foil during the last 20 years



3.4 Energy savings through metal production and use of aluminium products

energy resource % of electricity used for electrolysis (European model)



As far as energy conservation is concerned, aluminium also has a strong and improving environmental performance.

Firstly, the amount of electrical energy required to produce 1 kg of primary aluminium has been steadily reduced to reach today's level of 15 kWh.
In addition, in Europe today, approximately 51 per cent of the energy used by aluminium primary production units, is provided by renewable hydro-electric power.

It should also be noted that around 30 per cent of the aluminium used in Europe today is provided from recycled aluminium. Depending on energy sources, recycling saves of up to 95% per cent of the energy required to produce primary metal. As the amount of recycled material available increases, the energy profile for aluminium will therefore continue to improve.

Not only is energy saved in the production of aluminium, but also in its transport and use by the consumer. Aluminium conducts heat very well and thus allows ready-prepared meals to be reheated in the foil container. It has the widest temperature tolerance of all flexible packaging materials and thus reduces the amount of energy required to reheat or cool products packaged in aluminium.
It also improves the scaling and filling performance when lidding milk products.

4. Recovery of aluminium packaging

The recovery and recycling of used aluminium packaging is being carried out successfully all over the world. The methods vary depending on the packaging type, the mechanisms in place in the society where the material is collected and recycled and the legislative requirements.
The high scrap value is an integral part of the system's costs.

4.1 Collection and sorting of used packaging

The collection and sorting of used packaging in general, not only of aluminium packaging, is not an easy task due to the wide spread of the products in the market place. In the case of aluminium packaging one is speaking about 1 to 1.5 kg per inhabitant per year depending on the country.

For a number of years now, various national and private sector collection and sorting systems have been in operation and have had considerable success. The type of system and the type of packaging determine whether the aluminium packaging is recycled or incinerated with energy recovery.

4.1.1 Separate collection schemes

Used aluminium products in general are worth collecting due to their high scrap value and the infinite recyclability of aluminium. Thus the industry has a long tradition of collecting and recycling used aluminium products.

Over the years, in some European countries separate collection systems have been installed for used aluminium packaging containers which have achieved high success rates.

Aluminium Beverage Can Recycling in Europe (1995)

Country	aluminium market share (%)	recycling rate (%)
Germany	14	70[1]
UK	78	28
Italy	97	35
Greece	100	34
Austria	70	50
Sweden	100	91
Ireland	86	18
France	35	14
Spain	40	14
Benelux	21	10
Switzerland	100	85
Iceland	100	80
Portugal	68	17
Turkey	77	40
Centr. + E.Europe	40	n.a.
Others	90	n.a.
TOTAL	55	35[2]

[1] Figure represents official DSD data of aluminium fraction, as cans are not collected separately

[2] excl. Central and Eastern Europe and Others

Backed by a growing public awareness of the need to recycle and with the support of aluminium producers, programmes to collect and recycle aluminium beverage cans have grown rapidly.

The high scrap value of the material provides a cash incentive which has boosted the success of consumer-led collection and recycling programmes, as a result of which aluminium can recycling is currently growing rapidly in Europe.

This has been particularly true in countries where aluminium's high market share has justified investment in the infrastructure necessary to operate such schemes. As a result, in 1995, a minimum of 35 per cent of all aluminium beverage cans consumed in Europe were collected and recycled.

While activities vary from country to country, national aluminium can recycling organisations promote and initiate recycling programmes through education, advertising, public relations, marketing and technical assistance. In addition to the infrastructure and activities provided by subsidiaries of the sponsoring companies, other partners actively support the national programmes. These include can makers, can fillers, retail outlets, metal merchants, waste management companies and local government bodies. Assistance is also recruited from schools and other educational institutions, charities, youth clubs and so on.

4.1.2 Multi-material collection

Where used packaging is collected via multi-material collection schemes, which are being established in more and more European countries, aluminium packaging needs to be separated from other packaging materials when intended for material recycling. A growing number of sorting facilities are being equipped with eddy current separators, which offer the most comprehensive means of sorting the aluminium fraction. These separators involve the use of a magnetic rotary field, which results in all types of packaging containing aluminium being ejected from the assorted waste.

In case of an overall household waste collection such sorting can be done before or after incineration and will still collect the aluminium which can then be recycled. Although aluminium packaging is only a small part of the domestic waste stream, it contributes a high value in comparison with other materials' recovery.

4.2 Material recycling

Aluminium has one of the best recycling records of any material today. Used aluminium, once collected, is subsequently recycled without losing any of its original properties or quality; thus, the number of times it can be recycled is unlimited.

In general the collected packaging material has to be pre-treated in order to avoid impurities and to clean it from organic components and other materials. The collected aluminium is compressed and baled for transport efficiency reasons. Subject to quantities available, used aluminium products, once remelted, can be used for the same purpose again (e.g. a beverage can or a menu tray), or for wrought as well as cast alloys and therefore can go onto the market in a large variety of other products.

Today there is no shortage of the infrastructure required for aluminium can recycling and investment has increased over the past decade in dedicated used beverage can (UBC) remelt facilities. As a result, dedicated UBC remelt facilities with a total capacity in excess of 120.000 tonnes are currently in operation in the United Kingdom, Sweden, Germany, Greece, Italy and France. These facilities remelt used beverage cans into ingots for the use in new aluminium cans. Furthermore, a large number of refiners throughout Europe recycle UBCs into other high-quality aluminium products.

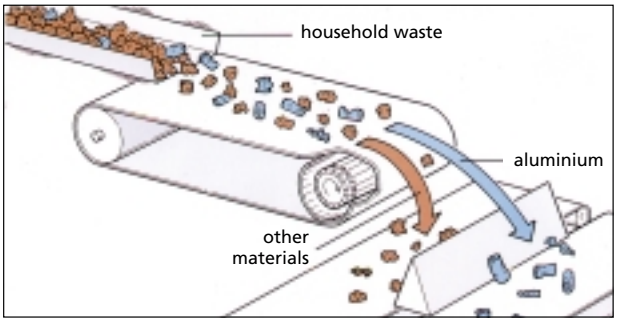
To valorise the aluminium in other types of aluminium packaging, there are a variety of processes applied in Europe. As aluminium packaging can present itself in coated or laminated form with paper or plastics, a variety of treatment systems to extract the metal from complex packaging systems are currently being developed or used in waste treatment plants, including repulping, mechanical separation and pyrolysis.

The repulping process can be used when the laminate involves a combination of aluminium foil and paper.
Mechanical separation methods involve selective grinding, based on the fact that different laminate materials behave in different ways under these conditions.
Pyrolysis has also proved to be an effective method of separating aluminium from the other laminate components as well as from impurities, such as the remains of the contents of the packaging. Through this process, the organic components are valorised. After the pre-treatment the recovered aluminium is refined and is recycled into high-quality aluminium products.

4.3 Incineration with energy recovery

Within the legal framework of domestic waste treatment and subject to available waste management practices and recovery systems in place, energy recovery from thin aluminium foil through incineration is a most ecological and economic operation.

Thin aluminium foil is widely used in packaging, either as a base material or as part of a composite paper-base or plastics-base packaging. In an incineration furnace, these foils combine with oxygen to release heat. At combustion temperatures of up to 900°C thin aluminium foil is completely oxidised, with a significant energy release of 31 MJ/kg aluminium. This specific energy release capability is equal to that of 1 kg coal or 0,8 kg fuel.



eddy current separator

However, recovering energy from waste should be seen as one component in an integrated waste management system, to be used alongside recycling and other measures. It should not encourage materials producers and users to neglect recycling where it is practical and worthwhile.
This is in particular the case for the thicker aluminium packaging in the domestic waste stream. Eddy current separators, which mechanically extract aluminium packaging from other materials, are increasingly applied in incineration facilities in order to recover the aluminium before and after the incineration process.

4.4 The European Packaging Directive

The aluminium industry will meet the requirements of the EU Directive on Packaging and Packaging Waste, which came into force at the end of 1994, and will actively collaborate on the extension of collection and sorting programmes which will be developed on a broader scale in many EU countries. The 15 EU Member States should have implemented the Directive into local national legislation by June, 1996.

The targets imposed by the Directive for the year 2001 are as follows :
- 50 to 65 per cent of total packaging waste will have to be recovered and
- 25 to 45 per cent will have to be recycled,
- with a minimum recycling percentage of 15% for each packaging material.

These targets will then be reviewed every five years.

5. Conclusion

In the modern eco-society, consumers ask for an efficient use of natural resources, limited health risks, high quality and convenience at reasonable cost. This applies also to the packaging sector.

The growing demand for recoverable and recyclable products will keep technologists increasingly occupied. Their concerns will not only include considerations about the product itself, but also about the environmental impact the material has throughout its life cycle.

Light weight aluminium packaging, with its wide range of beneficial applications and its intrinsic high value for recovery and recycling, will increasingly prove to be a strong and ideal partner through the combination of a "maximum of advantages, linked to a minimum of resource input".

Aluminium packaging is well positioned for the future !

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