ALUMINIUM PACKAGING

GUIDELINES FOR AN ECO-FRIENDLY DESIGN

Design for recycling

CiAl Consorzio Imballaggi Alluminio

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Any questions or comments on this guide, or requests for further information on packaging reviews, please contact CiAl Consorzio Imballaggi Alluminio at consorzio@cial.it
CiAl undertakes regular reviews of this guide to ensure updates and alignment with market developments.

Disclaimer: this document is provided as a general guide only. The environmental, financial and functional performance of packaging systems affects aspects related to the extraction and processing of materials, transport systems and usage patterns. To ensure the benefits of any of the observations displayed in this guide, an appropriate and detailed analysis of specific packaging systems is necessary.

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November 2018

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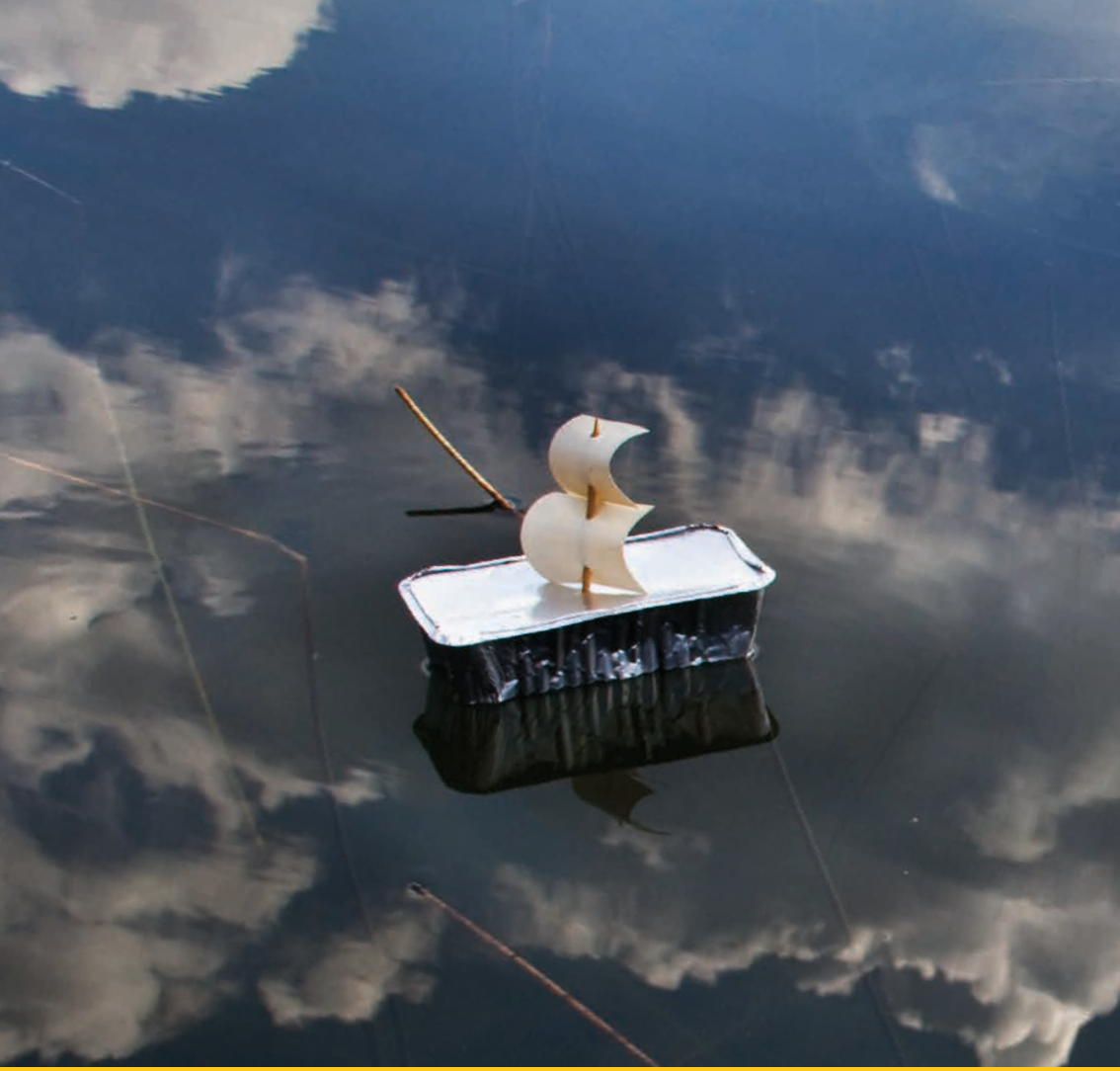


The ten principles for a sustainable design of packaging

THE TEN PRINCIPLES

☐ **1st PRINCIPLE** Start from materials that are commonly and easily addressed for separate collection organized by the municipalities: PET plastic, HDPE plastic, steel, aluminium, glass, paper, cardboard.

☐ **2nd PRINCIPLE** Design packaging using one single material. Single-material packaging is easier to identify in waste sorting.

☐ **3rd PRINCIPLE** Focus on the product-packaging relationship. Packaging should be as small as possible while still providing protection for the product and adequate brand recognition.

☐ **4th PRINCIPLE** Design the packaging taking into account the filling phase along the production line, be it manual or automated. The more efficient it is, the better it is.

☐ **5th PRINCIPLE** Avoid gluing and multi-layered materials. Multilayer lamination and glue make it difficult, if not impossible, to separate the materials for recycling and have therefore a negative impact in the concept of sustainable packaging.

☐ **6th PRINCIPIO** Design for distribution. From the very beginning, designs primary, secondary and tertiary packaging aiming for optimization and maximum efficiency of the whole packaging system, pallet included.

☐ **7th PRINCIPLE** Minimize secondary and tertiary packaging whenever possible. Look for opportunities to make the main packaging more robust while implementing useful solutions to guarantee display and communication functions at the outlet.

☐ **8th PRINCIPLE** Design for dis-assembly, in order to facilitate end users in the operations of separation and waste disposal of the packaging components after use of the product. Information on how to recycle explaining what to do is useful.

☐ **9th PRINCIPLE** Clearly mark the materials that make up the packaging for quick identification by the consumer.

☐ **10th PRINCIPLE** Life Cycle Analysis. Only by understanding the whole supply chain is it possible to understand the true benefits (or costs) of different packaging materials. Improvements in distribution could largely offset a selection of more valuable materials or an increase in production complexity.

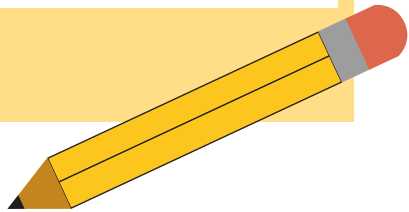


Image by Alexey Pivovarov

Foreword

The goal of these guidelines is to highlight the relationship between choices made in the design of aluminium packaging and the management of aluminium packaging post-use, describing the effects on both the packaging and their specific components.

As a matter of fact, it is quite important to understand, during the design phase of aluminium packaging, how such packaging will be managed in a post-use phase aimed at recycling. This work is designed to stimulate and inform designers on how design choices can lead to the optimization of packaging, taking into account the management of post-use processes and recycling, bearing in mind the fact that aluminium packaging could be produced and re-used multiple times in a “closed loop” system.

In brief, the reader is provided with a global picture of the aluminium and packaging production system, with its technical and environmental performance therefore highlighting the peculiarities of the material, whose infinite life cycle is characterized by its continuous

use in a “metal loop”, endless and emblematic of the systems and principles at the core of a circular economy.

The Guidelines can, of course, also be applied to other functions, such as production, marketing or sales, to forward an understanding of the relationships between packaging, products and customers, from a perspective of sustainable development. Moreover, another goal of this work is igniting an interactive process with and among producers and users of aluminium packaging, aimed at optimizing the packaging system with an understanding of new needs and opportunities the companies themselves can identify regarding environmental issues, a leading subject for today’s strategic choices and marketing.

Gino Schiona
CiAl General Manager

Objective

Image by Giovanni Diffidenti

The compatibility of packaging design and production to the sorting and recycling systems actually available at the end of their life-cycle is essential to better guarantee the recycling of any materials used

Insofar as the goal is optimizing the packaging, the purpose of the Guidelines is to further the eco-compatibility of the packaging system without compromising functionality or cost by providing a check list of sustainability aspects.

During the study phase, when looking for solutions to optimizing packaging sustainability, must be forward-looking and above all, give thought to the supply sources of the materials that will be used and their end-of-life usefulness, be it in the industrial or biological cycle.

To this end, it is essential that the design and production of packaging be in harmony with the collection and recovery systems actually available at the end of their life cycle, to better guarantee the recycling of the materials used. This necessity is confirmed by the observation that, often, the two ends of the chain, comprised by those who design the packaging and those who recycle it, do not communicate with each other.

This lack of communication can lead to the production of packaging that is difficult to manage during the collection and recycling phase, with a resulting waste of resources in landfills and the failure in closing the materials' cycle.

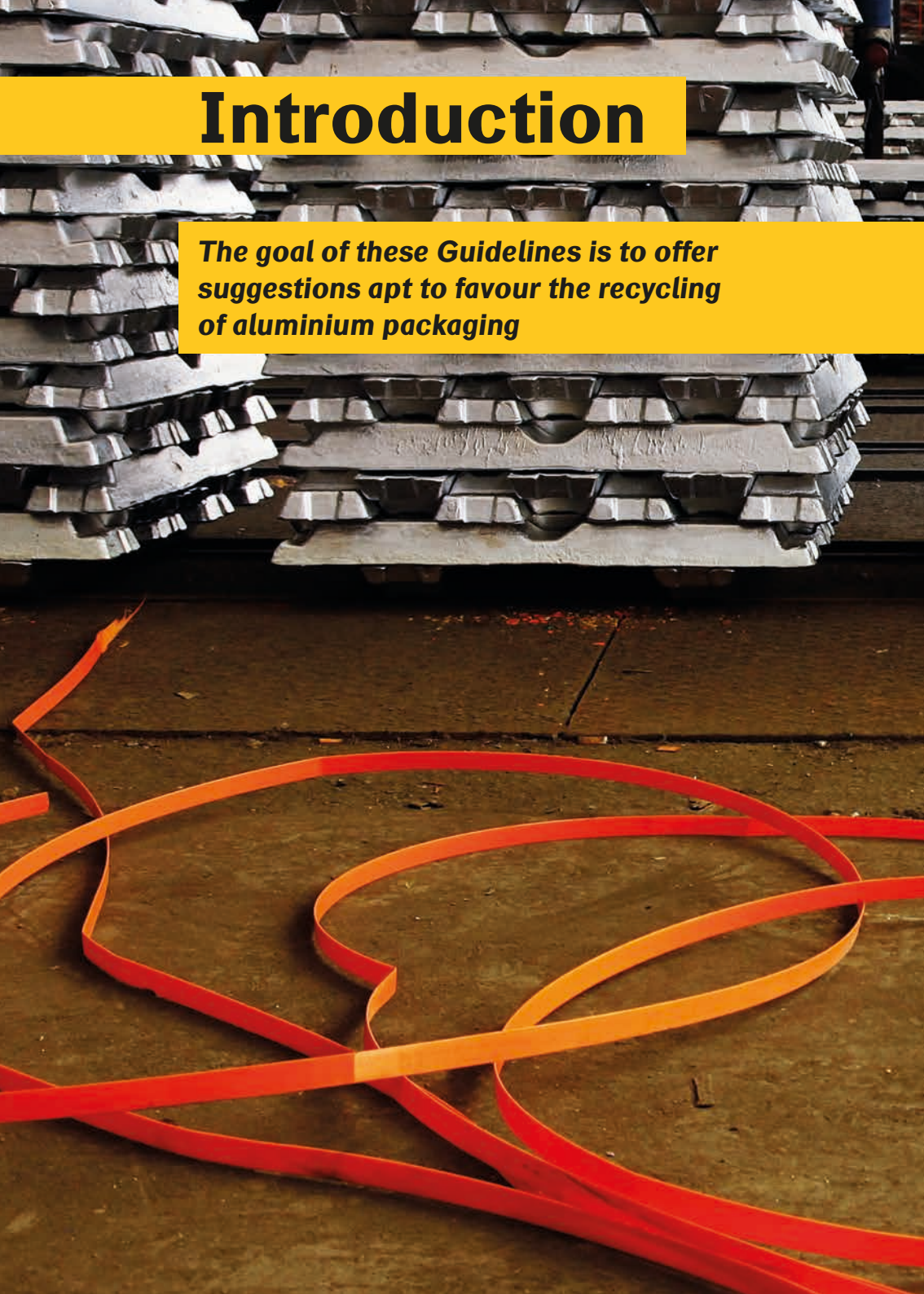
In some cases, increasingly less frequent, no great attention is paid to the recyclability of the packaging during the planning phase. This results in new packaging models being placed on the market without existing operational infrastructures for their collection and recovery, forcing the subjects who are responsible for organizing the recycling to seek ad hoc solutions.

The lack of communication along the entire supply chain is one of the potential obstacles responsible for missed information exchange, impacting both the choices of designers regarding packaging recyclability and the management of waste sorting methods, including the subsequent stages of selection logistics and recycling. This work wishes to bridge this gap by providing Design Guidelines for the recyclability of aluminium packaging that will offer designers all the information necessary to bring about optimized packaging that also take into consideration the recycling processes. The informations displayed in these Guidelines are based on the concept of life cycle that takes into consideration the impact of packaging throughout the supply chain, during use and at the end of life.

In order to contextualize the Guidelines, the document also provides an overview of the production processes of aluminium, of semi-finished products and packaging, as well as the available collection and selection systems, highlighting their correlation in the recycling process. ●

Introduction

The goal of these Guidelines is to offer suggestions apt to favour the recycling of aluminium packaging



Aluminium is a metal universally known for its unique characteristics. It is an essential metal to the era of technological development, open to immense possibilities for use in industry, construction, aerospace, electronics and, of course, packaging. Indeed, due to its characteristics, aluminium is the ideal partner for packaging production. It is light, malleable, resistant to impacts and corrosion and capable of guaranteeing a strong barrier effect that protects from light, air, humidity and bacteria. Aluminium is non-toxic and 100% recyclable. As it lends itself to any type of customization, it guarantees packaging an excellent aesthetic level.

Depending on the uses, features and functions the package must lend itself to, the properties of aluminium are calibrated to create an alloy in which minimum quantities of other elements such as copper, zinc, manganese, silicon and magnesium coexist. Since each application requires different characteristics, there are different varieties of aluminium alloys, each imbued with a unique combination of the materials' properties, such as: strength, ductility and malleability.

All alloys are compatible with the aluminium recycling systems currently available in Italy. All aluminium packaging collected through waste sorting is recycled and transformed, as a rule, into new aluminium alloy ingots, separated according to separate end uses and applications.

The most used types of aluminium alloys in packaging are those of the 1000, 3000, 5000 and 8000 series.

The **1000 series** alloy is an almost pure alloy containing 99.5% aluminium. Due to its flexibility, it is used in the production of aluminium foil, cans and tubes.

The **3000 series** alloy, whose primary alloying element is manganese, is used in the production of the bodies of beverage cans, food boxes and trays, and is the most common alloy for aluminium packaging.

The second most used alloy in packaging is that of the **5000 series**, containing magnesium to ensure greater hardness and used to produce can lids, tear-off tabs and facilitated openings in general.

Lastly, the **8000 series** contains iron and is used to exploit its malleability, for example in the thin metal sector, producing trays and screw caps.

In the case of aluminium packaging, the reference point is its minimum thicknesses, ranging on the micron scale (1 µm = 0.001 mm; 1 mm = 1,000 µm). Aluminium packaging uses minimum quantities of material to guarantee its performance; the following measurements refer to standard thicknesses in relationship to packaging types and characteristics:

- Flexible: 5 – 40 µm
- Semi-rigid: 30 – 170 µm
- Rigid: 90 – 300 µm

Image by Alberto Bernasconi

(aerosol cans are excluded, as their thickness is higly susceptible to variations).

There are many types of aluminium packaging. This document deals with the most common forms of packaging, from the ones entirely made of aluminium to the ones made of composite materials, in which the percentage of aluminium contained is prevalent, without neglecting the information regarding the various components that can be added to aluminium packaging. In wider terms, the different types of aluminium packaging are distributed in the three main categories: rigid (cans for drinks, spray cans, canned food), semi-rigid (bowls and trays, tubes, capsules), flexible (flexible hoes for food, aluminium foil, polylaminates with aluminium prevalence).

Aluminium is a recyclable packaging material and recycling it offers environmental and economic advantages.

It can be recycled for an indefinite number of times without its intrinsic qualities and characteristics deteriorating. This is exactly the reason why some decisions during the packaging and design phase should be avoided, to avert any negative impact on the recycling process in terms of quality and yield. As a matter of fact, every type of aluminium packaging uses a different combination of alloys, thicknesses and additional components, with the potential of conditioning all or part of the recycling process, resulting in a waste of energy and economic resources.

Aluminium packaging is produced to meet specific requirements defined by application, plus health and safety rules.

These Guidelines recognize the importance of these requirements from the off and underscore how necessary they are to ensure product safety and alignment with both regulatory and market requirements. The purpose of these Guidelines,in any case, is to offer suggestions useful to the increase of recyclability in aluminium packaging.

Lastly, we will come to understand how a number of obstacles to the recyclability of packaging can be attributed to the design phase of packaging. On the other hand, obstacles can also arise independently of the design phase, out of the behavior of consumers in using and disposing of the packaging, or from the management of waste sorting and selection, attributable to recycling infrastructures. ●

In the last 15 years

Waste sorting

+72%

increase in sorting and recycling of aluminium packaging

Energy conservation

4,786 million toe saved

toe > tonne of oil equivalent

CO_2

2,050 million tons avoided

thanks to the quantities recycled in the last 16 years

Recycling

600,000 tons

of aluminium packaging that was recycled and newly employed in traditional processes

Regulations and in-depth analysis

To help companies to check whether their packaging is recoverable or not, the ECS (European Committee for Standardization) has created harmonized European technical standards, translated and made available also in Italy by the national standardization body, UNI

Thanks to the Circular Economy Package, the month of July 2018 saw two amendments come into force: the Directive n. 851, May 30th, 2018, amending Directive 2008/98/CE dealing with waste, and Directive n. 852, May 30th, 2018, amending Directive 94/62/CE on packages and package waste. These directives must be incorporated on a national level by modifying D.Lgs 152/06 no laterali than 2020. This chapter is therefore objectively referenced to the legislations current to publication.

The legislation dealing with the essential requirements for packaging is on **Directive n. 62, stipulated December 20, 1994 on packaging and packaging waste** (G.U. L. 365/199 of 12.31.2004) and subsequent updates (hereafter Directive 94/62/CE).

Annex II to Directive 94/62/EC, as applicable to aluminium packaging currently available on the market, reads: "All. II Essential requirements concerning the composition and reusability and recoverability (in particular the recyclability) of packaging."

1. Requirements for the manufacture and composition of packages:

- the packages are manufactured in such a way as to minimize as much as possible the volume and weight to guarantee the necessary level of safety, hygiene and acceptability both for the packaged product and for the consumer;
- packaging shall be designed, produced and marketed in such a way as to allow its reuse or recovery, including recycling, and to minimize its impact on the environment if packaging waste or residues from packaging waste management operations are disposed of;
- the packages are manufactured in such a way that the presence of harmful metals and other dangerous substances and materials as constituents of the packaging material or of any component of the package is kept to a minimum in relationship to their presence in emissions, ash or residues of leaching in the case packaging or waste from packaging waste management operations is incinerated or buried.

2. Requirements for the reusability of a package (the following requirements must be fulfilled simultaneously:

- the physical properties and characteristics of the package must allow a number of movements or rotations under normally foreseeable conditions of use;
- possibility of processing used packaging to meet workers' health and safety requirements;
- compliance with the specific requirements for recoverable packaging if the packaging is no longer used and thus turns into waste.

3. Requirements for the recoverability of packaging:

- **Packaging recoverable as recyclable material**

Packaging must be produced in such a way as to allow recycling of a certain percentage in weight of the materials used, in the manufacture of marketable

products, in observance with the rules in force in the European Community. The determination of this percentage may vary depending on the type of material that constitutes the packaging.

- **Packaging recoverable as energy recovery**

Packaging waste treated for energy recovery purposes must have a lower minimum calorific value in order to optimize energy recovery.

- **Packaging recoverable as compost**

Packaging waste treated to produce compost must be sufficiently biodegradable so as not to hinder waste sorting and the process or composting they are introduced into.

- **Biodegradable packaging**

Biodegradable packaging waste must be of such a nature as to be able to undergo physical, chemical, thermal or biological decomposition by which most of the resulting compost will eventually decompose into carbon dioxide, biomass and water.

The provisions of Directive 94/62/EC have been fully implemented in Italy first by Title II of Legislative Decree 22/97 and then by Legislative Decree 3 April 2006, n. 152,"Environmental regulations", part IV.
Annex F to the latter presented criteria to be applied until the entry into force of the Inter-ministerial Decree provided for in Article 226, paragraph 3 of the same Legislative Decree and incorporates, without modifications, Annex II of Directive 94/62/EC, firmly establishing the requirements for the manufacture and composition of packaging, its reusability and recoverability.

To help companies verify whether or not their packaging complies with the essential requirements, the ECS (European Committee for Standardization)implemented a number of European harmonized technical standards that were therefore translated and made available in our country by the national body of standardization, UNI:

- **UNI EN 13427:2005** – Packaging – requirements for the use of European standards in the field of packaging and packaging waste;
- **UNI EN 13428:2005** – Packaging – specific requirements for manufacture and composition – Prevention for source reduction;
- **UNI EN 13429:2005** – Packaging – reuse;
- **UNI EN 13430:2005** – Packaging – requisites for recoverable packaging for recycling materials;
- **UNI EN 13431:2005** – Packaging – requisites for recoverable packaging in the form of energy recovery including the specification of the minimum lower calorific value;
- **UNI EN 13432:2002** – Packaging – requisites for recoverable packaging by composting and biodegradation – test scheme and evaluation criteria for final acceptance of packaging.

As of now, in Italy, in the absence of a Ministerial Decree implementing paragraph 3 of the art. 226 of Legislative Decree 152/2006, the application of the UNI EN 13427, 13428, 13429, 13430, 13431, 13432 technical standards is not mandatory, but "... taking into account the Communication of the European Commission 2005/C44/13 ...", they are nonetheless to be considered the only "Technical

standards on the essential requirements of packaging." The application of these standards in all European countries, among other things, establishes a presumption of conformity to the essential requirements. Compliance with the essential requirements through the adherence to technical standards results in an implicit full authorization by all the Authorities of the member countries in the European Union.

Follows a summary description of the contents of the main standards of reference in the world of aluminium packaging.

UNI standard EN 13428:2005

Technical standard UNI EN 13428:2005 provides both the manufacturer and the user the tools necessary to achieve the goals of reduction at the source.
The standard is a useful tool that companies can use to verify that their packaging is in compliance with the prevention requirement, as it specifies a procedure for the evaluation of packaging in order to ensure that the weight and/or volume of the same are the minimum ones in relation to the function they must perform, without this being in any way compromised.
The standard also specifies the methodology and procedure for determining the presence and minimization of substances or preparations dangerous for the environment that may be part of the packaging (CR 13695-2) marked with the symbol "N" in directives 67/548/EEC and 1999/45/EC, substances which, if they spread in the environment, may present immediate or deferred risks for one or more of the environmental components (air, water, soil) and the methodology and procedure for determining the presence of heavy metals Pb, Cd, Hg, CrVI (Cr 13695-1), that may be present in the packaging (qualitative prevention.

UNI standard EN 13430:2005

The UNI EN 13430:2005 standard, groups all of the interventions that the production and use chain of a given packaging solution can put into practice to allow its end-of-life collection, selection and recovery (back to its original function or for other purposes) aimed at reprocessing in a physical and/or chemical production and manufacturing process of tradable products.

All packaging (primary, secondary and tertiary) placed on the national and European market must be produced in such a way as to allow, at the end of life, the process of recycling of a certain percentage of the materials of which they are composed. To this end, the following requirements must be met:

- to demonstrate the "recoverability for recycling of material;"
- determine the percentage of recycling of matter.

The responsible party must demonstrate that an analysis throughout the entire life cycle of the packaging has been carried out, in relationship to the criteria that affect the recyclability of the materials, the recycling recovery

process and the marketing of the products. An analysis of the whole life cycle of a packaging product aimed at recycling the materials that compose it involves a survey of the design phase, the production phase, the phase of use of the packaging, the phase of sorting packaging waste by the final consumer and finally in the phase of collection and selection of packaging waste.

Packaging complies with this requirement when the analysis of the phases that characterize the packaging product's life cycle, in relationship to the criteria of recyclability, allows a definition of the percentage of recyclability of the functional unit of the packaging product and an affirmative answer to all of the following questions:

- Are the various necessary selection systems, in preparation for the recycling process, adequate to achieve the recycling of materials?
- Are the manufacture, composition and separability of the components such as to minimize the substances released into the environment during the recycling process?
- Is the control of all of the production, packaging/filling phases sufficient to guarantee the minimization of substances released into the environment during the recycling system?
- Can the packaging be emptied of contents sufficiently to minimize any additional substance released/residue from the recycling process?
- Can the packaging be collected and selected so as to minimize any further residues/substances released in the subsequent recycling operations?

UNI EN 13430:2005 therefore establishes that packaging design must use materials or combinations of materials that are compatible with known, relevant and industrially available recycling technologies. Cases of misalignment between recycling technologies and the development of new packaging materials with functional and environmental advantages are possible. In such cases, packaging can still be considered recyclable even when recycling technologies are not immediately available, if producers can demonstrate the existence of advancements towards the availability of industrial recycling abilities within a reasonable period of time.

UNI standard EN 13431:2005

The standard highlights the essential requirements for the recoverability of packaging as energy recovery, indicating that packaging waste treated for energy recovery purposes must have a lower minimum calorific value in order to optimize energy recovery, which must be greater or equal to 5 mJ/kg for all materials.
The interest is therefore set on the interventions that production and use chains of a packaging solution may put in practice to allow it, at the end of its life, to have a minimum calorific value of at least 5 mJ/kg and a calorific gain of over zero in order to optimize the energy recovery in a real industrial system.

Permanent material

Lately, the concept of "permanent material" has been taking hold and spreading, describing a material that is

not consumed, but endlessly used and reused, preserving the energy necessary for future and new employments throughout its many applications.
On this subject, the standard "Framework for the assessment of the sustainable use of materials. Guidance" BS 8905:2011 states, in Annex B "Environmental Aspect of Sustainability:"

B.2 origin of materials

[...]
Three concepts deal with the origin of the materials.

a. Non-renewable materials are those in the case of which the energy and raw materials used for their production are lost once their availability to society is lost at the end of their life cycle. This is the case of materials destined for landfills, incineration or other.
b. Permanent materials are those in the case of which efforts can be made to preserve the energy and raw materials used in their production at the end of the product's life cycle to the benefit of society, both through their re-use and through recycling and without compromising quality, regardless of the number of times the material is recycled.
c. Renewable materials are those in the case of which the energy and raw materials used in their production come from a renewable source. At the end of their life cycle, the materials may no longer be available to society or may be retained.
[...]

Also worthy of attention is the "Resolution of the European Parliament of May 24th, 2012 on a resource-efficient Europe" that overrules the distinction between "renewable" and "non-renewable" resources, taking into account also "durable" or "permanent" materials. More precisely, point G of the resolution states: "... considering that a future global resource policy should no longer distinguish between 'renewable' and 'non-renewable' resources, but also consider durable materials..."

The evaluations underlying the European Parliament resolution stem from considerations expressed by the European representation systems of metallic packaging. To be more precise, it stated that, when considering the sustainability credentials of different type of packaging, there should first of all be clarity regarding the relationship existing between the natural resources used to produce the materials that will then be transformed into individual packaging products.
Aluminium is a material that can be turned into packaging, used in many other applications and products: construction, automotive, aerospace, etc. Whenever these products reach the end of their life cycle, aluminium can be recycled and reused in the production of new goods. This gives rise to the virtuous cycle called Metal to Metal Loop.

Marking

Legislative Decree 152/2006, and smi, art. 219, paragraph 5, require that:
"All packaging must be appropriately labeled according to the procedures established by Decree of the Minister for the Environment and Protection of Land and Sea in agreement with the Minister of Economic Development in

accordance with the determinations adopted by the Commission of the European Union, to facilitate the collection, reuse, recovery and recycling of packaging and to provide consumers with information on the final destination of packaging.

The aforementioned decree must also prescribe the obligation to indicate, for the purpose of identification and classification of the packaging by the industry concerned, the nature of the packaging materials used, on the basis of Commission Decision 97/129/EC."

The annexes to Decision 97/129/EC, which establishes a voluntary identification system for packaging materials, provide the abbreviation ALU and number 41 for aluminium, the voluntary adoption and knowledge of which have been promoted over years.

The "Guidelines for Environmental Labeling of Packaging" are also a document drawn up by the Italian Packaging Institute that well explains the correct use of the symbols that identify the material with which a package is produced.

The goal is to provide companies with a useful tool that facilitates the identification and application of symbols and phrases for correct environmental information.
The documents contain the indications of the criteria for the selection and use of symbols and information addressed to the user and final consumer of the packaging, to facilitate re-use operations (when this is planned) or to recover packaging waste in different possible forms (such as recycling, composting, energy enhancement, etc.). ●

Labeling for the collection, recovery and recycling of packaging in Italy

Description	Labeling	Reference
Abbreviation and numbering identifying material	**ALU 41**	Decision 97/129/CE
Aluminium graphic symbol	alu	CR 14311:2002
Adherence to a national chain recovery system	CiAl Consorzio Imballaggi Alluminio	www.cial.it

Production and manufacturing processes of aluminium

From the production of primary and recycled aluminium, from semifinished products to finished products: a process based on the efficient use of resources

Image by Alberto Bernasconi

Overview on aluminium production and its manufacturing

There basically exist two methods to produce aluminium:

- primary production, by electrolysis of an aluminium oxide, the alumina obtained from the refining of the raw ore, bauxite;
- production or recycling, out of recast aluminium scraps.

All the aluminium produced in Italy comes from the recycling of various kinds of scrap. In 2017, with about 955,000 tons of recycled aluminium scrap, Italy confirmed itself a leader in the field for managed quantities, both at a European and world level, second only to the United States and on par with Germany.

Primary production of aluminium

Preparation of alumina

The preparation of alumina is brought about in specific refineries through the Bayer chemical process, often in proximity to bauxite mines for logistic reason. Pure aluminium oxide is separated from other substances present in bauxite using a caustic soda solution, filtered to remove all insoluble particles during the chemical process.
All insoluble residues, the so-called "red mud" (its coloring resulting from the abundant presence of iron oxides), constitute production waste. Once cooled, the resulting solution is filtered in order to separate the aluminium trioxide (called hydrate), which precipitates in solid form.
This crystalline material is calcined (heated) at temperatures over 1,000 °C, to eliminate moisture and transform it into aluminium oxide, called alumina. The alumina is then sent as a raw material to aluminium casting plants.

Aluminium production (Hall-Héroult process)

Primary aluminium is obtained through an electrochemical process called Hall-Héroult, taking place in specialized systems, called "smelters," in which pure aluminium is obtained out of alumina, aluminium oxide, by electrolysis.

The transformation of alumina into liquid aluminium takes place in special electrolytic cells, at a temperature of 950 °C, in a fluorinated bath run through by high-intensity electric currents.

The electrolysis of the melted compound involves the decomposition of the alumina in oxygen, which turns into carbon dioxide, therefore freeing the elemental aluminium that will then settle on the bottom of the tank from where it will become accessible.

Later, the primary aluminium is subjected to purification processes. Here, the traces of impurities which form a superficial layer are removed. After going through periodical clarifying and solidifying, this superficial layer takes on the name of "slag." The slag resulting out of primary production is called "white slag" and is mostly made

up of aluminium oxides and other alloy elements exposed to the air on the surface of the casting. Unlike slags deriving from secondary production, which take the name of “black slag” and do not contain significant quantities of aluminium, white slag can contain up to 70% of aluminium, that will be partially recovered through further melting during secondary production.

At this point, the different alloys can be created by incorporating various elements. Each alloy is characterized by a combination of material properties such as hardness, ductility and strength, to better comply to the necessities of future use. After adding the alligating elements to obtain the appropriate metallurgical characteristics.

Secondary production or recycling

Secondary, or recycled, aluminium is produced out of pre-consumer or post-consumer scrap, collected through waste sorting. All scrap must be selected first, in order to separate them from any magnetic metals or other different materials (glass, plastic, etc.). Pressed into bales and brought into the foundry, after the quality of the material is verifyed, the bales are pre-treated at about 500 °C to free them of any extraneous substances. The actual melting takes place in ovens at a temperature of 700 °C, till liquid aluminium is obtained and molded into ingots and plates for the production of semi-finished and new products.

Aluminium processing

Lamination of aluminium

The aluminium is extracted from the oven and solidified. Aluminium for packaging production is generally molded into plates weighing 10-20 tons, by direct shell casting (semi-continuous casting).
The plate is then heated (homogenizing annealing) and sent to the mill.
Laminating aluminium is a process that involves reducing the thickness of aluminium under “heat” and “cold.”

With the hot rolling the plate, preheated at a about 550 °C, pass through a number of cylinders and being both reduced in thickness and increased in length at each passage.
Through hot rolling, the plate is reduced from 600 mm to 2-6 mm in thickness. Once out of all the “hot” cylinders, the resulting strip is unrolled and transported to a “cold” laminator.

Cold rolling returns the aluminium to hardness and allows any thickness of choice. In the “cold” phase, at a temperature of about 100 °C, the tape is passed under a new series of cylinders. Cold laminating is performed at temperatures lower than the crystallization of aluminium so that at each passage through the cylinders, the metal will harden in a controlled manner depending on its deformation. After three or four passages through the cylinders, the tape is rewound and then reheated (annealing).

Normally the aluminium laminates have a thickness varying between 0.20 and 5 mm.

The laminates are then sent on to the next production stages for the actual packaging, be they flexible, such as sheets and composite, semi-rigid, like trays, or rigid containers, such as beverage cans, food tins or screw caps.

Combined rolling processes can produce aluminium laminates no thicker than 5 µm.

Sheet production

The aluminium strip used to produce the sheet does not normally exceed 2 mm in thickness.
It is possible to obtain an aluminium sheet thinner than 10 µm, passing two superimposed aluminium sheets under the cylinders. Once separated, each of the two sheets, very thin, will have a shiny side (the outer face that was in contact with the cylinders) and an opaque one (the inner face that was in contact with the other sheet). Once rolled and wrapped the thin aluminium foil is heated (annealed) to mitigate internal tensions, clean the surface and give it its natural flexibility. To manufacture aluminium foil for packaging, pure alloys are mostly used, out of the 1000 series.

Alternatively, the aluminium sheet can be produced out of an aluminium slab thanks to a process known as continuous casting or strand casting. This technique does not need to cast plates and go through a hot laminator, as it casts the molten metal directly into the shape of a thin sheet, which will then be cooled, wrapped and sent on for cold laminating.

Aluminium foil widely used for packaging thanks to the advantages it offers, such as the "barrier effect" against humidity, air and light, which allows storage and transportation of easily perishable goods.

Continuous casting is ideal for the production of aluminium foil, but is not suitable, for example, to the production of the aluminium strips necessary to the production of beverage cans.

Can shaping

Beverage **cans** are produced from aluminium sheets through a process called deep drawing.
The process is structured into successive stages.

- The aluminium sheet is lubricated to prepare it for contact with the machine.
- A circular punch engraves out of the aluminium sheet the rough circles, concave spoon-like shapes, that will be turned into aluminium cans.
- Each disk is blocked and pushed against a piston that will wire draw it and give it a narrower, longer shape called a cup at this first stage.
- The piston pushes the cup through three rings decreasing in diameter, "stretching" the walls of the cup, thus reducing the diameter and thickness of its walls.
- Another piston curves the bottom of the cup in, giving it a more resistant shape against the internal pressure exerted by a carbonated drink.
- The upper ridge of the can, still slightly wavy from the ironing process, is then trimmed. • The excess aluminium thus obtained is immediately directed to recycling.

- The lubricant is washed away and the cans, once dried, are ready to be decorated and coated.
- Turning on their axis, the cans arrive at the printer, which simultaneously applies ink of different colors. A layer of protective varnish is then sprayed and the cans are ready for drying in an oven. Since the ironing process leaves the walls of the can perfectly smooth, the ink can be applied directly on the aluminium surface, although sometimes a coat of paint is first layered as a base on which to print.
- Internally, a veil of paint is sprayed, suitable for food contact, to avoid direct contact between the contents of the cans and their inner walls, to avoid any form of chemical interaction.
- After being dried again, the neck of the can is crushed and the end portion flanged to accommodate the lid.

Can lids are produced separately out of a different aluminium alloy laminate. To begin with, the disks are cut out of a slab that was previously unfolded, lubricated and then finished with the same paint used to waterproof the inside walls of the can. A rivet is then pushed upwards, against the center of the lid, where the opening tab will be secured, and the area is engraved to ease cutting when opening. The tab, engraved with a matrix on another sheet of aluminium, is fastened to the rivet. The lids slide alongside the empty cans they will be assembled to after filling.

Food cans and screw caps are manufactured out of laminate much in the same way beverage cans are.

Other aluminium products such as bottles, spray cans, tubes and other rigid containers are manufactured out of aluminium laminates through a process called impact extrusion. In this process, a matrix is used to cut circles, called **fusion tablets**, out of an unfolded and lubricated slab, that will then placed between a matrix and a mechanical press. The press hits the **tablet** to push out through the matrix. This operation shapes the tablet to correspond internally to the piston's shape, and externally to that of the matrix. All excess material is trimmed and recycled and the container washed. Finally, the container thus obtained can be coated and decorated no differently than aluminium cans are. ●

Types of aluminium packaging

Image by Giovanni Diffidenti

Rigid, semi-rigid or flexible, ranging from sheets of a few microns to the thicknesses of cans, for every type of aluminium packaging as much material as needed is used to guarantee the highest level of technical and environmental performance

Aluminium packaging on the Italian market

Beverage cans and other kinds of rigid packaging such as boxes and spray cans, represent the main group of aluminium packages on the Italian market, 50% of which deals with the packaging sector. Semirigid packaging such as trays, tubes, caps and muselet represent 30%, while aluminium sheets, opening/closing systems, predominantly aluminium polylaminates and other types of flexible packaging cover the remaining 20%.

50%
rigid packaging

30%
semirigid packaging

20%
flexible packaging

Rigid

Beverage Cans

What are they?

Aluminium beverage cans are cylindrical containers that generally contain a beverage, are single-use and disposable. Their structure consists of three parts: the bottom and the body, deep drawn out of a single piece of aluminium alloy belonging to the 3000 series; the top, a circle made out of an alloy belonging to the 5000 series; the tab ring, also in an alloy of the 5000 series. First the can body is produced and filled, then the lid, its tear tab already affixed, is added. The lid is equipped with a rounded opening that opens when the tab is pulled up by detaching at least partially. The standard format for beverage cans is around 33 cl, but there are also many other formats, generally ranging from 15 ml up to 1,000 ml.

Why are they used?

Aluminium beverage cans offer several advantages. In addition to their high barrier properties ensuring extended storage times, they are extremely light, easy to open and quick to cool, allowing the drink to be kept fresh.

Where can they be found?

Aluminium cans are used for a variety of beverages such as beer, carbonated drinks, energy drinks, and many non-carbonated drinks such as tea, fruit and vegetable juices as well as caffeine-based beverages.

Recycling aluminium cans

Aluminium cans are completely recyclable and are historically the basis of the recycling system of all aluminium packaging. The cans, together with other forms of aluminium packaging, are sorted alongside plastic or glass and at collection centers or the

ecological islands in almost all Italian municipalities.

Beverage bottles

What are they?

Aluminium bottles are high-neck containers shaped to resemble glass bottles. They are manufactured out of a single piece of aluminium and use both re-sealable screw caps and tear-offs. When used for drinks they are usually single-dose,ranging from 250 ml to 500 ml in contents primed to be single-use containers.

Why are they used?

Aluminium bottles are generally used as an alternative to glass and plastic bottles. Be it for safety, where the use of glass could be dangerous, or aesthetics, aluminium enhances its contents to their utmost, giving brands a more sophisticated look.

Where can they be found?

Aluminium bottles are used in the beer segment, to be distributed at gathering places such as beaches, parks, concerts, amusement parks and bars, where glass can be a danger. Aluminium bottles are also used for soft drinks and energy drinks. Usually packaging of this kind is adopted to distinguish the product from the competition. Some body care products are sometimes presented in aluminium bottles with screw caps or dispensers, as an alternative to plastic bottles, as an enhancement for the brand and the product.

Recycling aluminium bottles

Aluminium bottles are absolutely recyclable. Usually manufactured in a 1000 or 3000 series aluminium alloy, they are extremely compatible with the recycling operations and used to create new laminates or for other purposes. The alloys of the 1000 series have less than 1% alloy content, therefore making them compatible with secondary recycled alloys during recycling operations.

Boxes

What are they?

An aluminium box consists of a rigid container with raised edges and a removable lid. When used for food storage, the lid may be liftable, in which case it will have a tab on one of the edges to indicate the point from which to start opening the container. Alternatively, the lid may have a “can opener” type of opening. For other applications the container can be supplied with a screw cap or simply with an airtight lid.

Why are they used?

As with most aluminium packaging, rigid containers are used for their storage capacity (barrier effect). Many rigid aluminium containers for food keep the product fresh for a long time without refrigeration, an advantage not just in situations where there is no refrigerator. For non-food applications, aluminium is preferred to other materials thanks to its lightness and the seductive appearance it is conferred by the mirror-like surface.

Where can they be found?

Rigid aluminium containers are mostly used to preserve fish products (anchovies and sardines), legumes or canned meat, generally on sale

in grocery stores and supermarkets. There are also various applications of rigid aluminium containers in the non-food sector in the cosmetics and smoking industries, to contain cigars, for example.

Recycling rigid containers
Rigid aluminium containers are completely compatible with the aluminium packaging recycling systems. They are generally manufactured in aluminium alloys belonging to the 3000 and 5000 series, to ensure the containers hte necessary stiffness and strength.

Spray cans

What are they?
Spray cans are used to contain and distribute a heterogeneous variety of liquids, creams or gases. Spray cans are manufactured using the impact extrusion technique that creates the body from a single aluminium billet. A spray valve is then inserted on top of the container's dome, in the large upper opening.
The valve is a composite piece made of plastic and metal parts, and acts as a supply valve, besides regulating and giving direction to the contents. To ensure the necessary thrust to allow the contents escape through the can's spray valves, they are pressurized with different kinds of propellant gases. There are two general classifications of propellants: hydrocarbon-based propellants, such as propane, and compressed gases such as carbon dioxide. The product can be separated from the propellant by means of an internal bag, or by placing a plunger between the liquid product and the gaseous propellant.

Why are they used?
Spray cans have the unique ability of atomizing their content, a useful quality for those products that need to be evenly distributed on surfaces. Moreover they represent the only type of packaging capable of containing and supply gas while ensuring control.

Where can they be found?
Spray cans are used in many fields. They are primarily used for packaging body care products, such as shaving foams, hairsprays, deodorants and sunscreens. Other uses are related to the food industry, household cleaning, air fresheners, repellents and compressed air cans.

Recycling spray cans
Spray cans are compatible with the aluminium recycling process, but are often excluded from the recovery program for safety reasons. When aluminium recyclable products are compacted and pressed into bales, at the selection/recovery facilities of the materials gathered through waste sorting, spray cans risk damage and escape of any rapidly expanding propellant they contain.
There is a fire risk in processing spray cans containing hydrocarbon-based propellants. This is the reason why not all recycling operators deal with spray cans in their management system. Nonetheless, most spray cans are used to package body care products that don't usually contain hydrocarbons based flammable propellants, and this is the reason why CiAl actively promotes their collection and recycling throughout the Italian country.

Instructions specify that only cans used to contain toxic, harmful and inflammable products (as properly indicated on each product through special pictograms) should be brought to ecological islands.
Almost all spray cans are made of aluminium alloys belonging to the 1000 series and are thus compatible with recycling operations and recovery. It's very important to remove the cap and, if possible the valve, from the spray can, as they generally contain plastic and steel which could create problems for the recycling operation.

Semi-rigid products

Bowls and trays

What are they?
Aluminium bowls and trays are semi-rigid structures made of aluminium foil through an impact shaping process. They are usually combined with a lid produced out of an aluminium sheet and coupled with cardboard.

Why are they used?
Aluminium trays are generally used to pack food products thanks to their ability to retain and reflect heat and cold. The aluminium protective barrier also represents a further asset for food packaging, although aluminium bowls and trays are rarely designed to have a watertight seal.

Where can they be found?
Aluminium bowls are often produced for domestic use and are frequently used to transport food. Those with rounded edges, designed to curl around a cardboard lid, are commonly used both as home products and in the catering world. Aluminium trays are also used to substitute plates and trays in presenting food, for buffet set-ups or as cake trays, for example.

Recycling aluminium bowls
Aluminium bowls and trays are mainly produced in alloys belonging to the 3000 and 8000 series, perfectly compatible with the aluminium recycling processes, from a metallurgical point of view. Due to the thickness of these products, there is a possibility of oxidation during the melting phase of recycling, if they are not adequately compacted.

Aluminium tubes

What are they?
Aluminium tubes are flexible tubes with a conical end. They can be entirely manufactured in aluminium or have a composite structure with a layer of aluminium coated in plastic. The tubes are produced out of aluminium billets through impact extrusion and are generally equipped with a snap cap flip top or a rigid, plastic or aluminium, screw cap.

Why are they used?
Aluminium tubes are chosen to exploit two of the main qualities of aluminium at the same time: the barrier effect and flexibility. Compared to other materials, aluminium has an excellent response to torsion and permanent folding ("dead fold"), meaning that they can stay bent without breaking. These are essential quality for a container destined to be crushed and bent to allow delivery of the product. This quality is crucial to preventing the access of air and the inevitable oxidation of the packaged product.

Where can they be found?
The tubes are mostly used to package creams and thick liquids where control of the dispensing system is important. The all-aluminium tubes are mostly used to package colors intended for fine arts, or other supplies for domestic use, such as adhesives, glues or other products that can not be exposed to air. Aluminium tubes are also frequently used for foods such as tomato paste and anchovy paste as well as for body care products, such as toothpaste or hair dyes, and for pharmaceuticals such as ointments and gels. Food and body care products can be packaged in tubes of composite material.

Recycling of the tubes
Aluminium tubes create no problem for recycling operations. They are manufactured with a 1000 series aluminium alloy, its purity allowing the tube to bend, affording it at the same time an elastic consistency. The 1000 series alloy is totally compatible with recycling operations. Any plastic caps on the aluminium tube should be removed and separated before delivery to waste sorting.

Screw caps

What are they?
Screw caps are threaded to close bottles multiple times. They are all produced from a single aluminium tablet with the impact extrusion process. Generally they are produced with aluminium alloy of the 8000 series. Sometimes the screw closures are combined with a safety/tamper-proof collar that typically once detached from the screw cap is separable and removable to provide for its recycling separately.

Why are they used?
Screw caps are used because they can be sealed again once opened, a quality that makes them a valid alternative to corks or crown corks. Moreover, the manufacturing of screw caps allows for easy combination to that of aluminium containers in the same production site. In the case of wine glass bottles, screw caps can replace cork stoppers and eliminate the necessity for corkscrews. In other cases they can also be combined with the bottle to give it a more pleasant appearance.

Where can they be found?
Aluminium screw caps can be found on tubes, aluminium bottles, wine bottles, and other bottles such as those used for liqueurs and spirits.

Recycling screw caps
Screw caps do not represent a problem for the aluminium recycling process, however, due to their small size, some are likely to be left out of the compacting process of the sorted waste packaging therefore never getting to the recycling plant. Considering the specificities of the product, CiAl, has started a program for the recovery of aluminium caps and capsules directly at glass treatment plants.
The recycling rate of aluminium screw caps in Europe is about 45%. Despite their small size, aluminium screw caps are either collected and recycled together with aluminium packaging, or relocated on the original bottle and collected with the glass sorting. Special technologies allow the extraction of the aluminium in both

cases, to be further recovered in its entirety. Packaging collection and recycling systems vary widely in Europe as they depend on national waste legislation in different countries. The percentage of recycled aluminium screw caps differ according to the waste sorting and collecting infrastructures available in each country, ranging from over Germany's 80%, Italy's 65% and Great Britain's 45%.

Muselets

What are they?

In the past, tradition required wine bottle corks to be enveloped in a lead cap to preserve the cork and prevent wine from oxidation. Once the dangers of lead were discovered, it was gradually abandoned for aluminium. Nowadays, the capsules for wine bottles can be produced from aluminium foil, possibly coupled with plastic films.

Why are they used?

Muselets on wine bottles are mainly used to protect the cap. Even the bottles of wine closed by an aluminium screw cap can be wrapped by an aluminium band that starts from the cap to imitate the shape of the traditional wine bottle stopper. In this case the extension of the aluminium can also act as a safety collar.

Where can they be found?

Muselets are universally used for the bottling of both still and sparkling wines, besides other beverages being sold in bottles with a shape similar ot that of traditional wine bottles.

Recycling wine muselets

Aluminium capsules for wine bottles are created with aluminium alloy sheets belonging to the 1000 series, wholly compatible with recycling operations from a metallurgical point of view. However, their very thinness can cause these packaging products to oxidize in the melting furnaces rather than melt.
The capsules must be designed to be completely detachable from the bottle, so that they do not remain attached to the glass when it is recycled. Glass producers pass the scrap through an eddy current sorter to separate all aluminium parts.
In order to implement and guarantee the recycling of this important aluminium segment, CiAl has been proposing that glass treatment plants should separate the material once it has been purged of the other residues and sort it for aluminium recycling.

Flexibles

Aluminium sheets and wrapping

What are they?

Aluminium wrappers are manufactured in aluminium sheets less than 40 µm thick. Aluminium packaging foils are produced in an aluminium alloy belonging to the 1000 or 8000 series, characterized by the highest qualities of flexibility and ductility. The aluminium sheet is exceptionally resistant to torsion and folding, meaning it keeps its shape once folded.

Why are they used?

Aluminium wraps are usually used because they are light, they can

envelope irregular shapes, are resistant to torsion and folding ("dead-fold") and offer good protection. Even very thin, aluminium foils offer a total barrier against air, humidity, light and microorganisms. Aluminium foil is also used as décor, thanks to its attractive refractive index.

Where can they be found?
Aluminium wraps have a number of applications such as packaging material for the food, confectionery, pharmaceutical and tobacco industries. Although not all, most food is chemically compatible to contact with the material. Despite not technically belonging to the packaging sector, aluminium foil has become an integral part of kitchen supplies, for grilling, heating or storing food.

Recycling aluminium wraps
Aluminium wrapss are produced with a 1000 or 8000 series aluminium alloy, 100% compatible with the recycling operations. However, they are so thin they can oxidize in the melting furnaces. This problem can be solved by compacting the material more homogeneously. Before disposing of aluminium foil in waste sorting, it should be wrapped in aluminium casings or sheets.

Peel-away openings

What are they?
Peel-away openings are created in aluminium sheets that can be coupled with one or more support layers in plastic or paper. Some peel-away openings use metallised plastic films, created through a different process (see the section on metallised films).

Why are they used?
Peel-away openings are used for the barrier effect conferred by the aluminium sheet and the resistance of the plastic or paper support. The combination creates barrier against air and humidity that is also particularly resistant to tears and holes.

Where can they be found?
Peel-away openings can be closed again once opened, and are therefore mostly used for single portion containers of products such as yogurts, soups, microwave products and some beverages. They are usually combined with single dose tubes with wide openings. They can be both the primary opening to the package or the secondary one, placed under a rigid outer cap, that is neither air tight or tampering proof.

Recycling peel-away openings
No less than any other packaging making use of thin layers of aluminium, peel-away openings, must be compacted and pressed to facilitate recycling when the aluminium is prevalent, to be sorted with the rest of the aluminium packaging and containers.

Other types of packaging in composite material with aluminium

"Composite packaging material" is a generic descriptor for any type of packaging produced with a combination of different materials. There are several types of packaging that include

an aluminium layer or aluminium components, such as beverage cartons, blisters, laminates.

Blisters

What are they?

Blisters are packages, comprised of a shell bearing a series of pre-shaped "pockets" to house a single dose of the product (such as tablets, pills, compresses) covered by a thin sheet of aluminium. The shell can be in aluminium or plastic. To use the product, the consumer need simply exert slight pressure with a finger and extract the desired amount of product.

Why are they used?

Blisters combine the barrier properties of aluminium foil and the strength and malleability of the shell to create a package that is both easy to open and secure. It is the ideal packaging for small dry, single-dose solids.

Where can they be found?

Blisters are especially used for pharmaceutical products and chewing gum.

Recycling blisters

100% aluminium blisters are completely recyclable; a pyrolysis process allows the separation of aluminium in aluminium/plastic blisters, though it is not yet used on a wide scale.

Beverage cartons

A note on terminology

Beverage cartons are commonly and erroneously referred to as "aseptic," "brick," "composites," or by their given trade mark.

What are they?

Beverage cartons are packages assembled in layers of polymer, aluminium and cellulose fiber. Their composition is 75% fiber, about 20% of LDPE film and 5% of aluminium foil.

Why are they used?

Beverage cartons offer several advantages like barrier effect, efficient volume use, reduced weight, long storage and rigidity. In particular, the barrier properties of the aluminium layer allow food products to have an aseptic packaging that guarantees long conservation.

Where can they be found?

These cartons are used to store soups, broths, juices, milk, soy milk, tofu, tomato based products and wine. Some of these cartons can be closed again once opened and are therefore outfitted with screw caps, ring pulls, and plastic spouts.

Recycling beverage cartons

Following waste sorting and the selection, beverage cartons can proceed to the recycling process of the main material, cellulose fiber. A pyrolysis process can be applied to separate the aluminium, but it is not yet largely used. Beverage cartons can otherwise be recovered by converting waste into energy (incineration, RDF).

Metallic

What is it?

Metallizing is the process by which the slightest of layers, almost imperceptible, of vaporized aluminium is applied under vacuum-seal to a substratum of another material by way of a vacuum-seal or transfer metallizing process.

Recycling metallics
Metallics should not be sorted and sent to aluminium recycling processes, but to those of the dominant material, be it plastic or paper.

Additional components

Inks and paints

What are they?
The greater part of aluminium food and beverage packaging products are printed directly onto the metal surface with different color inks.
In the case of aluminium containers, inks and varnishes are usually applied directly to the surface of the container's body and then oven-dried.
Clear varnishes can also be applied, both on the external and internal surfaces of aluminium containers.

Why are they used?
As in other kinds of labeling, inks and varnishes applied to aluminium containers have a double function, being both decoration and a medium for information. Logos, graphic signs, nutritional information and other forms of text can be appear in a single ink-based application. Transparent paints are applied for protective purposes. Internal coatings have protect against direct contact of the contents with the aluminium surfaces, something that is especially important for some food products. External coating are instead applied to protect the ink.

Where can they be found?
Most aluminium beverage containers are first stamped and then painted. The internal coating also is applied to most aluminium containers, be they for food or drinks, as well as to most of non-food containers.

Recycling inks and paints
Inks and paints do not represent a problem for aluminium recycling operations. Once at its destination in a treatment plant, aluminium waste is crushed and heated in an oven where inks and paints are almost completely disposed of. Any residual coatings surviving the decoating furnaces are separated from the molten aluminium in the melting furnaces, where residues migrate towards the layer of slag floating on top of the metal and are disposed of once solidified. ●

Designing aluminium packaging

Any innovative approach in packaging design must take into account the following criteria, listed by decreasing priority: avoid, minimize, reuse, recycle, recover and, only as a residual option, dispose of, as suggested by EU legislation

Image by Giovanni Diffidenti

FOUR CRITERIA

Designing for purpose

1st CRITERION

Designing for:
- better accessibility
- withstanding and favoring piling
- minimizing waste for consumers
- finding a compromise between primary, secondary and tertiary packaging

Designing for resource efficiency

2nd CRITERION

Designing for:
- minimized thickness of aluminium laminate
- minimized primary packaging
- minimized secondary packaging
- use of secondary or return packaging
- recovery of packaging losses on the filling line
- maximizing the weight/volume ratio between product and packaging
- maximizing transportation efficiency

Designing with low impact materials

3rd CRITERION

Designing for:
- maximizing recyclable content in primary packaging
- maximizing the recyclable content in secondary packaging
- minimizing the use of troublesome chemical substances in inks and lacquering

Designing for resource recovery

4th CRITERION

Designing for:
- ensuring the compatibility of secondary components with sorting and recycling systems
- supplying consumers with clear informations
- maximizing the value of recovered materials
- stamping directly on the aluminium packaging

Package design must be inspired by an efficient use of resources.

An innovative approach in packaging design must take into account the following criteria, listed by decreasing priority: avoid, minimize, reuse, recycle, recover and, only as a residual option, dispose of, as suggested by EU legislation. The efficiency of this general hierarchy is supported by significant results observed in life cycle assessments (LCA, Life Cycle Assessment).

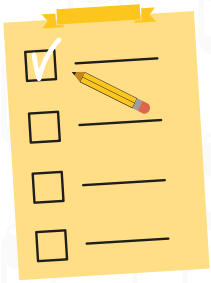
The priority of this design model from the point of view of an efficient use of resources, highlights the need to maintain or improve the functionality (suitability to purpose) of the packaging system and to minimize product losses.

We have therefore come up with some general considerations for the design of aluminium packaging, taking into account an efficient use of resources to reduce impact and improve recovery.

When designing a packaging system, all the below criteria and aspects must be taken into account.

The design criteria described have been showcased with reference to real cases. The assignment of priorities should be considered limited within the individual group criteria.

1st CRITERION



Designing for purpose

Improving accessibility

High priority

Evaluate possible alternatives to the conventional pull tab. When making use of pull tabs, design them to be easily accessible to the consumer, by placing them in a raised position or by some hollow space beneath them. Make sure there are no sharp ends on the cover or tab.

Removable aluminium foil ends(peel-away type) can improve accessibility, when easily opened. Ensure that the force required to remove the peeling does is not in excess of 22 newtons and avoid closings that require the use of a tool to open or puncture them.

Minimize the rotational force required to break the first seal on screw caps. Rotational forces above 1.1 Nm (newton/meter) often exceed the functional abilities of disabled or elderly individuals.

Withstanding piling

High priority

Regarding thickness, ask suppliers to verify that completed packaging is sturdy enough to withstand the required piling of the product.

Minimizing waste for consumers
Medium priority
When dealing with spray cans, choose a propellant that maximizes product content.

Finding a compromise between primary, secondary and tertiary packaging
Medium priority
View primary, secondary and tertiary packaging as an integral system. More specifically, evaluate the functional compatibility between primary and secondary packaging. For example: thanks to the lightness and piling ease of primary packaging, secondary packaging requires (possibly) no more than a minimal ability to withstand weight. Evaluate the possibility of minimizing tertiary packaging components to ensure the necessary pallet load. Such as: straps, thin and perforated stretch films, shirts, low-residue adhesives, plastic crates that lock into place on pallets with minimal use of straps or pallet boxes.

2nd CRITERION

Designing for resource efficiency

Minimizing the thickness of aluminium laminate
High priority
The thin aluminium foil used in packaging, because of its minimal thickness, requires some attention in sorting and processing. It would be best to make a ball of the foil or press it to increase its density and promote its recycling in the foundry. When dealing with aluminium packaging, the volume should be reduced as much as possible, while maintaining its functional performances so as to minimize the packaging's footprint.

Minimizing primary packaging
High priority
To provide information on the product, consider using shelf ready packaging in the store rather than relying on components to be added to primary packaging. For example, avoid using cardboard wrappers around aluminium tubs.

Rigid plastic components can generate problems in the aluminium recycling process. They can cause both quality and safety problems during the decoating process of aluminium waste. Aluminium remodeling companies have

been known to reject aluminium scrap batches if the levels of contaminants such as plastics are too high. Plastic components should be left out or minimized as much as possible in packaging design to increase recyclability and improve the quality of the recycled material.

Elements made in stiff plastic represent a problem for aluminium recycling processes. They can cause both quality and security problems during the decoating process of aluminium waste. Aluminium reworking companies can reject batches of aluminium scraps containing too high a level of contaminants such as plastic. The presence of plastic elements should be either eliminated or minimized in aluminium packages at the design phase to increase recyclability and improve the quality of the recycled material. Plastic film labels (made, for example, in heat-shrinkable material) on aluminium packaging are not particularly problematic either during recovery of the packaging at recovery facilities, or at the following reworking, but should be avoided or minimized as much as possible anyway. PVC films should be avoided due to their high chlorine content, a contaminant for aluminium reworking processes. Favour instead printing directly on the aluminium container.

In the case of beverage composite packaging with an aluminium layer, only the structural materials are normally recyclable. Packaging in this kind of material is used to contain products such as long-life milk, broth or fruit juices and has excellent characteristics such as barrier properties, shelf stability, strength and low weight. A typical composition of this laminated material is 75% cellulose fiber, 20% LDPE film and 5% aluminium.

Minimizing secondary packaging
High priority
Minimize secondary packaging wherever possible. Shelf ready packaging is becoming mandatory for many foods and groceries in general, promoting an optimization in the relationship between packaging and products. Costs and environmental impact should be reduced at the design table. Minimize the dimensions of the front side in single dose packages to ensure easy visibility for consumers. Take into consideration the use of openings in multi-pack boxes, reduce the size of secondary packaging as much as possible, ensuring that the integrity of the primary packaging is not compromised.

Using secondary or return packaging
Medium priority
Returnable plastic trays or boxes that can be folded or stacked are ever more widely used on the market, especially in larger supermarket chains. The benefits in terms of life cycle and cost of plastic-based crate systems rather than cardboard boxes are potentially significant. Loss of products along the supply chain is also decidedly lessened using systems based on plastic returnable boxes. However, their use is mostly prevalent in the field of fresh foods such as fruits and vegetables rather than applied to more resistant shelf products in aluminium packaging. This is the direction the market is taking though, so taking into consideration

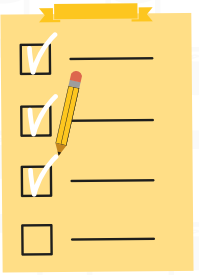
whether the product could be supplied in a returnable plastic box is worth a shot.

Recovery of packaging losses on the filling line
Low priority
However minimal the losses of aluminium packaging may be along the filling line, verify with line operators the existence of aluminium collection systems allowing its recovery through recycling.

Maximizing the weight/volume ratio between product and packaging
Low priority
Many products that are packaged in aluminium have almost optimal weight and volume ratios between product and pack. that are almost optimal. However, it would be advisable to address the calculation of some of these ratio directly at the design phase of the packaging system.

Maximizing transportation efficiency
Low priority
Verify the efficiency (volumetric) of palletizing: its improvement can significantly reduce the costs of storing and distributing products.

3rd CRITERION



Designing with low impact materials

Maximizing the recyclable content in primary packaging
Medium priority
Ask suppliers for information on the percentage of recycled packaging material. Request information on the availability of aluminium packaging that maximizes the content of recycled material, always in compliance with current legislation and good manufacturing practices (Regulation EC 2023/2006).

Maximizing the recyclable content in secondary packaging
Medium priority
Evaluate what the utmost possible level of recycled content is for the carton or polyethylene casings as well as for the shelf ready packaging, maintaining the functional and resistance performances of the secondary packaging.
Keep in mind that many references equipped with aluminium packaging support themselves and may have less need for structural strength in the secondary packaging.

Minimizing the use of troublesome chemical substances in inks and lacquering

Medium priority

Inks and lacquers are applied inside and outside almost all aluminium containers, including beverage cans, to be then oven-dried. These coatings must be removed but generally do not cause problems during aluminium remodeling. These coatings often involve a great use of Volatile Organic Compounds (VOC), particularly in solvents. These chemicals can be harmful to human health in closed, unaired spaces, and to the environment as a whole. Furthermore, their use involves the application of considerable and costly pollution control measures, such as gas-fired afterburners. Check with the supplier of the packing material if a suitable alternative is available for use, with reduced content of VOC and using water-based inks and lacquers. This type of choice can reduce both the costs related to emissions control and the overall carbon footprint, while improving the local environment's health.

4th CRITERION

Designing for resource recovery

Ensuring the compatibility of secondary components with the sorting and recycling systems

High priority

Rigid plastic components are problematic for aluminium sorting and recycling processes. They can cause quality and safety problems during the decoating of aluminium waste. Aluminium remodeling companies may reject batches of aluminium waste if the levels of contaminants such as plastic are too high. Omitting or minimizing plastic components as much as possible is the appropriate thing to do in packaging design to promote recyclability and improve the quality of the recycled material.

Plastic film labels on aluminium packaging, such as those made of heat-shrinkable material, are not excessively problematic either for the recovery of the packaging at recovery facilities or for the subsequent recasting, however they must be avoided or reduced to the minimum as much as possible. PVC films must be avoided due to the high chlorine content. Direct printing on the aluminium container should be the first choice when possible.

Supplying consumers with clear instructions
High priority
Aluminium beverage cans at life-end have been recycled at high – and growing – rates for many years. Other types of aluminium packaging are recycled at lower rates. The marking and messages describing sorting and recycling should therefore be visible and provide consumers with clear instructions. Affixing the double arrow circular mark with the initials ALU in the middle is advisable, immediately conveying what type of material the can is made of and its recyclability, as well as the acronym ALU 41, in accordance with Decision 97/129/EC, and any other messages about collection and optional recycling, such as "Recyclable aluminium can, collect separately" or "Collect separately when completely empty" (for sprays). Provide a clear message against littering, the dispersal of waste in the environment, for products that are most likely to be used outdoors.

Reducing the thickness of the laminated or aluminium components
Medium priority
In the case of aluminium foil and packaging aluminium, in order to minimize the packaging footprint, the thickness should be reduced as much as possible while maintaining functional performance.

Aluminium screw caps, such as those used for wine and water bottles, are generally made in aluminium from the 8000 series, and offer no problem in recovery and recycling. However, due to their small size and the custom of consumers to re-screw them onto bottles, they are unlikely to be recovered in the aluminium systems.

CiAl has therefore begun collaborating with glass treatment plants to guarantee their selection and recovery. The caps thus recovered, still containing high residues of glass, require additional processing steps to separate the aluminium from other materials.

Avoid using bimetallic beverage cans with a steel body and aluminium fastening. Electromagnets in material recovery facilities typically collect these composite metal packaging in the initial steel packaging sorting flow and aluminium components are therefore lost during steel casting.

Maximizing the value of the recovered materials

Medium priority

Most aluminium spray cans are made in aluminium from the 1000 series, completely recyclable. However, consumers are often not fully aware that such cans are recyclable. Apply clear instructions for sorting and recycling on spray cans and, as previously indicated, minimize the use of components made of other materials, for example plastic. Propellants in sprays can be hydrocarbon based, i.e. propane, or not, i.e. carbon dioxide or nitrous oxide. In particular, hydrocarbon-based propellants can cause safety problems when the container is drilled, something that will very likely happen during compacting at a material selection and recovery facility. Although the potential security risks associated with hydrocarbons are usually well managed by the operators of material recovery facilities, assess the feasibility of using a non-hydrocarbon propellant to increase the safety of aluminium spray cans recovery. Remind consumers to fully empty the cans well before sorting.

Stamping directly on the aluminium packaging

Low priority

Paper and plastic film labels, fsuch as heat-shrink materials used on aluminium packaging, are not excessively problematic either for the recovery of the packaging at recovery facilities or recycling. However they must be avoided or minimized as far as possible as they are not themselves recoverable.

PVC films must be avoided due to its high chlorine content. Printing directly on the aluminium container is preferable.

Design example: Spray cans

This design example describes some of the aspects of sustainable design that need to be taken into consideration when developing or verifying packaging. The information refers to a deodorant spray can. Standard market packaging is in aluminium with an integrated valve.

Designing for efficiency

- Verify the availability of aluminium maximizing the percentage of recycled material.
- Reduce weight as much as possible.

Designing for accessibility

- Ensure easy removability for caps, when present
- Increase the volume of the actuator to make it both ergonomic easy to press

Designing for recyclability

Spray cans are recyclable. Ideally, plastic components should be removed before sorting as they minimize the quantity reducing the value of the aluminium collected for recycling. Hydrocarbon propellants are potentially dangerous during compacting at the sorting and recycling compound. This is however a risk generally manageable by the operator.

TO MAXIMIZE RECYCLABILITY

- Design the nozzle for easy removal from the spray can
- Verify the fact that the product can be dispensed 100% when in use, optimizing, for example, the base's arching
- Offer consumers clear instructions (as detailed below)

LESSER IMPACT PROPELLANTS

- Choose a non flammable propellant with minimal environmental impact
- Evaluate techniques allowing for less propellant to dispense the same amount of product

Labels for consumers

Many consumers are unaware that spray cans are recyclable. Informations on the spray can should be made available in a visible position and include:

- The circular symbol comprised of two arrows with the ALU acronym at its center that immediately conveys the material type and recyclability of the product;
- The acronym ALU 41, as per Decision 97/129/CE;
- Any other information regarding optional possibilities for sorting and recycling, such as "container in recyclable aluminium, sort separately" o "recycle when completely empty";
- Remove cap and nozzle after use.

An impeccable example: the latest spray can for an Unilever deodorant was shrunk in volume from 150 ml to 75 ml, but dispenses the same amount of product using less propellant. ●

TO MINIMIZE PRODUCT RESIDUE IN PACKAGING

THE DEVELOPMENT PROCESS

- ☐ Do you know the common level of unintentional residue of your product?
- ☐ Have you compared the level of residue in your packaging to that of your competitors?
- ☐ If residue reduction or elimination is possible, how much could you and your clients save?
- ☐ Can you develop a method to measure the "residue traits" as they relate to your packaging options?

THE PRODUCT

- ☐ Can the physical composition of the product be modified for residue reduction?
- ☐ Does the product last long enough before turning unusable?
- ☐ Can old products be revived?

THE PACKAGING

- ☐ Is packaging single doses practical?
- ☐ Does the packaging support the consumer in verifying the level of content?
- ☐ Can the consumer easily access residues of the product through, for example, removable latches, big openings, or thanks to the absence of corners and cracks?
- ☐ Can the packaging be easily closed again once opened to better allow conservation of the product?
- ☐ Does the selection and size of your packagings allow consumers to buy the correct dose needed?
- ☐ Does the packaging display indications on how to make the utmost use of the product?

THE CONSUMER

- ☐ Do you know how consumers empty the packaging in full?
- ☐ Does your packaging design help the consumer?
- ☐ Do you need to offre suggestions on how to fully empty the packaging?
- ☐ Does the packaging convey clear instructions on how to preserve the product?
- ☐ Do the packaging and the information displayed on it help the consumer in choosing the correct dose of product?

Prevention and management of packaging waste scenario

Image by Alberto Bernasconi

Prevention is a major priority for sustainable development. Packaging must be designed to offer the best performance, greater efficiency, easier use, possible reuse and recycling

Prevention

Prevention is one of the pillar principles of a proper managing system for packaging.

Prevention means minimizing quantities (quantitative prevention) and increasing eco-compatibility (qualitative prevention), of both materials and substances used,be it in packaging or packaging waste, especially by developing non-polluting products, processes and technologies.

Prevention is a relevant priority to achieve a proper approach to sustainable development. Packaging must be conceived to offer the best performances, the best efficiency, greater ease in use, a possible second use and finally recyclability. By law, the entire supply chain is entrusted with the responsibility of implementing prevention actions. Producers share a primary role, nonetheless, the behavior of industrial and commercial users have great influence over production, logistic and market activities of products, giving incentives and creating advantages that favor the development of preventive actions.

In these years, CiAl's role has been promoting, supporting e monitoring any prevention activities, be they of a qualitative or quantitative nature, put into action thanks to the partnership between producers and users of aluminium packages, besides giving testimony to the main innovations being introduced in the industry, to facilitate the circulation of virtuous models of sustainability.

Research, development and innovation, both technological and in design, have always characterized the industry of aluminium packaging and almost always walk hand in hand with growing improvements of environmental performances. Reducing weights, new printing technologies, developing of new formats and systems facilitating consumption come along with modern and innovative forms for each of the different sectors of packaging.

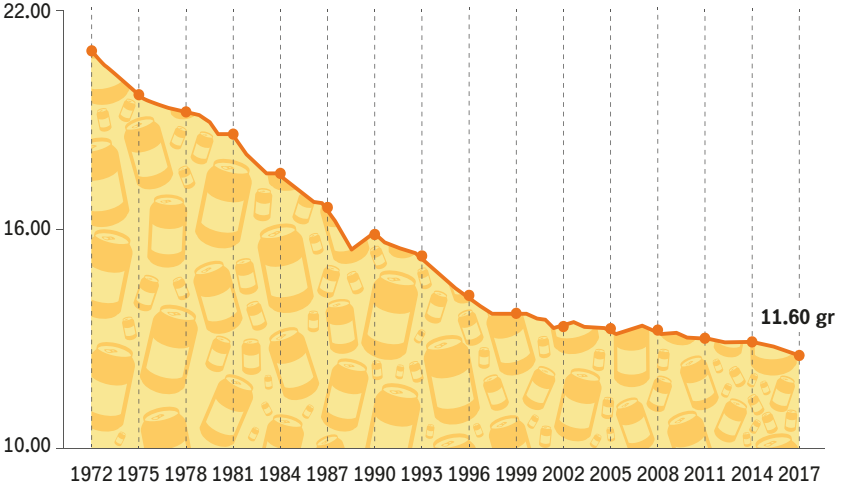
Follows a breakdown analysis of the progress made by supply chains dealing with different types of aluminium packaging.

Cans

Recent years have seen excellent results in the canning sector from the point of view of weight reduction, for both can bodies and lids. These results were possible thanks to the development of new technologies, both in terms of production and process automation; as a matter of fact, processing ever thinner laminates was only possible thanks to the technological innovations introduced to the production lines. The reduction in thickness of the laminates used for manufacturing cans since 1997 is up by 6.9% – the reduction obtained, as a whole, between 1977 and 2014 amounts to 37%. The full weight of cans has been reduced by over 30% since 1990. In 1990, a can weighed 16.58 g, nowadays, it weighs 11.60 g. Lithography techniques used to print on aluminium cans have been developing in recent years. Used already for commercial decorations, they can be used to provide high visibility of expiration dates thanks to color changes or writing.

Aluminium cans weight

Average weight of aluminium cans



The latest interesting evolution of the can format dates back to 2009 when the sleek, or "elegant," "slender" can was born, about 3 cm higher than "classic" 33 cl cans, yes carrying the same content. These cans are light, lighter even than the classic version (the contribution of a reduction in the material used while maintaining volume is evident, as well as the optimization of logistics and transportation).

Bottle-Can

An important result in the search for new and innovative packaging solutions for the beverage market has led to the introduction of aluminium bottles as a spin-off of cans. More specifically, the bottle-can production process is starts from cans and introduces an Italian born technology capable of molding cans into the typical shape a bottle.
It therefore represents an interesting opportunity to create a new category of beverage packaging.

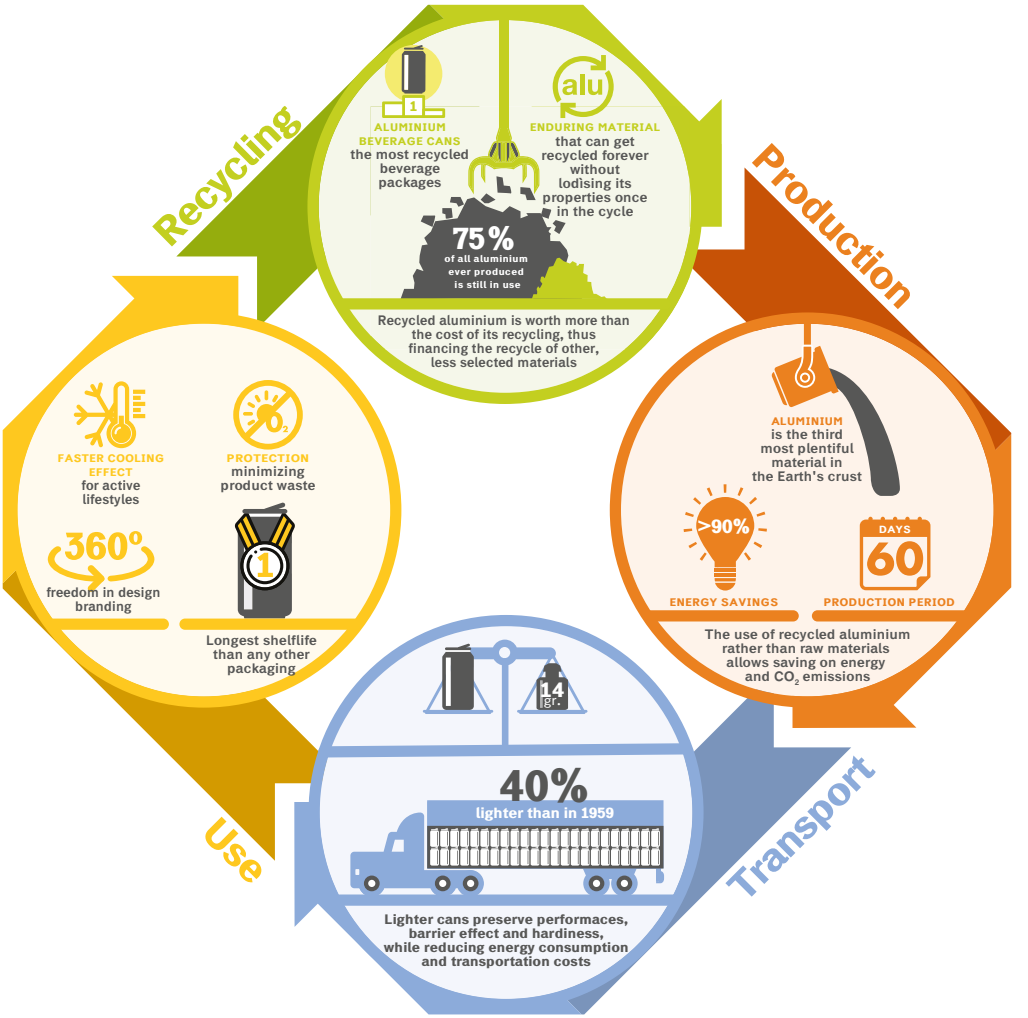
The new line of standard Fusion bottles in the 33 cl and 25 cl formats, comes in 3 different kinds of closing systems: ROPP caps (that can get screwed closed again), Maxi P pull-out caps and standard crown caps.
Clients therefore have the possibility of choosing what kind of fastening better suits their markets.
Thanks to the possibility of di pasteurizing and using Fusion bottles for a wide range of beverages, sparkling or not, including single portions of wine and flavored drinks, beer, energy drinks and sodas, this new kind of packaging should find its way to many markets.
The most important quality of Fusion bottles is their ability to hold ideal cool temperatures for a prolonged stretch of time, and the resulting feeling of freshness with them.
Fusion bottles are an excellent combination of lightness and stability, bringing together the advantages

of beverage cans bottles, besides being unbreakable and subject to being closed after first use. Thanks to its intrinsic characteristics, Fusion's aluminium offers complete protection against light, air and microorganisms, besides being 100% recyclable in a never ending loop. Their environmental performances are not limited to recyclability. Thanks to the light weigh of aluminium bottles, other benefits reaped are energy saving, reduced emission during transport, products' logistics and cooling.

Boxes

The introduction of new alloys, experimented with in recent years, has brought about a reduction

Circular economy of a beverage can



in weight for containers. Unlike beverage containers, that come in a maximum of five standard capacity formats, "food boxes" come in a disparate number of capacities.

Further weight reductions for "food boxes" will be possible, in the future, thanks to direct involvement of the canning industry. As a matter of fact, such reductions in thickness and therefore weight, will only be possible if the sterilization systems are modified with the massive use of static sterilizers, capable of working counter-pressure and therefore allowing control of the internal pressure, so as not to put the container itself under stress.

The canning sector has undergone the strongest acceleration of all in innovative development, both in relationship can bodies and, especially, lids. In the last few years, cans have been in the spotlight and their design features have benefited of it with the birth of new, modern and innovative shapes, characterized by softer and rounded contours. The latest design in boxes has also been graced by new and interesting ideas for lids and opening solutions, characterized by greater safety and ease of use. Boxes equipped with Easy Peel lids have been on the market since 2002, using peelable membranes about 70 microns thick, much thinner than rigid lids, 200 microns thick.

Trays

In the case of semi-rigid packaging, preventive actions have been developed to reduce the weight of trays. In particular, new molds have been designed and constructed, characterized by traces, small shelves of different radius allowing the molding of thinner trays than market standard, without sacrificing performance in comparison to previous versions (average reductions of 5 µm, about 6.6%); the quantity material "rolled" in the "G" edges of the hot-tubs has been reduced, allowing to stack the same number of trays in smaller spaces (thus reducing the size of secondary packaging or, alternatively, increasing the number of pieces packed).

Caps

One of the most recent and interesting applications of aluminium in the packaging sector concerns the increasingly widespread adoption of screw caps for wine bottles, due to their significant technical and environmental performance. As a matter of fact, aluminium screw caps in the wine sector guarantee:

- a perfect solution to the problem of "cork flavored wine," responsible for the waste of thousands of bottles a year;
- simplicity in opening and closing bottles, doing away with the need for tools;
- optimal consumption and good conservation of wine, preventing waste production;
- an economic advantage for the whole supply chain, from wineries to final consumers.

Aluminium is a highly functioning material for product conservation, besides its important characteristics in terms of recyclability and sustainability.

As a matter of fact, aluminium can be recycled an infinite number of times, and its reuse allows saving up to 95% of the energy necessary for its first manufacture, meaning a corresponding reduction in greenhouse gas emissions. These are, in short, the levers on which one of the recent campaigns promoted by EAFA was based, recalling the interesting recycling performances of aluminium caps in Europe and guaranteeing, for the future, an additional potential for growth achievable by the various countries in the European Union. The percentage of recycling of aluminium screw caps averages 45% across Europe. Despite their small size, aluminium caps are collected and recycled either separate from other aluminium packaging materials or alongside the collection of glass. As a matter of fact, both possibilities allow the aluminium to be completely separated and recovered. Packaging collection and recycling systems vary widely in Europe since they depend on the national waste legislation of each country.
The portion of recycled aluminium screw caps also differ according to the infrastructure available for waste sorting in each country, ranging, in the year 2014, from over 80% in Germany to 65% in Italy and 45% in Great Britain. Nonetheless, even in countries with the lower market shares, at least 20-30% of all aluminium screw caps are recycled. The European information campaign "Aluminium caps: a 360° revolution," launched at the end of 2012, aims at providing detailed information on the many advantages of aluminium caps. The campaign, particularly tailored for wine producers, provided insights on the sustainability and recyclability qualities of aluminium screw caps, in view of an efficient use of resources.

Closures and covers

Peel Seam closures, once only used for the packaging of dry products (powdered milk, coffee) are increasingly present in the Italian and European market, applied to a growing number of products. As a matter of act, thanks to the use of materials that resist sterilization, this type of closures are easily applied to the packaging of products that require heat treatment for storage.

More specifically, the Peel Seam 99 Saferim, 99 mm of diameter, comes with a fold on the lid covering the cutting edge to be found once open, to protect the customer from getting cut in case of accidental contact with a finger. The cover has also been combined with a newly designed ring which, while still allowing for an ergonomic grip, offers less resistance when being lifted, requires less effort to perforate the scoreline and a 20% decrease in thickness.
In the case of boxes drawn in two pieces, the system allows perfect stacking on supermarket shelves, with no risk of damage:
the box bottom rests on the protective fold and doesn't interfere with the nose of the cover of the box under it.
A new technology has been adopted to write on the cover, allowing it to be done in relief molding – still in the same relative position to the ring – resulting in clear and perfectly legible characters.
Made of a rigid aluminium ring on which

a flexible aluminium membrane is heat-welded, the Peel Seam is therefore easy and safe to open for any consumer: when pulling the tongue, the "peeling" of the ring membrane is triggered. The combination with jars of special shapes (bowl, dome, rectangular), achieved thanks to deep drawing technology, brings forth the creation of original and customized packaging designs, suitable to consumers' needs and mostly composed of one material, thus facilitating waste sorting and recyclability.
PeeliCan lids are based on a complete system of caps primarily used in the fishing industry. It is a modern, clean and easy-to-use alternative to traditional ring-opened fish boxes. This product offers containers and covers completely made in aluminium.
The sheet's specifications, for printable containers and covers both, have been designed to meet the specific requirements for final use and easy recycling of the material.
The Easy Peel technology is also applied to the field opening and closing systems for painting boxes. An aluminium film is kept in place by a ring. At opening, this aluminium film detaches easily and effortlessly, simply by pulling the appropriate tab. The box is closed again with a soft capsule that will keep the product intact for any future use. The Peel & Paint concept ensures package inviolability, while allowing correct reuse of the closing and an increased life of the paint, therefore reducing stocks and resource waste.

Aluminium sheet

The aluminium foil used for the production of flexible packaging, polylaminate included, allows to close original packs (chocolate, sweets, butter, etc.) after opening them for a more rational use of food resources. In the last 15 years, the average thickness of aluminium foil has been reduced:

- by 30% in chocolate packaging;
- by 30% for polylaminate applications in long-life beverage cartons;
- 33% for application in flexible coffee blend packages (from 12 to 8 microns).

Furthermore, the high barrier effect of aluminium allows to minimize the use of other materials; a laminate including an aluminium sheet needs less paper and plastic than a laminate that does not. Take, for example, sterilized long-life foods, that don't need to be kept in refrigerators thanks to the complete barrier effect of the aluminium foil; this kind of packaging guarantees transport and stock of food resources in less space and with minimized added packaging weight, guaranteeing la long shelflife and reduced energy consumption for cooling.

The reduction in thickness and weight are the results of innovations in the processes of melting and lamination, the application of sophisticated automation and control systems, and the development and use of new alloys tailored to specific uses.

Tubes

When dealing with the issues of conservation and protection of products, aluminium tubes are very important. Indeed, aluminium is, as of yet, the most suitable

material when packaging materials that are particularly sensitive, such as those to be found in the pharmaceutical sector.
The outside finish of the tubes, glossy and smooth, can limit the access of dust, humidity, bacteria and micro-organisms present in the air, all elements that are responsible for changes in the nature of the product.
Moreover, aluminium is also capable of remaining neutral and inactive when in contact with other materials or products. These properties guarantee a longer and more effective protection for the tube's contents.
Another important characteristic, facilitated by the devices present at the filling plants and the spouts used in closures, is the ability to hinder the absorption of oxygen bringing in a number contaminants. This kind of solution is therefore ideal for packaging perishable goods and reducing waste.
Thanks also to the advantage offered by the collapsible capacity of the material when folded, allowing the product to be fully used and the tube to be completely emptied, the presence of residues is minimized.

Management and recycling of packaging waste

A description follows of how aluminium packaging waste is commonly managed from sorting to recycling.

Sorting and collection

The collection of aluminium packaging is handled in Italy as part of the national recovery system overseen by CiAl and covers all types of containers (beverage cans, food cans and trays, spray cans, capsules and bottle caps, containers for oil, wine and liqueurs, tubes for preserves and creams, confectionery and chocolate foils, yoghurt lids and aluminium foil rolls for the preservation of food).
The actual waste sorting is organized by each municipality or by the operators they appoint. Aluminium packages, with very few exceptions, are usually collected alongside other kinds of materials, using a multi-material system differing depending on the collection equipment and the installation locally available. The aluminium, along other materials, can be collected in bags, building bins, dumpsters or bell-shaped containers.
Collection ranges from the most recent option of "light multi-material" (metal and plastic packages) to that of metal and glass, to the "multi-weight" (metal, glass, plastic) and the simple collection of metal packages.
Recycling centers in particular, offer the possibility of disposing of materials that are either not collected at home and in road dumpsters, or too bulky to be.

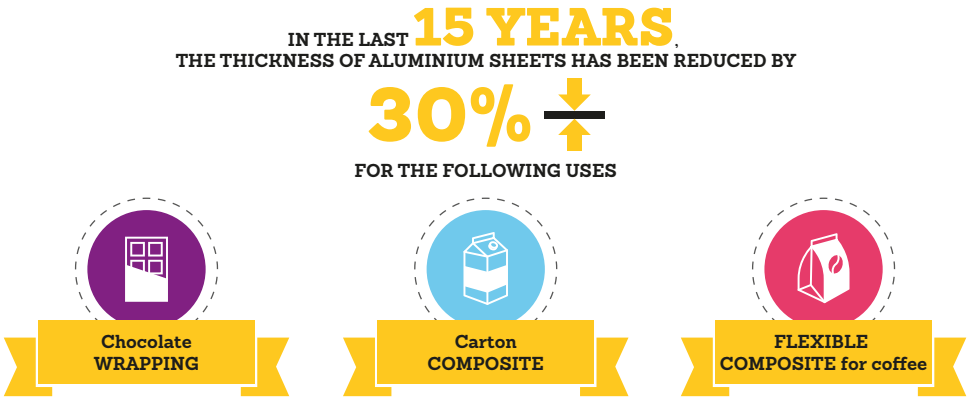
Commercial waste collection systems can be managed like those for household waste collection if, for example, bars and restaurants deliver in large containers to be used exclusively for the collection of cans and other used packaging. Other examples of enterprises that produce large quantities of used aluminium packaging are hotels and airlines, or cruises.
Systems collecting large quantities of recyclable waste that has already been sorted have the advantage of producing an ongoing supply of uncontaminated

material to be sent directly to recyclers/ foundries.

Platform and separation

All of the aluminium collected in multi-material collection systems must be separated from any other materials before being recycled. The materials collected are usually sorted at selection plants thanks to a series of automated devices. For the sorting of aluminium, a device using eddy currents exploits the electrical conductivity of the metal to separate from other materials. The device consists of a rotor equipped with magnets that are configured with alternating poles on which mixed multi-material flows are delivered. Thanks to their circular movement and the disposition of the magnets, the rotors generate an electric field among the non magnetic materials.
The electrical currents thus induced induce the surfaces of conductive materials to swirl, thus creating an "Eddy Current".
Such currents generate, through the non-ferrous metal objects, a magnetic field of their own, opposite to the main one. The objects are therefore pushed away from the separator.
A barrier erected in proximity to the separator, keeps those metal objects rejected away from other non-metallic materials. The distance between the eddy currents separator and the barrier is precisely calculated to allow the recovery of expelled metal objects, such as aluminium beverage cans, while all other objects not interacting with the magnets fall off just after the barrier.

The repelling force exerted on metallic objects by the eddy current separator depends on ta combination of shape, weight and electrical conductivity of the object itself. In this process, conductivity is usually the determining property. Most of the metal objects are rejected over the barrier. However, some objects do not have the right combination of shape and weight that allows separation. A flat object, like a metal sheet, will generate a stronger induced current with its wide surface, but its shape, combined with its lightness, will offer greater resistance to air, another condition that keeps metallic objects from falling with others. A magnetic separator is therefore usually used before the eddy current



separator, to capture steel waste. This is how almost all of the metal reaching the eddy current separator will be aluminium.
The quality of the aluminium thus selected is checked and the material sent to the foundries for recycling. Any waste is then sent to waste-to-energy plants or recovered through the production of RDF.

Compression and transportation

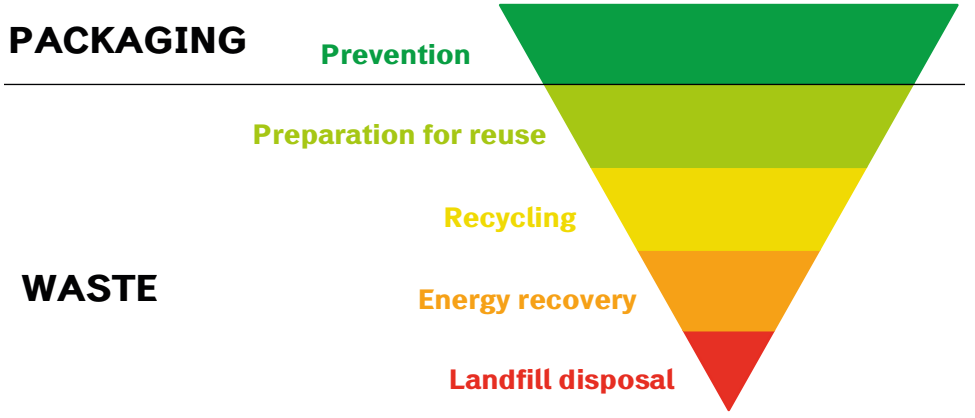
Once selected out of the multi-material flow, aluminium is compacted into bales to optimize transport to the final destination, the foundry. Pressurized spray cans could represent a potential hazard at this stage of the process. This is the reason why information and awareness campaigns encourage consumers to empty the cans completely before recycling them, thus eliminating all risks at the plants they are destined to.

Foundry

The material is here pre-treated at about 500 °C to be relieved of paints or any other kind of substances sticking to it and then melted at 700 °C into liquid aluminium from which ingots and slabs are obtained, destined to be processed for the production of semi-finished products and newly manufactured articles. All and any measures, technologies and processes are adopted at foundries to minimize losses from oxidation (such as using salts and specific techniques for loading materials). Recycled aluminium has the same properties and quality as the original aluminium and is used in the automotive industry, in construction, in the production of household goods and for new packaging.

Sorting, separation and recycling

Unfortunately, packaging waste and materials that should be sorted separately still end up in the black bags, i.e. or in the bins allotted to non-recyclable waste. Selection technologies allow the separation and enhancement of those portions of aluminium (packaging and the like) still present in both mechanical-biological treatment plants (TMB plants) and RDF secondary



solid fuel production plants. The flow of aluminium, after adequate quality control and possible further selection, is brought to the foundries for recycling.
Undifferentiated collection, waste-to-energy recovery, extraction-recycling
Waste that is not sorted at the start by citizens ends up as undifferentiated collection, also treated in incineration plants, producing energy thanks to the heating value of waste.

Aluminium packaging less than 50 µm thick, even coupled with other materials, produces energy especially in the combustion phase. Packaging and other aluminium objects thicker than 50 µm end up in the post-combustion slag (heavy ash) at the end of the incineration process and can be extracted through sorting sections and, after adequate quality control, once more recycled in a foundry. ●

Aluminium life cycle

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ALUMINIUM PACKAGING
GUIDELINES
FOR AN ECO-FRIENDLY
DESIGN

Design for recycling

Publisher:
Edizioni Ambiente srl
via Natale Battaglia 10, 20127 Milano
tel. 02.45487277, fax 02.45487333
www.edizioniambiente.it

Editing
Diego Tavazzi

Design & Art Direction
Mauro Panzeri

Layout & infographics
Roberto Gurdo & Michela Lazzaroni

This book has been composed in
Dejavu Pro di *Ko Sliggers*

Published and printed in Italy at GECA S.r.l.,
San Giuliano Milanese (Milan)

Printed on carta Favini,
www.favini.com

This book is printed
on FSC forest friendly paper.
The FSC logo identifies products which contain paper from forests managed according to strict environmental, economic, social standards defined by the Forest Stewardship Council.

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