Diploma in Packaging Technology

Unit 2
Rigid Metal Packaging

Unit 2 Rigid Metal
Learning Outcomes and Assessment Criteria

Learning Outcomes (What you need to know/understand)

1. Understand the properties of materials which make them suitable for packaging

Assessment Criteria (What you need to do)

1.1 Compare and contrast the properties of packaging materials.

1.2 Assess the advantages and disadvantages of using a material or combination of materials for packing a particular product

1.3 Evaluate the properties that encourage and/or limit the use of particular raw materials, packaging components or processes

Unit 2 Indicative Content - Properties

- The common glass, metal, plastic and paper and board materials used in packaging
- The common packaging polymers: polyethylene family, polypropylene, polystyrene, polyvinyl chloride, polyethylene terephthalate.
- Other polymers used in packaging: polyvinylidene chloride, Ionomers, polyamide, polyethylene naphthalate, styrene copolymers, polycarbonate, ethylene vinyl acetate, ethylene vinyl alcohol, poly vinyl acetate fluoropolymers, thermoplastic elastomers, and biopolymers.
- Properties of the materials commonly used in packaging: glass; plastics; metals; paper and board.
- Material and process developments,
- Properties and uses, both rigid and flexible where applicable, advantages and disadvantages.
- Uses in different markets, threats and opportunities.
- Processing, treatment and preparation of raw materials
- Use of recycled materials and impact on material performance
- Comparison of the use of different material types in terms of cost, properties and performance, as a basis for making an informed and justified selection of the most appropriate material for a range of uses. An understanding of material imports and sourcing from low labour cost areas.
- Environmental considerations related to the use of particular materials.
- An overview of "new" and "smart" materials being developed for packaging applications and their advantages and disadvantages.
- The common uses of combinations of materials in packaging
- The functions and advantages of different materials in combination
- Examples of packs made of combined materials and why.
- Trends in the use of packaging materials, components or processes

Unit 2 Rigid Metal
Learning Outcomes and Assessment Criteria

Learning Outcomes (What you need to know/understand)

3. Understand the conversion of raw materials into packaging materials and packaging components

Assessment Criteria (What you need to do)

3.1 Describe in detail conversion processes from raw material to finished component

3.2 Compare alternative conversion processes used to produce specific components

3.3 Explain the role of coatings and treatments for a given material

3.4 Produce a specification for a given component or material and describe methods of testing to evaluate performance

Unit 2 Indicative Content - Process

- Main approaches to packaging manufacture for each major raw material from the basic material itself to the finished product
- Quality aspects, typical defects, on-line and off-line inspection processes. Packing, labelling and traceability of batches.
- Alternative materials and processes for specific performance requirements
- The use of re-cycled materials
- Materials used for coating, coating processes and why coatings are used.
- An overview of the decorative processes used for each material.
- The different parts of a packaging specification – specification checklist
- Product/pack compatibility requirements
- Qualitative and quantitative aspects of a specification
- The influence of product/pack compatibility
- Complete specifications for different packaging requirements
- Do's and don'ts of producing specifications
- Introduction to pack testing techniques and applications
- Advantages and disadvantages of various tests

Manufacturing the material (part 1)

- Origins of Canmaking
- Introduction to light metal packaging
- Materials of construction
- Manufacturing route for packaging steel

Shelf Life

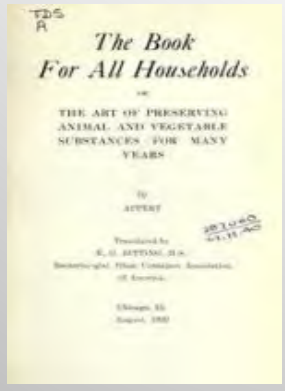
The greatest packaging innovation to extend shelf life?

Emperor Napoleon's Competition of **1775**.

Nicholas Appert invented the method of canned food preservation

Shelf Life

The greatest packaging innovation to extend shelf life?


TDS
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The Book For All Households

THE ART OF PRESERVING ANIMAL AND VEGETABLE SUBSTANCES FOR MANY YEARS

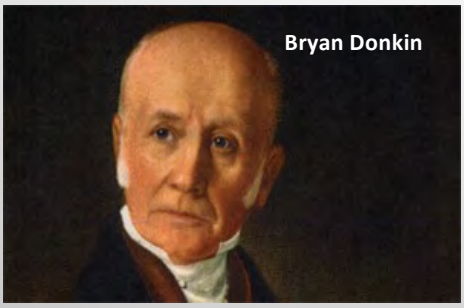
APPERT

In **1810** in England, **Peter Durand** patented the **metal canister** which was apparently invented by Frenchman, **Phillippe de Girard**.

M Girard came and brought his preserved foods. We tasted the milk and the broth and the roasted meat. All good but the milk was yellow and had a bad taste. The broth had been kept since August last, he said. The milk and beef six weeks. He had a phial of a large size, milk, broth and gravy in tin kettle with covers soldered on... His patent is taken out in the name of Durand.

Early Days of Food Canning

The greatest packaging innovation to extend shelf life?



"Hole and cap" can

1812 **Bryan Donkin** and **John Hall** bought Durand's patent for £1000 and set up the world's first canning factory in Blue Anchor Road, Bermondsey, London

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Early Days of Food Canning

The greatest packaging innovation to extend shelf life?

Early cans made at Donkin's factory

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Early Days of Food Canning

The greatest packaging innovation to extend shelf life?

Early cans made at Donkin's factory

Emagine Packaging Ltd.©

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Early Days of Food Canning

The greatest packaging innovation to extend shelf life?

1825

Emagine Packaging Ltd.©

1875 **Arthur A. Libby** and **William J. Wilson** developed the tapered can for corned beef in Chicago.

Modern can

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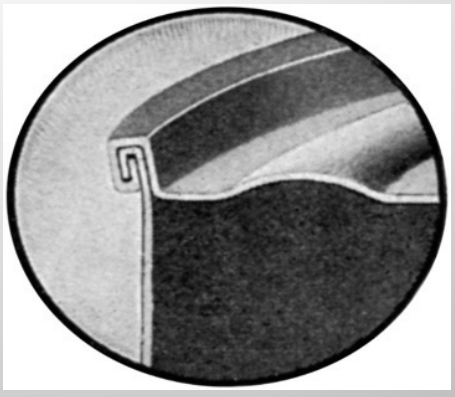
Early Days of Food Canning

The greatest packaging innovation to extend shelf life?

1888: Development of the ***sanitary can***.

1904: Max Ams' invention of the double seam was patented.



Early Days of Food Canning

The greatest packaging innovation to extend shelf life?

Please watch the following clip from the **American Can Company**'s vintage 1956 documentary entitled:

"How Canned Food Changed America: Miracle of the Can"

In particular, see the sequence from 8 mins 20 secs to 17 mins:
https://www.youtube.com/watch?v=s-Mc7A6nr_A

Origins of canmaking

1795	Napoleon's prize
1810/13	Appert / Durand / Bryan Donkin
1824	Perry / North Pole
1850/70	Soldering perfected
early 1900s	Double seaming applied
1929	Eric Rotheim patents early aerosol
1933 / 36	3 piece soldered beer cans
1953	3 piece soldered soft drinks cans
1962	Easy open ends

Origins of canmaking

1963	2 piece DWI beer cans (aluminium)
1969/71	2 piece DWI soft drink cans (al/st)
mid 1970s	High speed can welding and 2 piece DWI beer cans (steel)
1977	2 piece DWI food cans (st)(USA)
1978	2 piece DWI food cans (st)(Europe)
1997 →	Shaped / embossed beer / soft drink DWI cans
2001	Bottle can developed in Japan

Modern Food Canning

The greatest packaging innovation to extend shelf life?

3-piece tinplate food can

2-piece single drawn and multiple drawn cans
(i.e. Draw & Redraw or, DRD)

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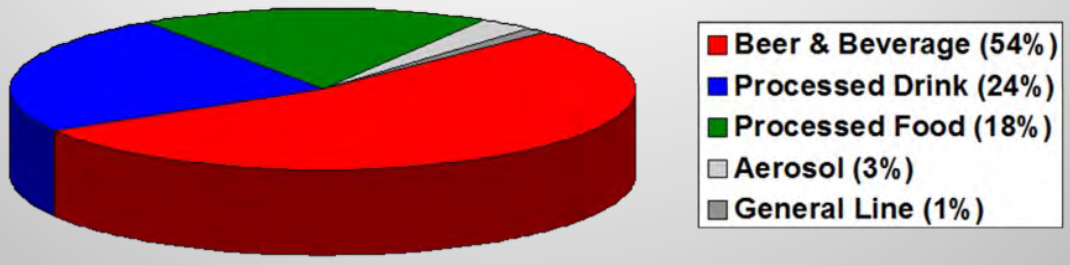
World consumption of metal cans

Est. Share of World Consumption of Metal Cans

Total 410 billion



Source: Canmaking - the technology of metal protection and decoration - T.A.Turner

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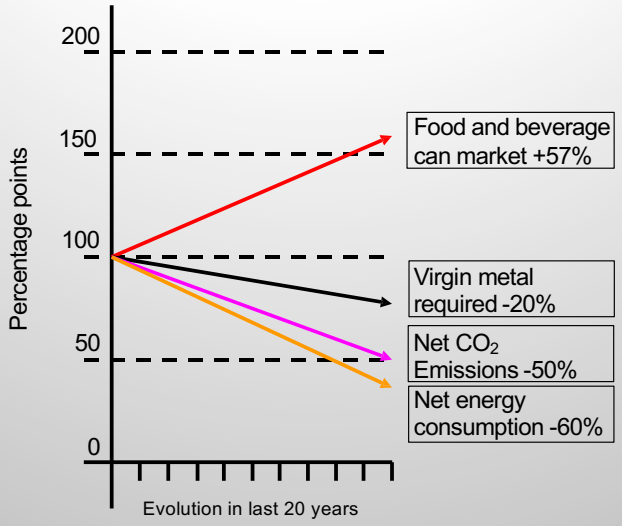
Evolution of market, metal and energy use - metal food and beverage cans over last 20 years



Reproduced by courtesy of Empac

Shelf-Life Extension

20th Century:

- **Canning:** major global industry
- **Aseptic Cartons:** Since 1960s e.g. Tetra Pak's Tetra Brik Aseptic (TBA)
- **Freezing:** Rapid growth of domestic refrigeration in 1950s. Stand alone domestic freezers widespread in UK by 1970s
- **Chilling:** Fast growth since 1980s
- **MAP:** Strong growth since 1990s

Birds Eye frozen foods

Source: google images

Videos

The Ingenious Design of the Aluminium Beverage Can
https://youtu.be/hUhisi2FBuw

How it's made Aluminium Can
https://youtu.be/V4TVDSWuR5E

REXAM Aluminium and Can manufacture
https://youtu.be/7dK1VVtja5c

3 piece Pail. https://youtu.be/cCcfOVNWiHw

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Light metal packaging - examples

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Overview of can physical requirements (1)

Processed food – raw food filled into can, sealed with end, heated to 120°C or 132°C for up to one hour to sterilise/cook product. After cooling down the pressure in the can is negative.

Drinks – beer and carbonated soft drinks filled cold and sealed with End. Depending on ambient temperature internal pressure may rise to 5 atmospheres (72.5 psi) during storage. Some non-carbonated products are heat processed after filling.

Aerosols – filled with product and liquid/gas propellant to expel product. Treated as pressure vessels. Internal pressure during heat processing of some fragrances can reach 18 bar.

General line industrial – some subject to filled can drop tests where hazardous materials are being transported.

Overview of can physical requirements (2)

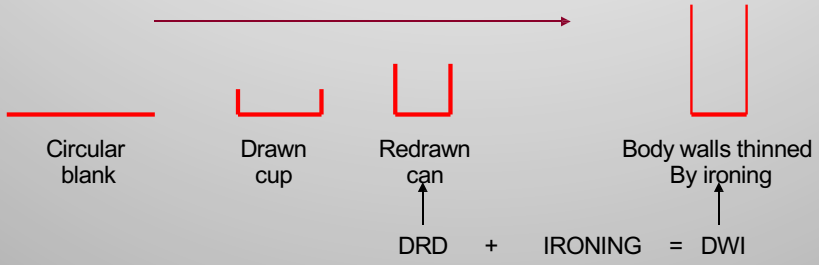
- Productions speeds of individual containers up to 2500 per min through 12 to15 linked processes. These speeds for individual products only equalled in cigarette manufacture. Filling speeds up to 2200 per min for drinks cans (140-180 filling heads on carousel) and 800 per min for food cans.
- High levels of dimensional accuracy are required to ensure speeds can be maintained. Containers have high integrity with effective interchangeability between can bodies and ends. Typical thickness range of thin wall can body is 0.120 – 0.125 mm.
- One of the few high volume / high precision manufacturing processes
- Quality assurance achieved by statistical sampling techniques throughout whole supply chain (metal manufacture – conversion – filling – heat processing). Engineering tolerancing not used.
- Package specified by physical performance as well as dimensions

Can body manufacture

Two basic routes of manufacture:

3-piece can – body with side seam plus two ends

2-piece can – seamless body with one end



Materials of construction

- Basic requirements:-
  - Food safe
  - Easy to form
  - Good anti-corrosion properties
  - Adequate strength properties
  - Plentiful - low cost
- Iron → low carbon steel → blackplate, tinplate & tin free steel
- Aluminium
- Lacquers or plastic laminate / coating used for barriers, protection and lubrication of metal surfaces
- Steel and aluminium process waste and finished packaging is all fully recyclable an unlimited number of times without degradation. As there is no difference between remelted and virgin metal, using recycled metal presents no problems.

Materials of construction -
Steel

- Low carbon (0.04-0.12%) steel is the most common metal used for can making.
- Very complex material which permits physical properties such as temper and hardness to be adjusted by cold forming and annealing under controlled conditions.
- Temper is a measure of “springyness” and basic strength. This is measured on a tensile testing machine.
- Hardness itself not important for can making but often used to indicate temper as easier to measure and the relationship between these properties has historically been reasonably good.
- Standard EN10202:2001 uses tensile strength to define different grades of packaging steels. Range is from 230 to 620 N/mm^2

Steel variants for packaging manufacture

Blackplate - Has no additional metallic coating so has poor natural resistance to corrosion even when coated with a lacquer. Used without internal lacquer for products such as wax oil or grease.

Tinplate - blackplate with a coating of tin metal electrolytically applied to both surfaces. Coating weight may be different on each surface to suit product packed or manufacturing process.
Typical weights for inside of cans with lacquer 1.4 - 5.6 g/m^2. Typical weights for inside of cans without lacquer 8.4 - 11.6 g/m^2. External weight normally 2.8 g/m^2 without need for lacquer.

Tin gives good corrosion resistance and because it is soft it is used as a solid lubricant in the 2-piece DWI can making process. Tin on surface aids the 3-piece can welding process. Used with or without internal lacquer, as necessary, for any products and most can/end making processes

Steel variants for packaging manufacture

Tin-free steel (Electro chrome coated steel) - blackplate with chrome & chromic oxide electrolytically applied.

Less expensive than tinplate. Needs lacquer / plastic laminate or coating on both surfaces to complete corrosion protection system as natural resistance is poor.

Chrome, chromic oxide surface is very hard and brittle and needs to be removed locally to permit satisfactory welding. It will also damage soft forming / cutting tools unless coated with lacquer. For this reason TFS cannot be used for wall ironed cans.

Surface is rough so provides superior key for lacquer and plastic laminate systems. Often used for can ends and pre-coated 2-piece shallow and deep drawn food containers

Internal lacquer on tinplate - yes or no?

In UK approximately 25% of processed food cans do not have lacquer over the internal tinplate surface.

- For white fruits (pineapple etc.) the reaction between any residual oxygen in the can and the free tin on the tinplate surface eliminates the oxygen and prevents discoloration of the packed fruit.

- For tomato based products (beans in tomato sauce etc.) a similar reaction takes place to that described above. This time the elimination of the oxygen helps to retain the red colour of the tomato as well as giving a more piquant flavour to the product.

Tin levels in the products are kept below the statutory 200 p.p.m.

Materials of construction - Aluminium

- Aluminium alloy for packaging contains approximately 95% pure aluminium with the main alloy elements being manganese and magnesium. Its temper / hardness is increased by cold rolling.
- Aluminium for packaging cannot be welded or cemented so it commonly used for 2-piece cans and ends. Ranges of different alloys and hardness are available for the various end products. Lacquer or plastic laminate / coating is needed on both surfaces for protection of metal and product.

Typical uses for Tinplate / Tin free steel / Aluminium

TINPLATE

- Inherently stronger than aluminium
- Used for seamless thin wall cans and those made by rolling flat sheets and side seaming by welding or folding.
- Products include:-
- Processed food, drinks, aerosols
- Homecare, DIY (paint for example), industrial, promotion and giftware containers
- Lug caps (for glass jars), crown caps (for drink bottles

Typical uses for Tinplate / Tin free steel / Aluminium

TIN FREE STEEL

- Same strength properties as tinplate
- Used for seamless shallow drawn cans,

  ends Products include:

- Processed food
- Plain and easy –open food can

  ends Lug and crown caps

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Typical uses for Tinplate / Tin free steel / Aluminium

ALUMINIUM

- Generally only used for metal containers that have internal pressure after filling, or where the strength of the side wall is not critical.

Products include:-

- Seamless thin wall cans and easy-open ends for beer and carbonated soft drinks
- Seamless shallow fish and other food cans together with most caps and closures other than those listed for tinplate.
- Aerosols and flexible tubes made by impact extrusion
- Aluminium is also available as thin foil and can be vacuum deposited on to polymer film to increase the barrier properties

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Metal Packaging Europe

- Infinitely recycled with no loss of quality
  - Metals such as Aluminium (Al) and Iron (Fe) are elements and so cannot be destroyed.
  - In the case of metal packaging, it is the product application that reaches the end of its useful life, not the material.
  - The metal from which the product applications have been formed remains as a permanently available material resource to be used again and again by recycling.
  - The elemental properties of metal mean that it can be infinitely recycled with no loss of quality.

Metal Packaging Europe

- A dynamic new approach – What is happening?
  - A new **Metal Recycles Forever** mark has been developed to unify environmental messaging across rigid metal packaging throughout Europe.

  - This brand mark has been adopted and endorsed by **Metal Packaging Europe** members as the one definitive recycling mark for metal packaging.
  - A strong visual identity communicates to the consumer the intrinsic environmental benefits derived from the permanent properties of metal

How Steel is made video

https://youtu.be/xejnSzbFMQA

Packaging steel manufacture additional information

1. Hot rolling (1250°C) changes dimensions but not physical properties. Cold rolling (ambient temperature) refines grains in metal and increases temper (hardness)
2. Annealing (heat treating) softens the metal to produce thin metal for can making, after hot rolling and cooling, cold rolling is used to thin the metal until it becomes too hard to use.
3. It is then annealed to soften. A second step of cold rolling can then take place to reach close to the desired gauge and temper. A final cold roll stage, without further annealing, but with minimal thickness reduction is used to achieve the final desired properties.
4. In some can making processes, 3 piece welded for example, the can forming does not change the material properties.
5. In other processes, 2 piece draw and wall iron for example, the process starts with relatively soft metal but the thinning (= cold rolling) which takes place during the process increases the temper (hardness).

Coil finishing and delivery to canmaker

Coils pass through visual inspection process

Metal either delivered to the canmaker as coil or as cut sheets to stockist or canmaker

Coil / sheets delivered to canmaker have all been made to special order to reflect the specific dimensions required to produce cans in the most metal efficient way.

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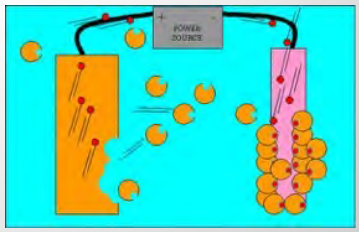
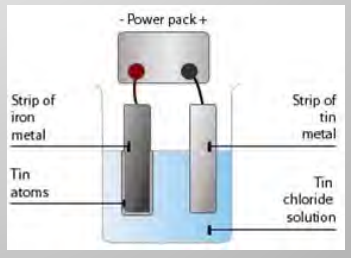
Electroplating

What is electroplating?

Electroplating involves passing an electric current through a solution called an electrolyte. This is done by dipping two terminals called electrodes into the electrolyte and connecting them into a circuit with a battery or other power supply.



The electrodes and electrolyte are made from carefully chosen elements or compounds. When the electricity flows through the circuit they make, the electrolyte splits up and some of the metal atoms it contains are deposited in a thin layer on top of one of the electrodes — it becomes electroplated. All kinds of metals can be plated in this way, including gold, silver, tin, zinc, copper, cadmium, chromium, nickel, platinum and lead.



Making tinplate

Electroplating is very similar to electrolysis (using electricity to split up a chemical solution), which is the reverse of the process by which batteries produce electric currents.

(Source: Chris Woodford, explainthatstuff.com)

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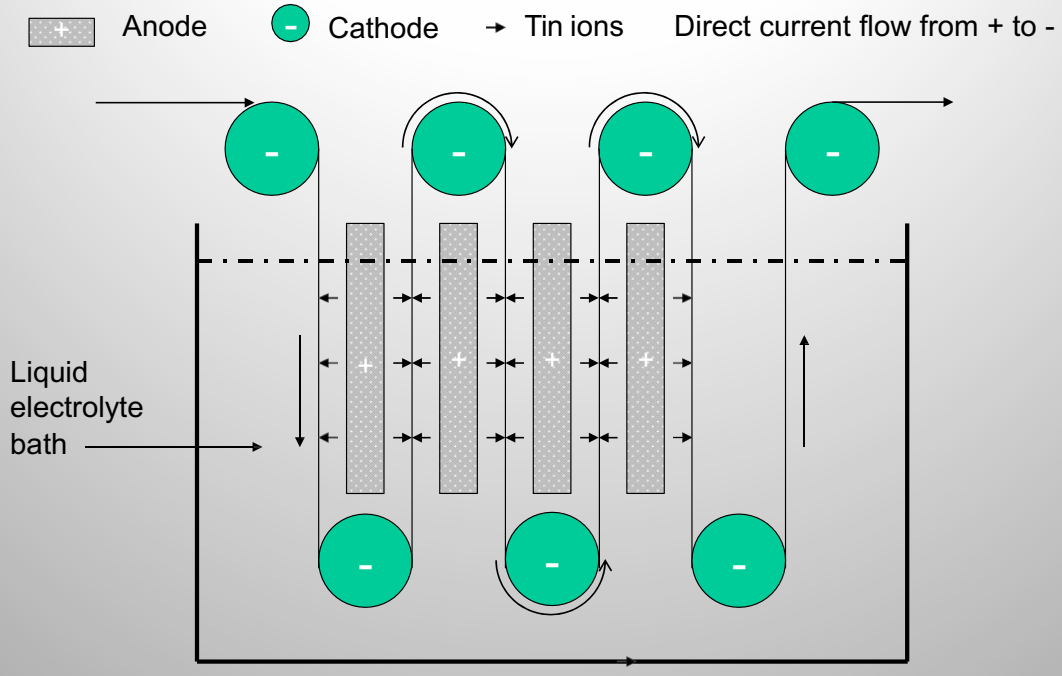
Continuous electrolytic plating of tin onto steel coil



Contents of presentation (part 2)

- Functions of cans
- Types of can construction
- Why different types of cans ?
- Typical cross-sections
- Can ends
- Closures
- Quality assurance
- Specifications
- Can coatings

Functions of cans

- Preserve & protect product over shelf life indicated
- Resist chemical actions of product
- Withstand handling & processing
- Withstand external environment
- Correct dimensions / interchangeability
- Supermarket shelf display
- Easy opening / product removal
- Recyclable

AND ALL AT THE RIGHT PRICE !!

Types of can construction Overview

- 3-piece can Open ended cylinder, with side seam, plus two ends

- 2-piece can Closed end, seamless, cylinder plus one end

- Bottle Can Either closed end seamless with cap or seamless body with one end plus cap

Order of presentation

BODY FORMING PROCESSES

3-piece welded and built up containers

2-piece single and multiple draw

2-piece draw and iron

2-piece impact extruded

Order of presentation

BODY FORMING PROCESSES

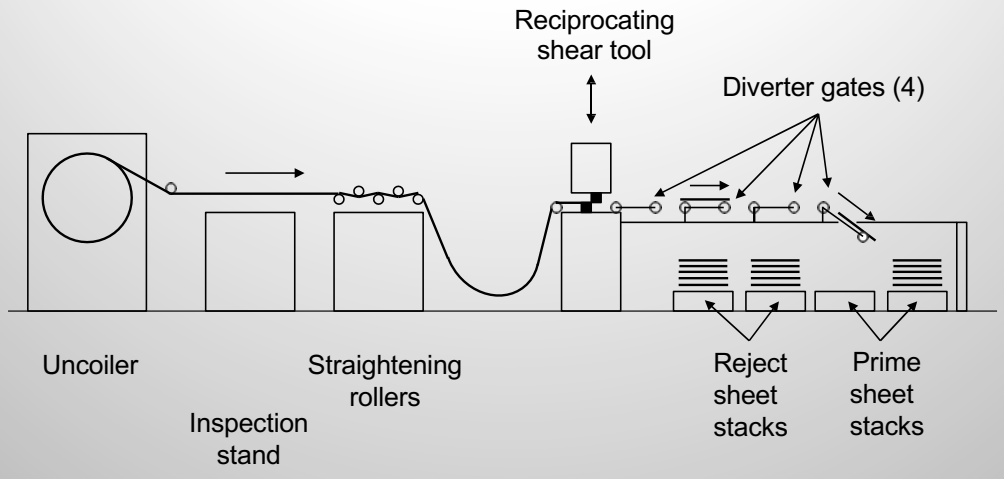
3-piece welded and built up containers

2-piece single and multiple draw

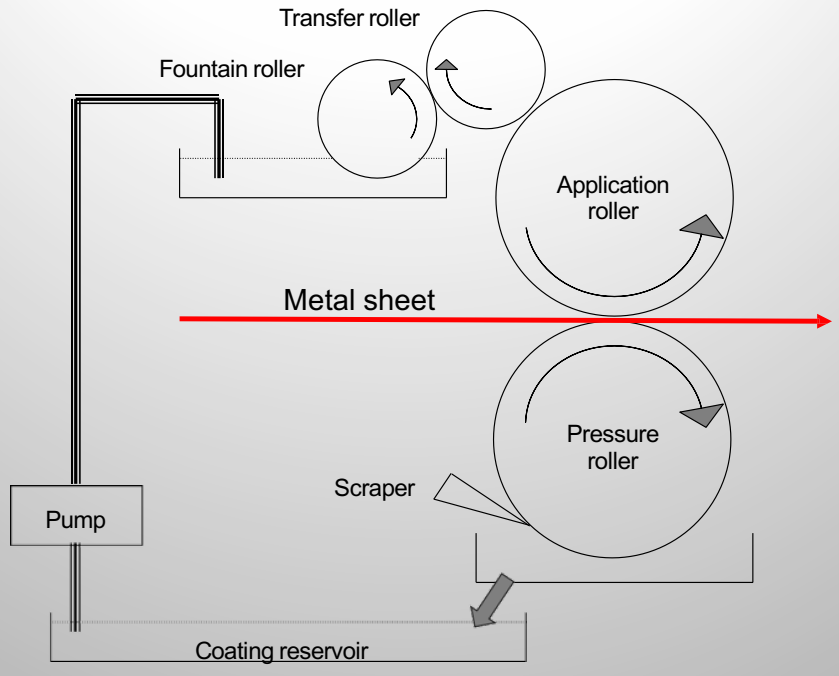
2-piece draw and iron

2-piece impact extruded

Shear Line for cutting coil into large sheets



Coater for applying lacquer to sheets



Curing (drying) of inks and organic coatings

Two systems available depending on needs of product / package and chemistry of ink / coating

1. Thermal (heat) cure

Sheet passed through tunnel oven, peak metal temperature reached in range 150 / 210°C for 10-15 mins. Liquid solvents (including water) driven off first then remaining resins chemically cross-linked to form hard / flexible surface on metal.

2. Ultra-violet (UV) cure

Sheet passed under ultra violet lamps, photo initiators in ink / coating create instantaneous chemical cure.

Thermal v UV curing systems

Note: Thermal and UV curing materials are not interchangeable between the two different processes.

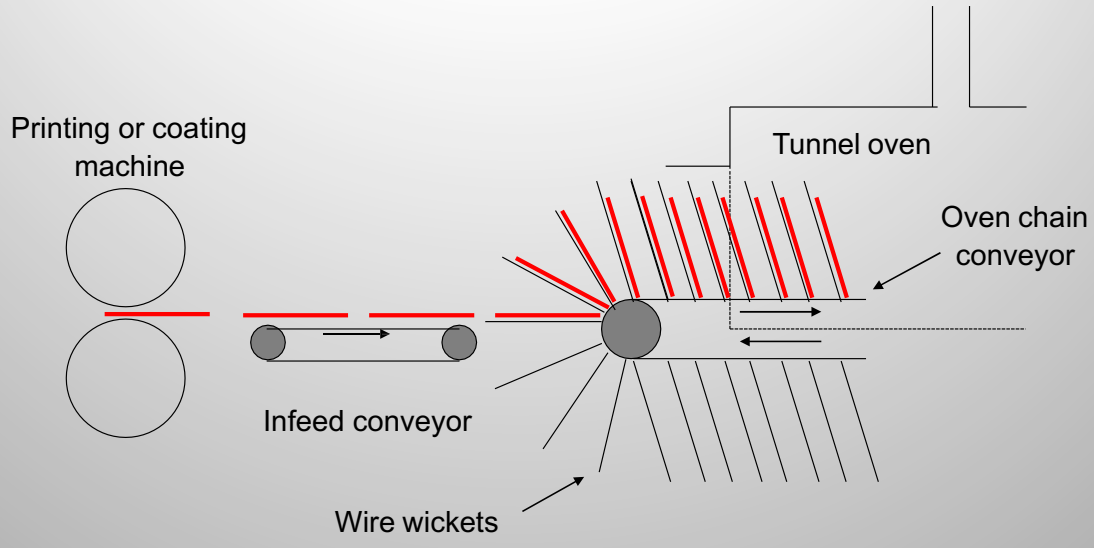
Thermal curing

Thermal cure coatings mandatory for food contact on internal surfaces of heat processed containers. Thermally cured inks may be better for withstanding heat processing conditions. When used for printing inks, max. number of wet ink colours applied prior to a curing cycle is limited and will depend on type of printing process in use, how much half toning etc.

UV curing

UV coatings not approved for food contact on inside of food / drink cans/ends but recently approved for lip contact on outside of drink cans, for example: after chemical curing not all the ink / coating may set hard allowing residues to offset onto clean side of next sheet in the stack. This previously was not acceptable for food contact surfaces. Regulations now more relaxed as more known about properties of UV products. UV allows curing between each deck of a multi-colour machine.

Wicket oven for thermal curing coated / printed sheets



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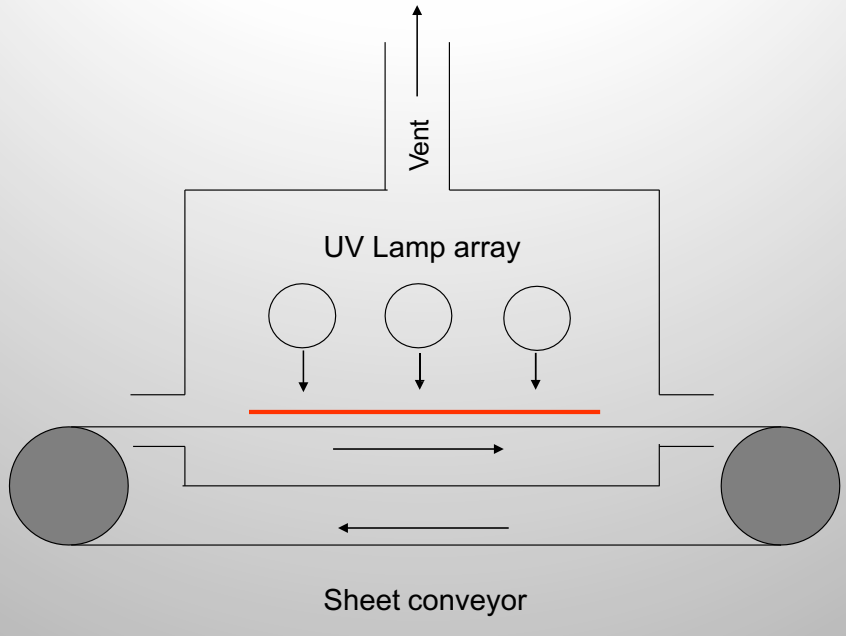
Ultra-violet lamp system for curing coated / printed sheets



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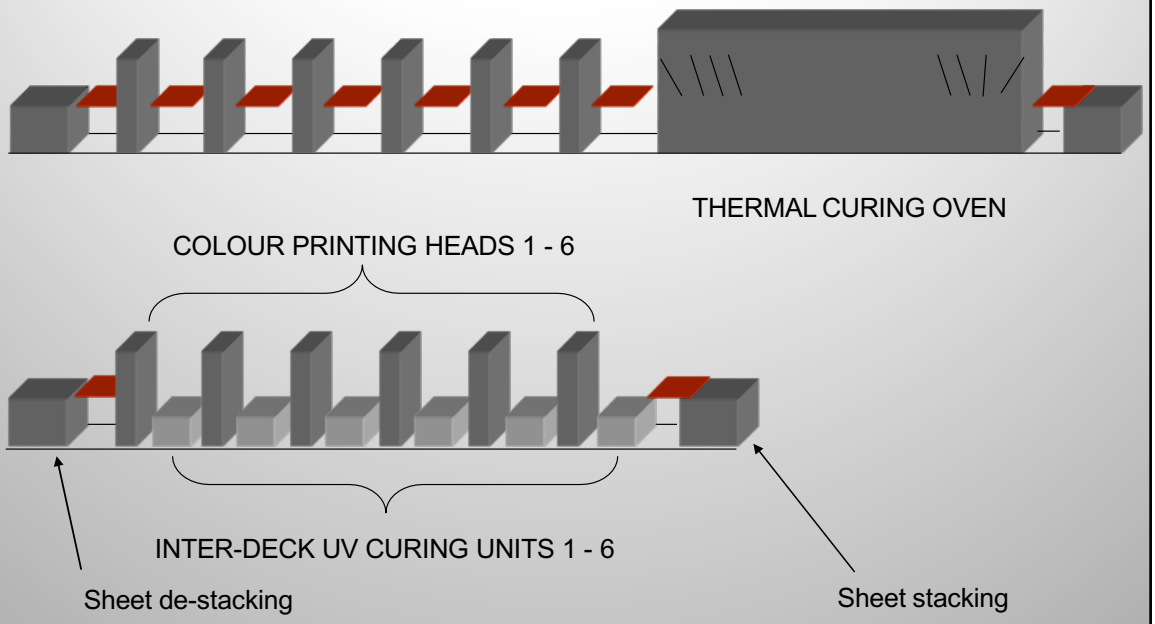
Multi-colour printer with ink curing system



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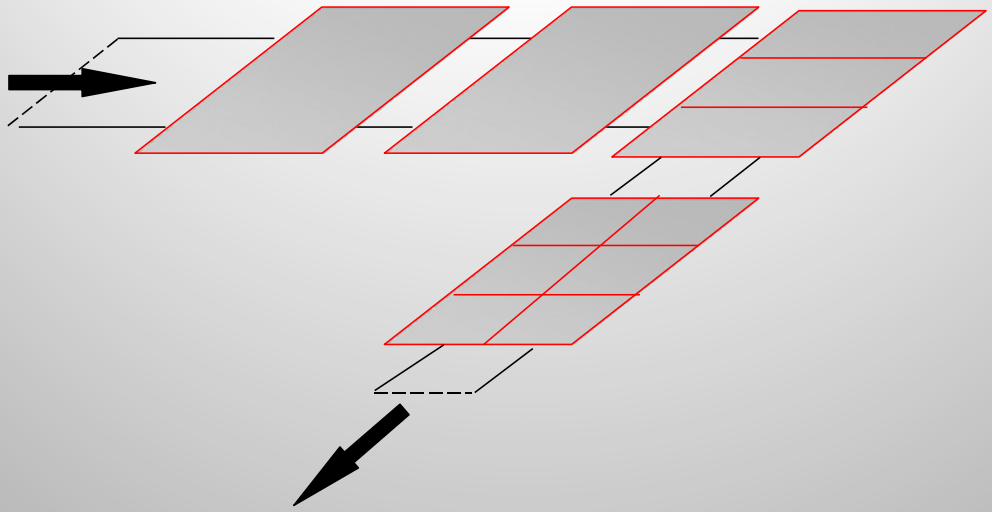
Slitter for cutting large sheets into small sheets, one for each can body



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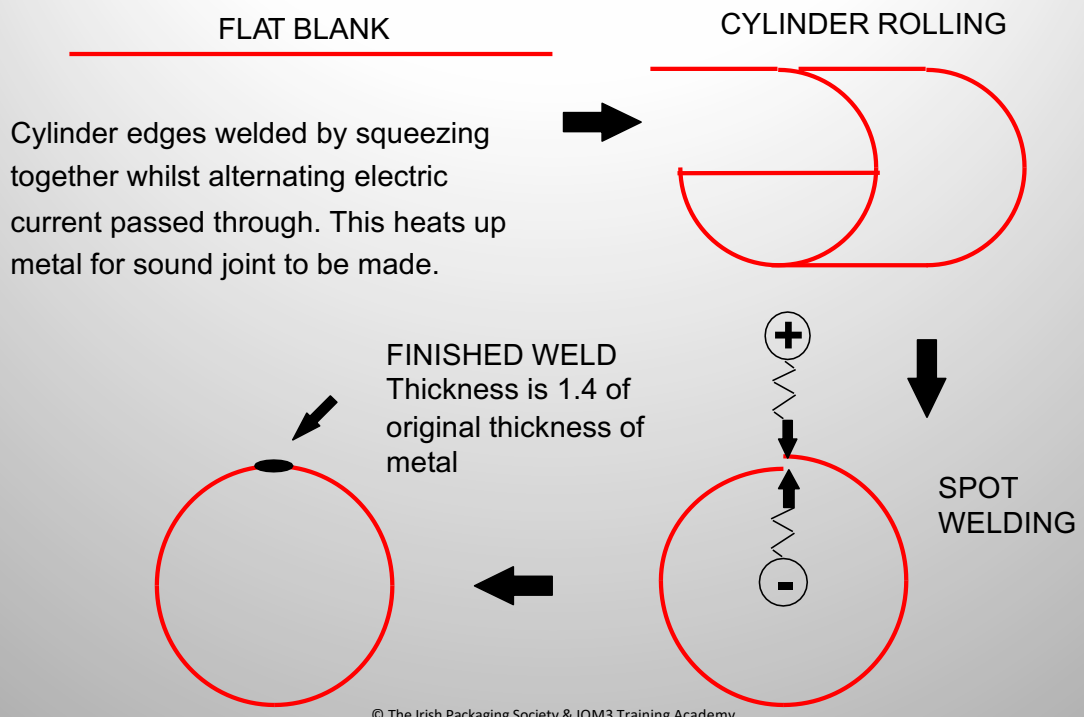
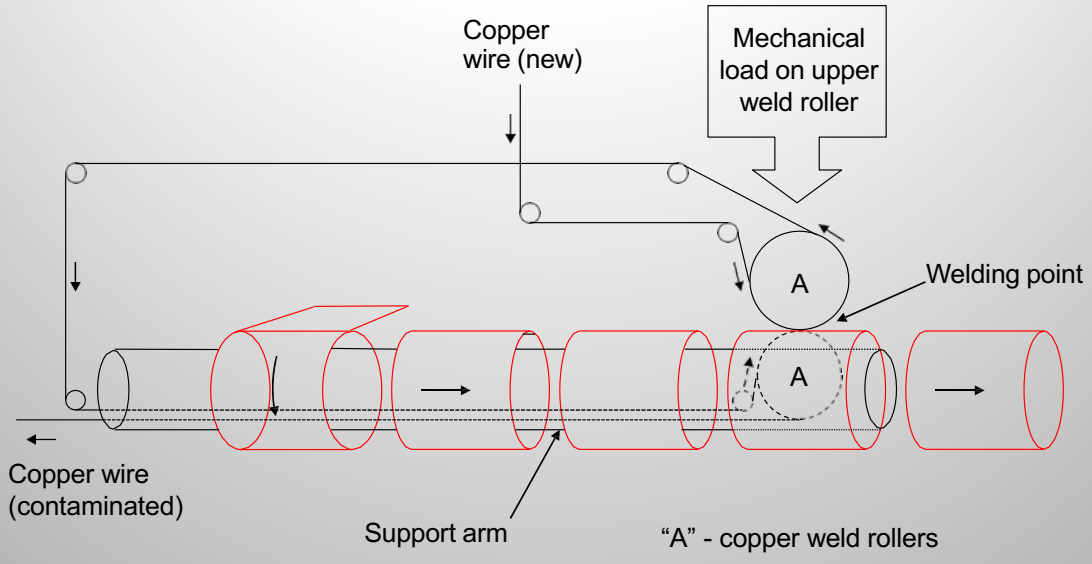
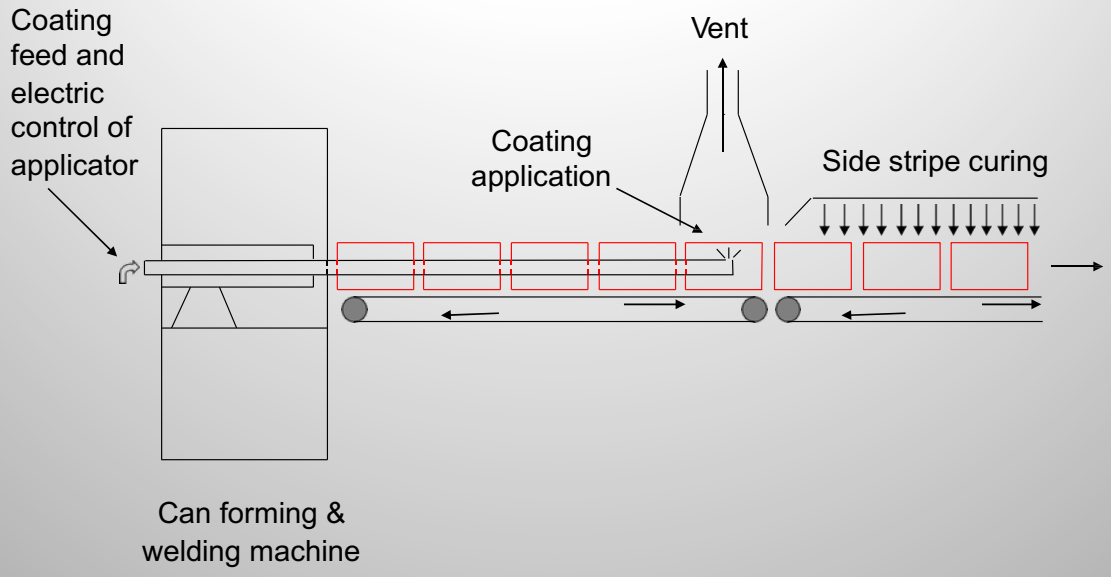
Three-piece can body forming and welding



Soudronic can welding system



Welded can side stripe & cure to repair internal lacquer in the area of the weld



3 piece can parting operation

Parting is an optional process that may used when short height 3 piece welded cans are being made.

During the body forming / welding process the cans are moving with the axis horizontal and cans with height less than the diameter may become unstable and tend to fall over when running at high speed.

To avoid this, multiple short cans bodies (say 2 or 3) may be made from one single metal blank. After the welding and side striping processes are complete the long cylinder is split out into 2 or 3 short can bodies which are then flanged, seamed etc. with the axis now in the vertical position.

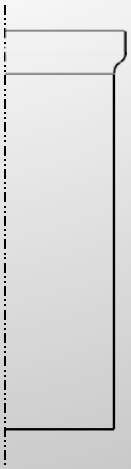
To permit easy splitting, blanks are pre-scored before the body rolling process

3 piece cans typical neck profiles

Inward neck
(drink cans only)

Single
step

Outward neck
(food cans only)



Single
step

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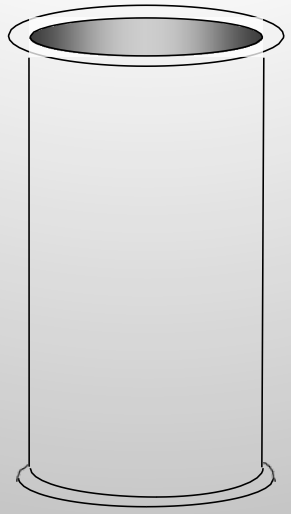
Flanging

3 piece cans are passed through a flanger where the top and bottom are spun outwards to accept the ends.



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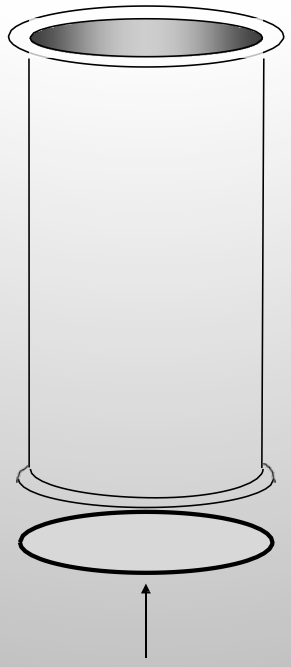
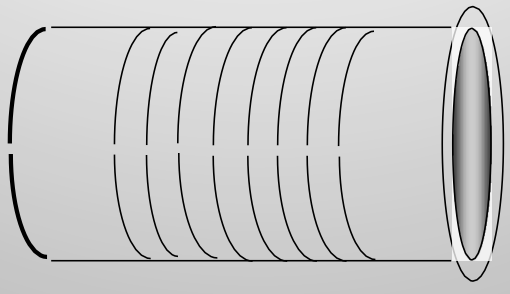
Canmaker's end seaming to base

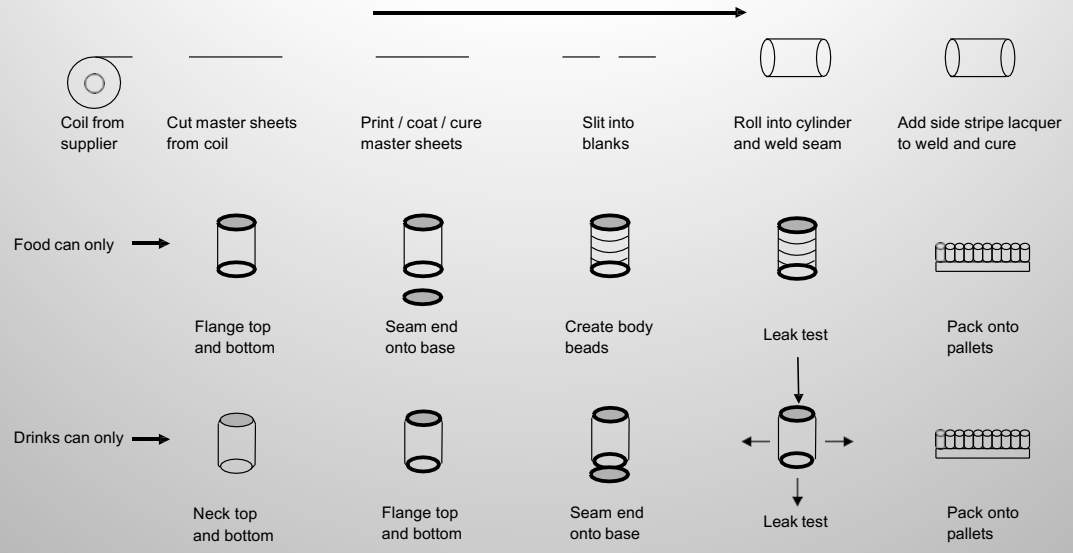


Wall beading

Most tall and some short thinwall food cans are passed through a beader where the walls of the cans have circumferential beads formed in them to give added strength to resist heat processing conditions.



Three-piece welded side seam can Process flow diagram

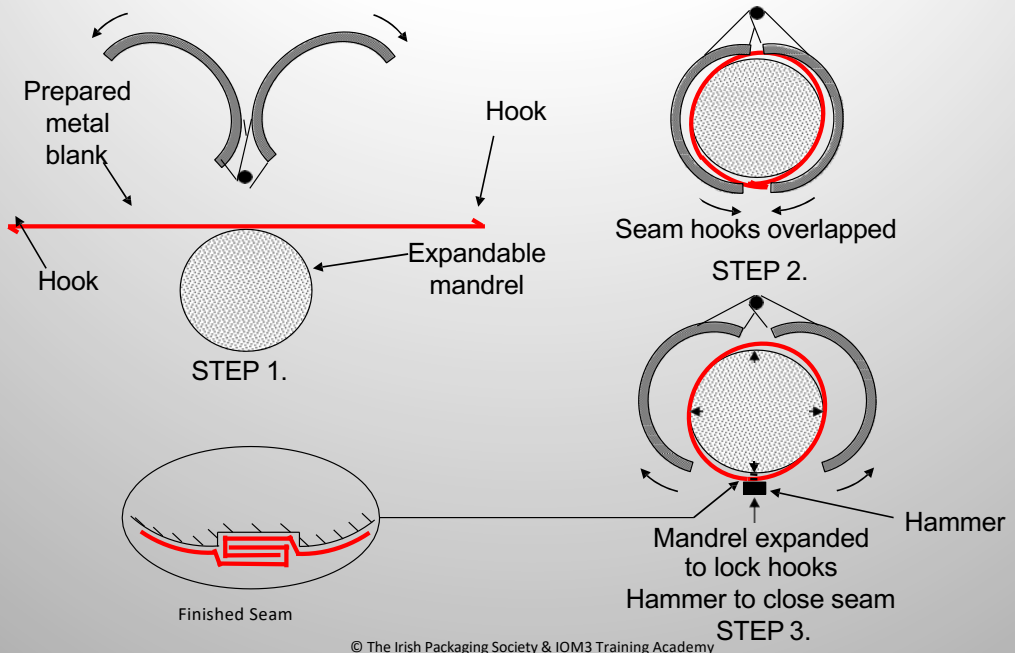


Types of can construction

3-piece built-up cans with folded (lock) seam (steel only) for dry and promotional products and certain liquids

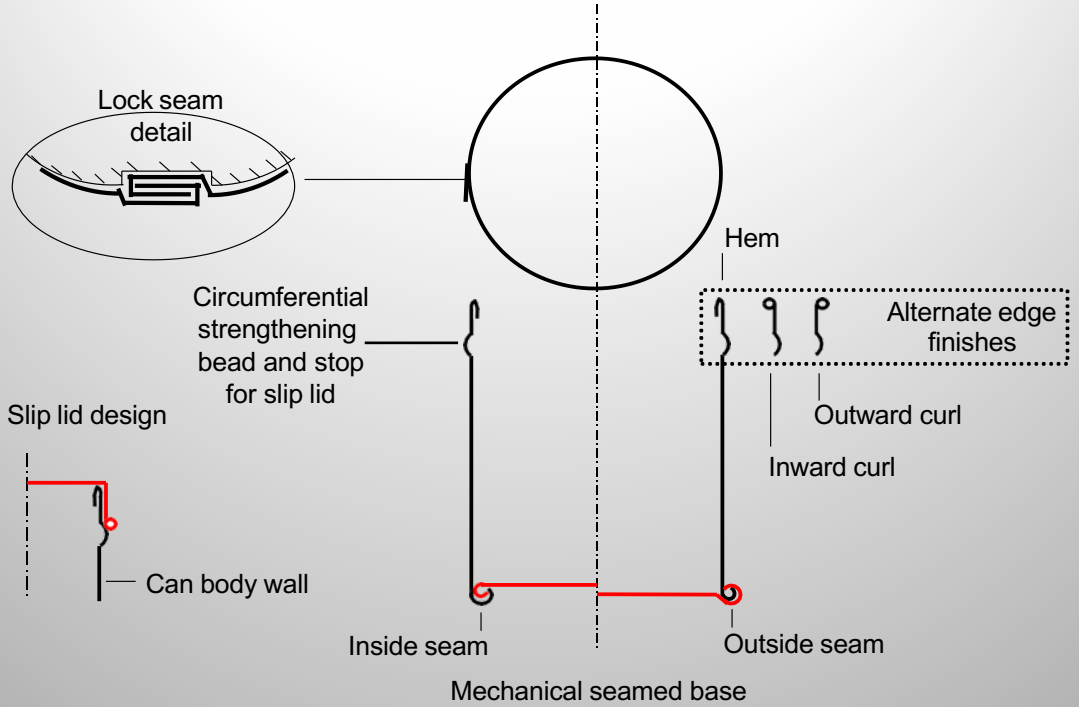
- Rectangular flat blank cut from sheet, seam edges folded, body wrapped around mandrel of suitable x-section and seam folded over. Hot melt adhesive material may be included within the seam to improve integrity for certain liquid products.
- One end seamed onto base
- Open end either prepared (rolled, curled) to accept slip lid or lever lid ring etc seamed on.

Body forming 3-piece built-up can, folded (lock) seam

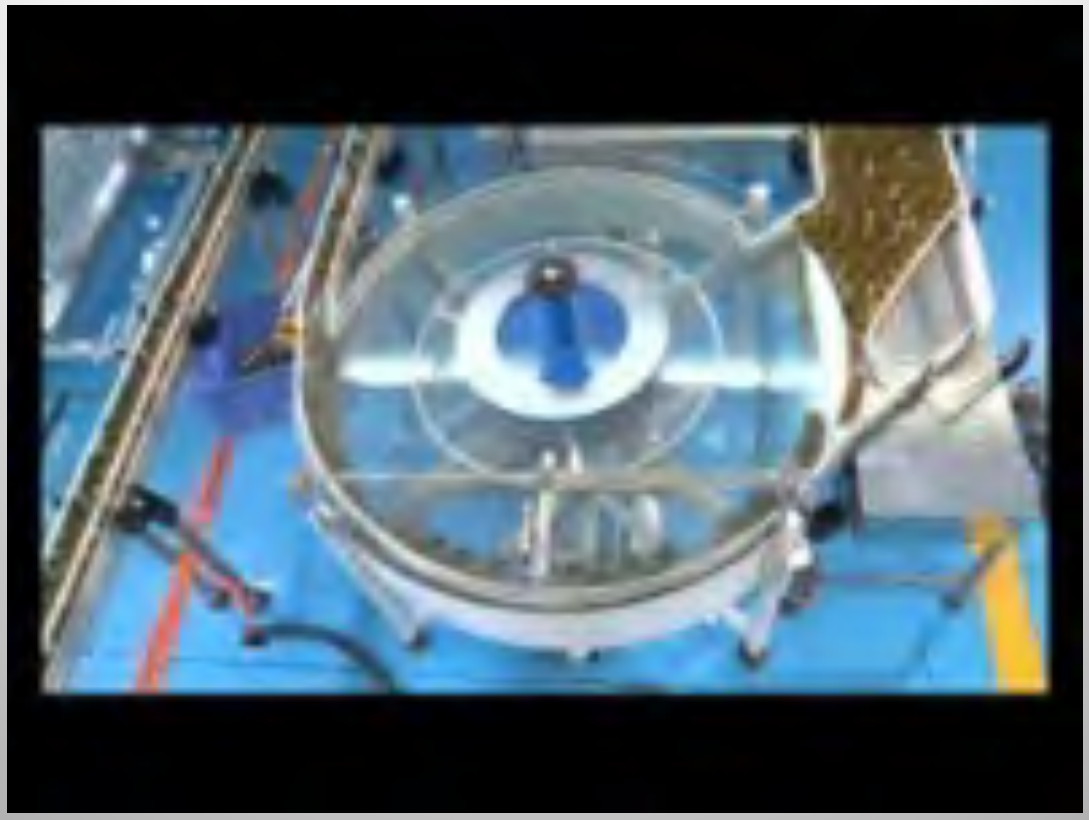


66

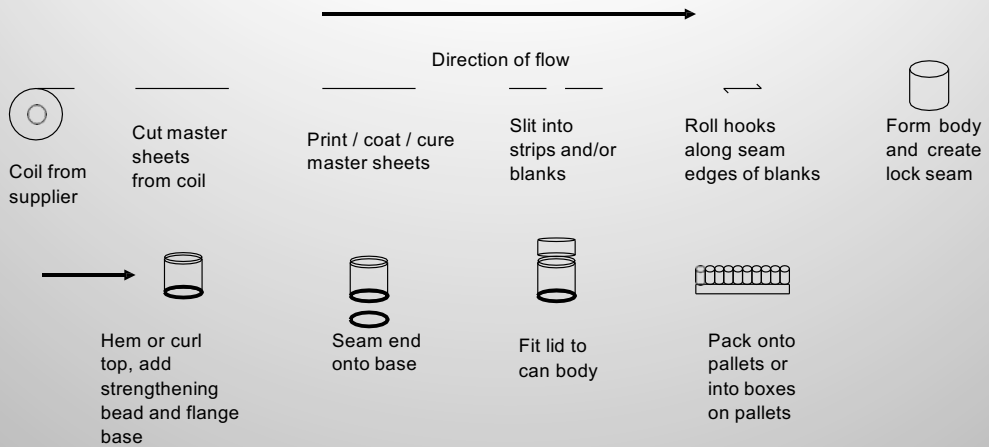
3-piece built-up body (non-performance) with seamed on base



67



General line lock seam can – process flow diagram



Order of presentation

BODY FORMING PROCESSES

3-piece welded and built up containers

2-piece single and multiple draw

2-piece draw and iron

2-piece impact extruded

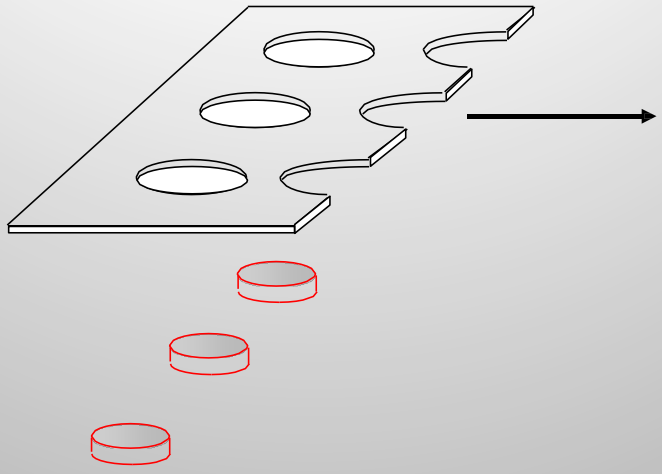
Body forming

2 piece drawn (& redrawn) can

Circular disk (blank) cut from precoated / printed and / or lubricated sheet/ coil

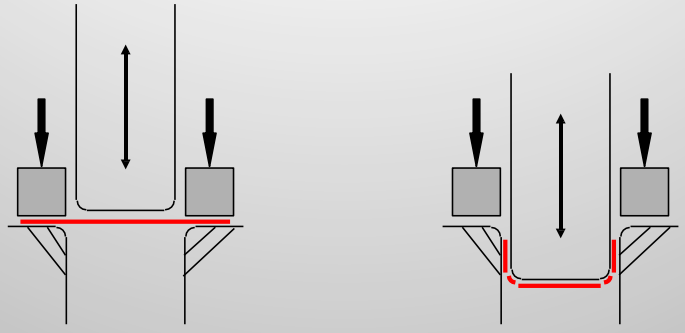
Cupmaking

For drawn cans, press cuts circular blanks from sheets and draws into cups in one operation



Drawing a can (cup) from flat sheet metal

Surface area remains constant and metal thickness does not change as metal is drawn from flat disc to shaped cup



Videos

The Ingenious Design of the Aluminum Beverage Can
https://youtu.be/hUhisi2FBuw

How it's made Aluminium Can
https://youtu.be/V4TVDSWuR5E

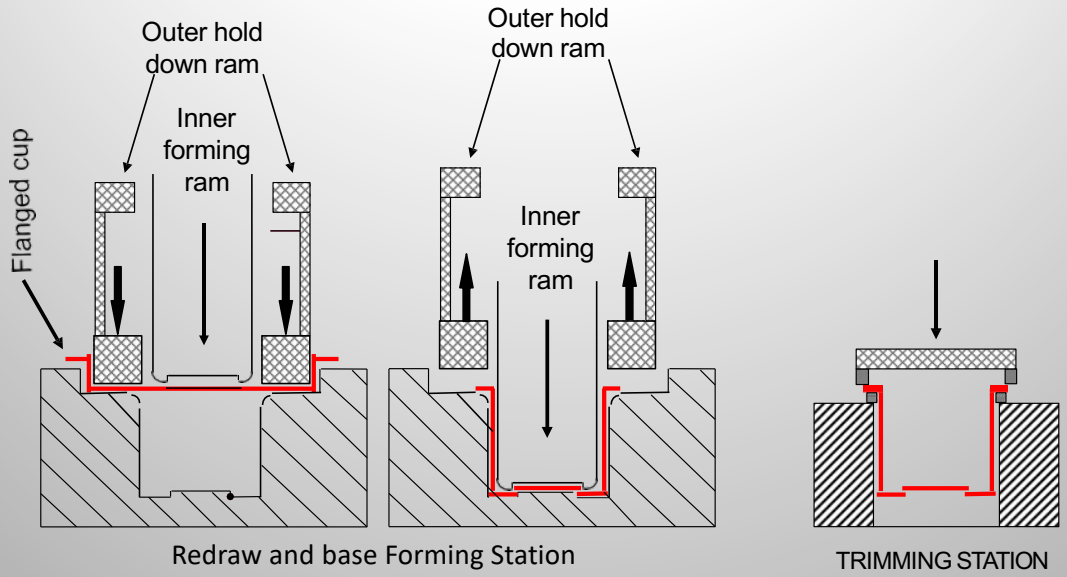
REXAM can manufacture
https://youtu.be/7dK1VVtja5c

3 piece Pail. https://youtu.be/cCcfOVNWiHw
3 piece can. https://youtu.be/2tK7mjmqamw
3 piece - https://youtu.be/IMxf3wHManA
Crown 3 piece Cans - https://youtu.be/qW7c6bWr4wE

Fancy Tins
https://youtu.be/rUmOqgZNIdk

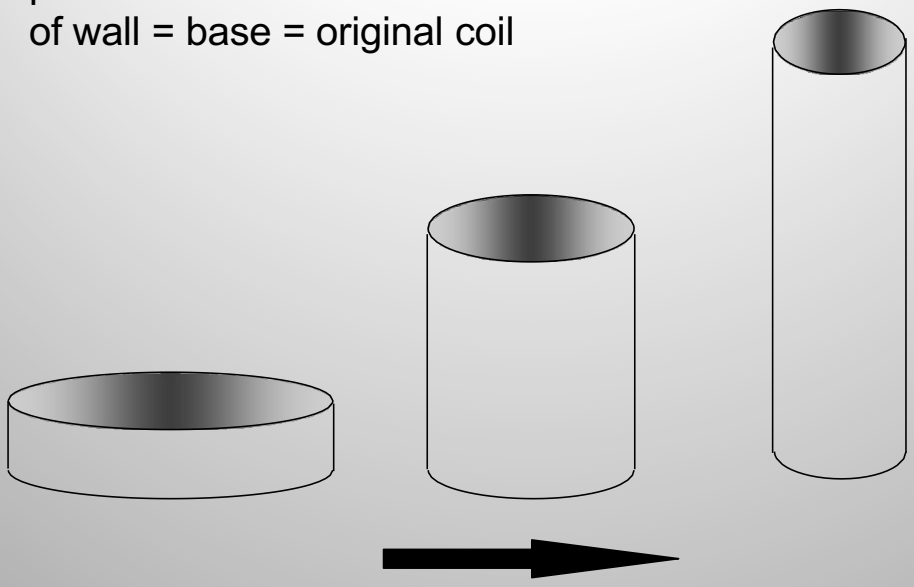
Redrawing cup into a taller can and flange trimming

N.B. Cup made in cupping press with flange left in place



Draw redraw can overview

From the cup, the can may be redrawn, once or twice, to produce a taller can of smaller diameter. Metal thickness of wall = base = original coil



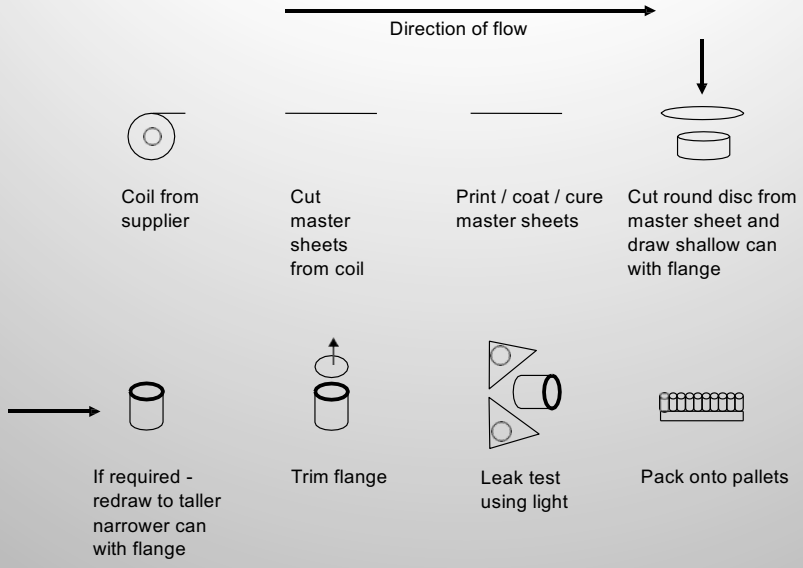
DRD can neck profile

Outward neck for selected products

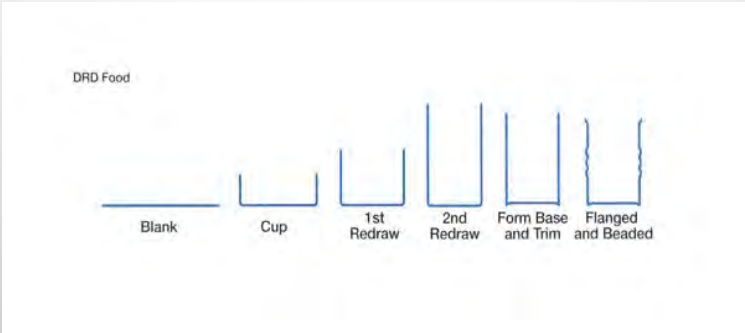
Single step

Note: To create this profile the can must be drawn without a flange. After necking, a flange will need be formed by inserting a spin forming tool.

Two piece draw / redraw can – process flow diagram



Draw and redraw - DRD



Metal sheets can be printed before forming - print must allow for distortion during drawing.

Body and base of finished can are of even thickness.

Diagram taken from Tata Steel

Order of presentation

BODY FORMING PROCESSES

3-piece welded and built up containers

2-piece single and multiple draw

2-piece draw and iron

2-piece impact extruded

Body forming

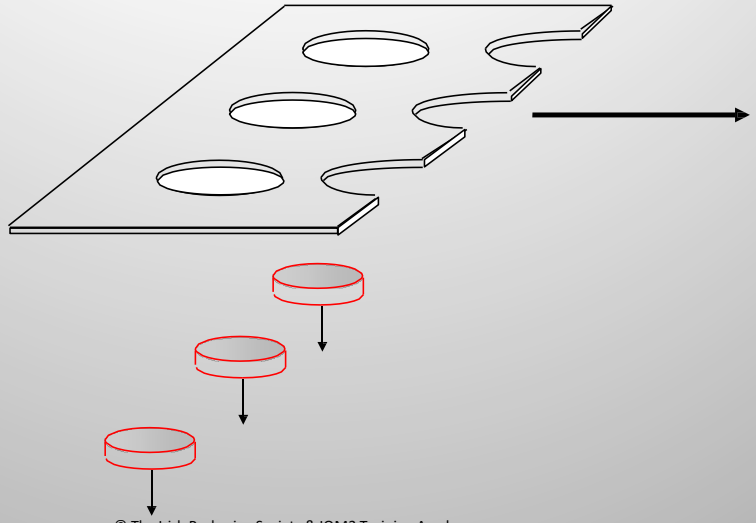
2 piece drawn and ironed can
(food and drink cans)

First step as for drawn Can, except made from lubricated uncoated coil

Coating applied after can is formed into a cylinder

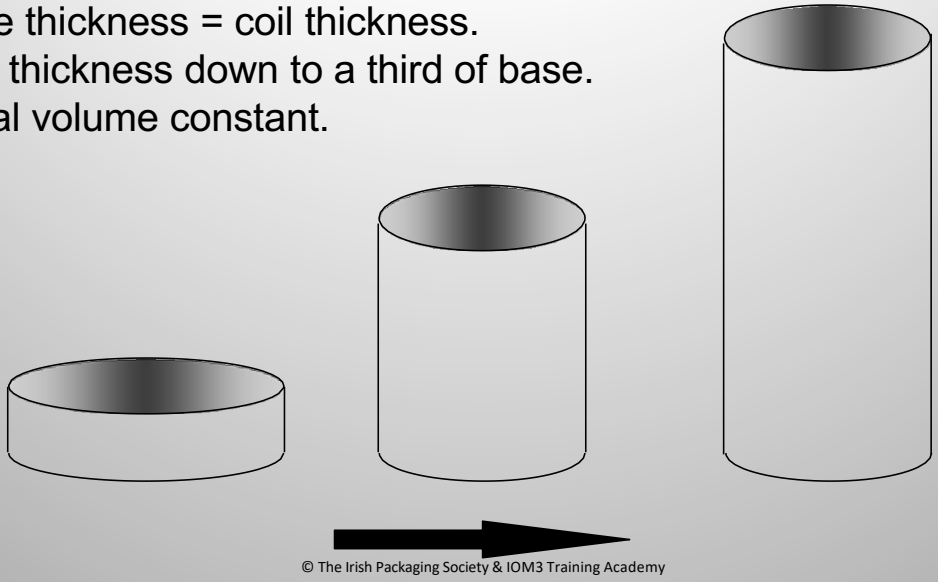
DWI cup making

For DWI cans the strip, in coil form, is lubricated with a thin film of liquid and then fed continuously through a cupping press, which blanks and draws thousands of shallow cups every minute.



DWI can overview

The drawing and ironing process redraws the cup to a smaller diameter and thins the walls, whilst increasing the height.
Base thickness = coil thickness.
Wall thickness down to a third of base.
Metal volume constant.



Draw and wall iron - DWI

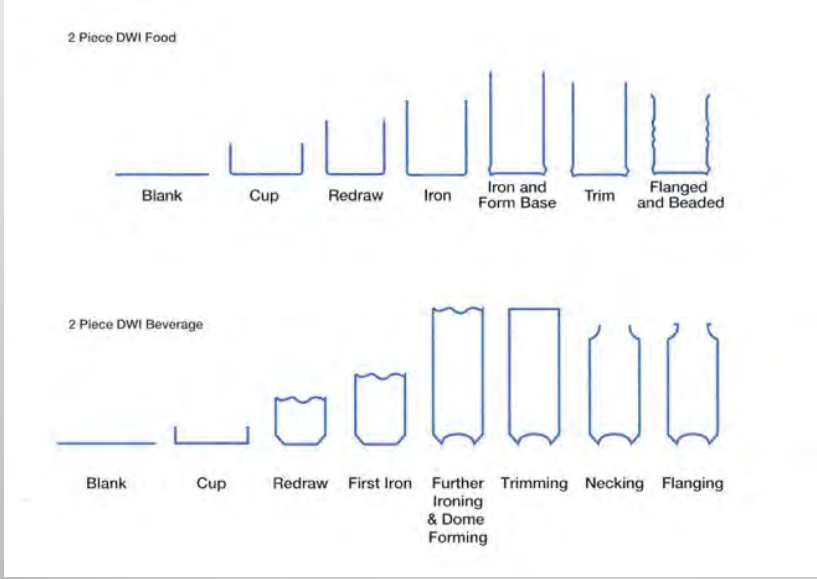


Diagram taken from Tata Steel

Cans can only be printed after forming.
The ironing process thins the walls of the can - see for yourself by examining a typical drinks can

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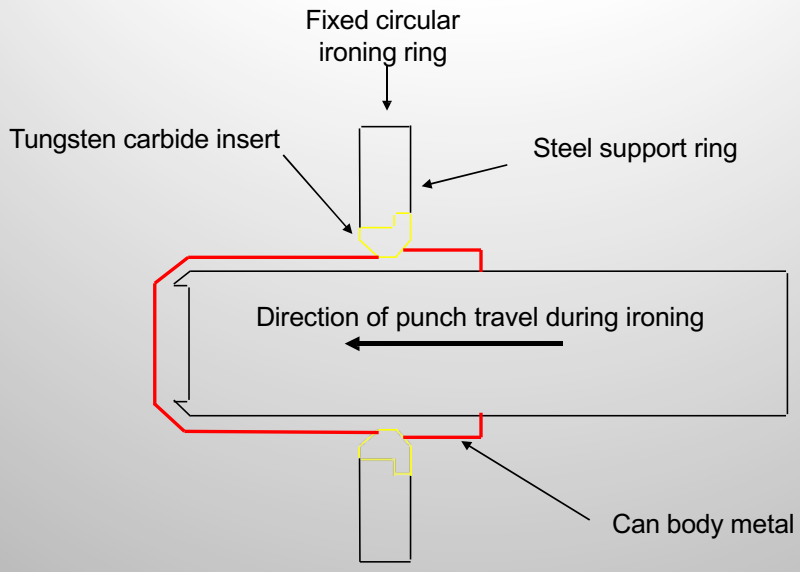
Wall ironing detail



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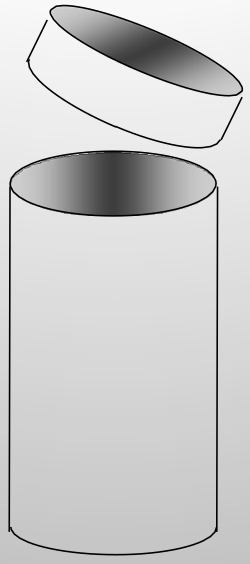
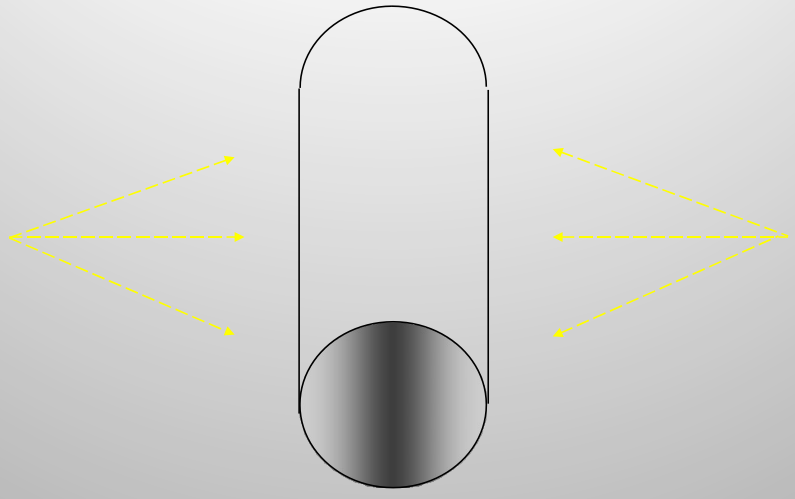
DWI can wall trimming

Removes the irregular edge and leaves the can wall at the correct height.



DWI can washing

Can washing (and drying) DWI cans to remove all traces of lubricant and prepare surfaces for coating internally and externally.

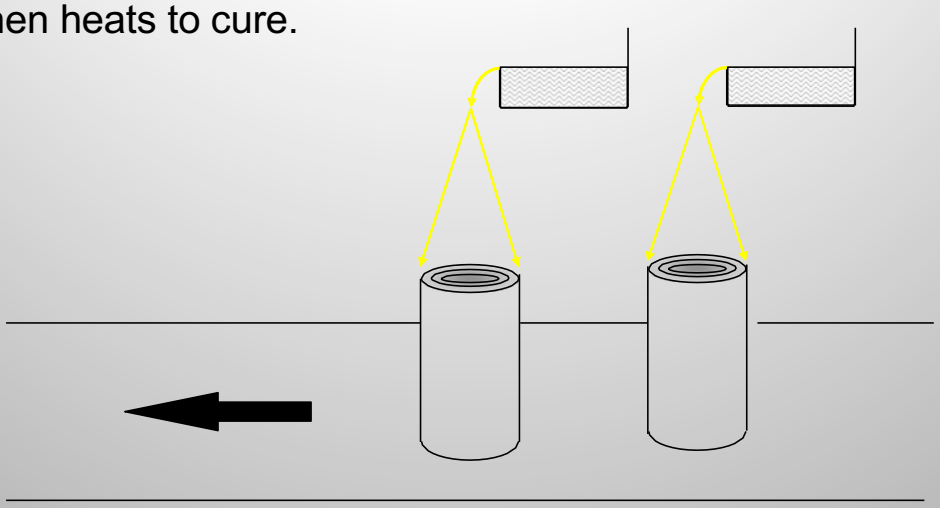


DWI Can finishing operations

2 piece drawn and wall ironed food cans only

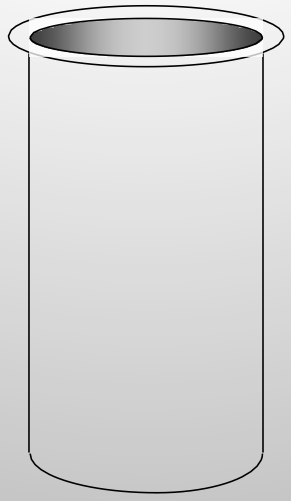
DWI food can washcoating / curing

Applies external coating to upturned DWI food cans by passing them under a waterfall of clear lacquer and then heats to cure.



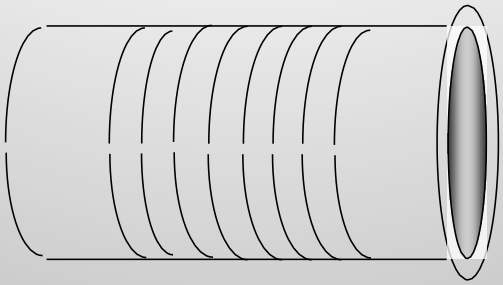
DWI food can flanging

Flange formed by spinning to prepare can body to accept mechanically seamed end



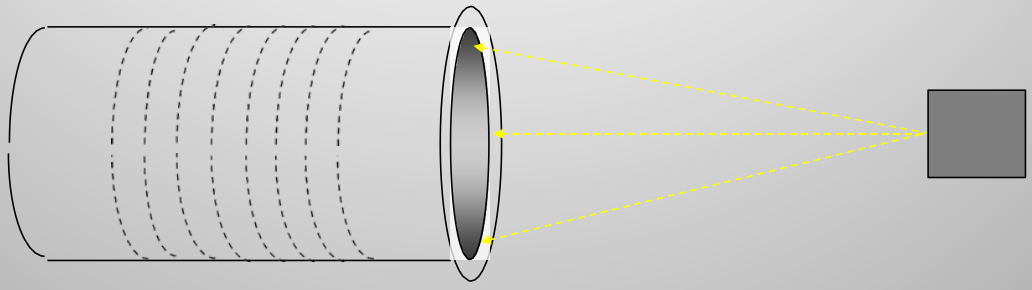
DWI food can wall beading

Circumferential beads rolled into can wall to increase resistance to heat processing conditions.



DWI food can internal coating

Applies internal lacquer by airless spray then cures in horizontal belt oven. For food cans this is done after the last mechanical operation of wall beading.

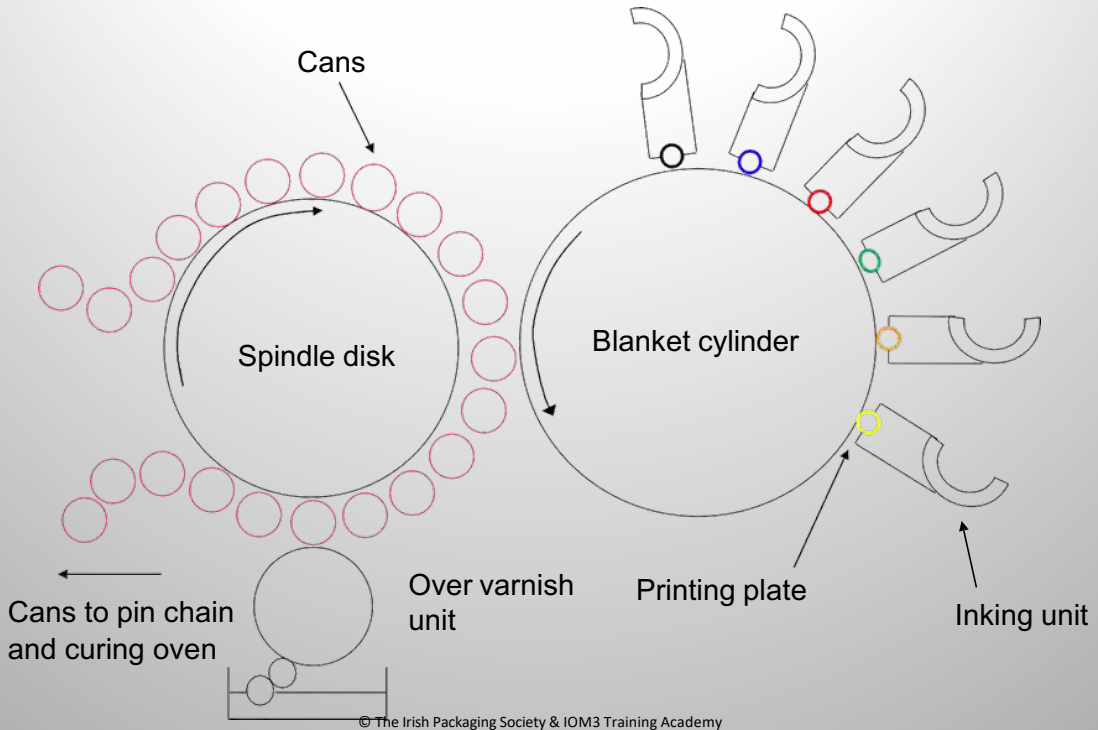


Finishing operations

2 piece drawn and wall ironed drink cans only

DWI drink cans cylindrical decorating

(cylindrical coating uses same principles)



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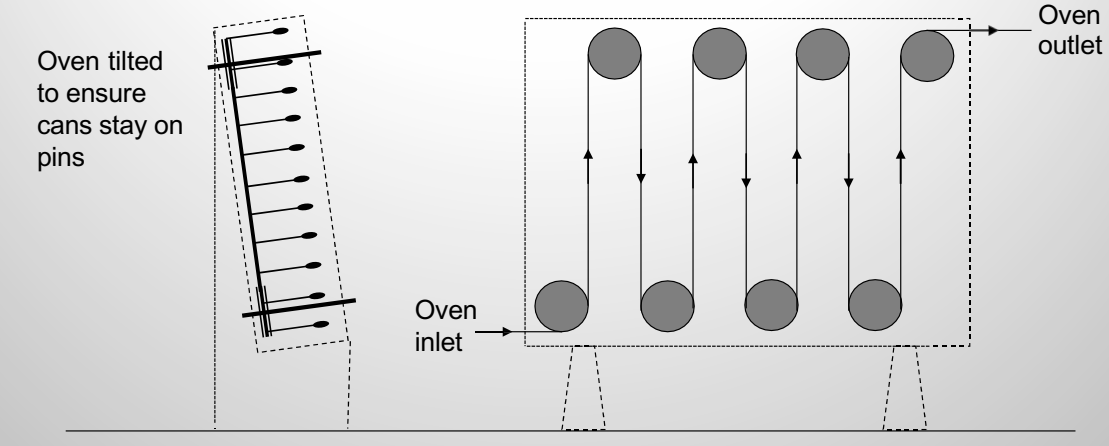
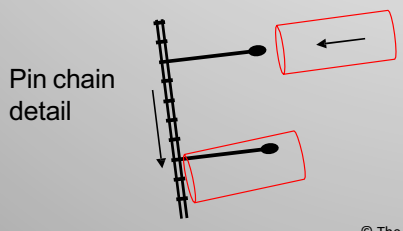
DWI drink cans drying (curing)oven





At regular intervals along the chain, the link pin is extended to hold the can which has wet coating or ink on the outside surface.

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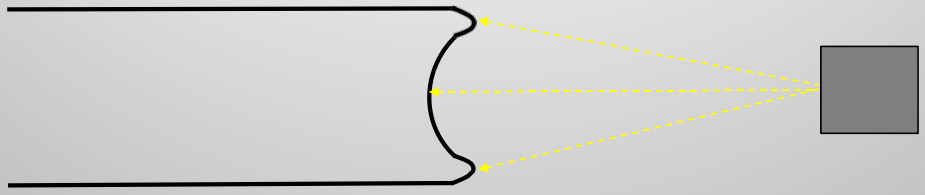
DWI drink cans external base coating

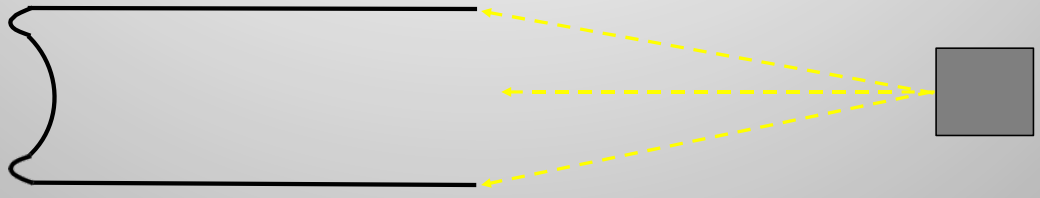
Coating may be applied by airless spray or in powder form. In both cases the coating must be heat cured. Ideally cured coating should be thick and capable of resisting abrasion as the can is conveyed during manufacture and filling. Coating should prevent external corrosion of the base whilst the filled can is in storage.



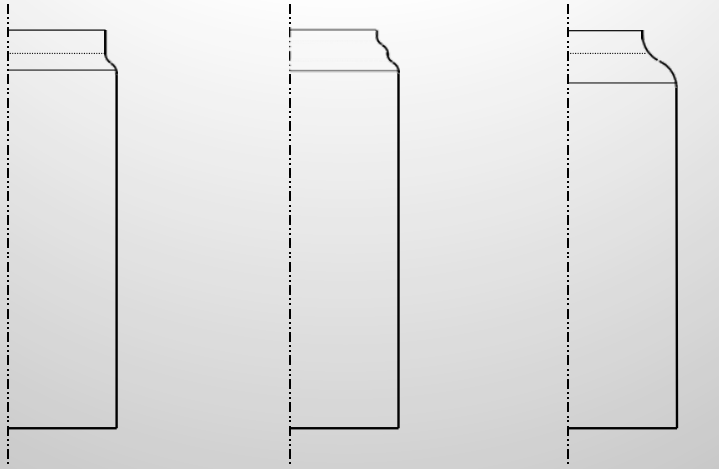
DWI drink cans internal coating

Applies internal lacquer by airless spray then cures in horizontal belt oven

For beverage & aerosol cans this is done prior to necking and flanging as lacquer assists necking operation



DWI drink cans – typical neck profiles

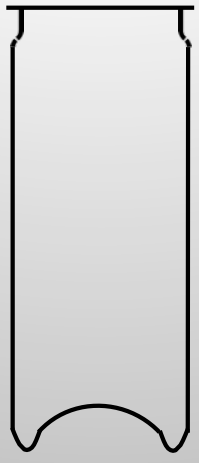


Single step | Multiple step | Smooth multiple step

100

DWI drinks can flanging

Flange formed by spinning to prepare can body to accept mechanically seamed end



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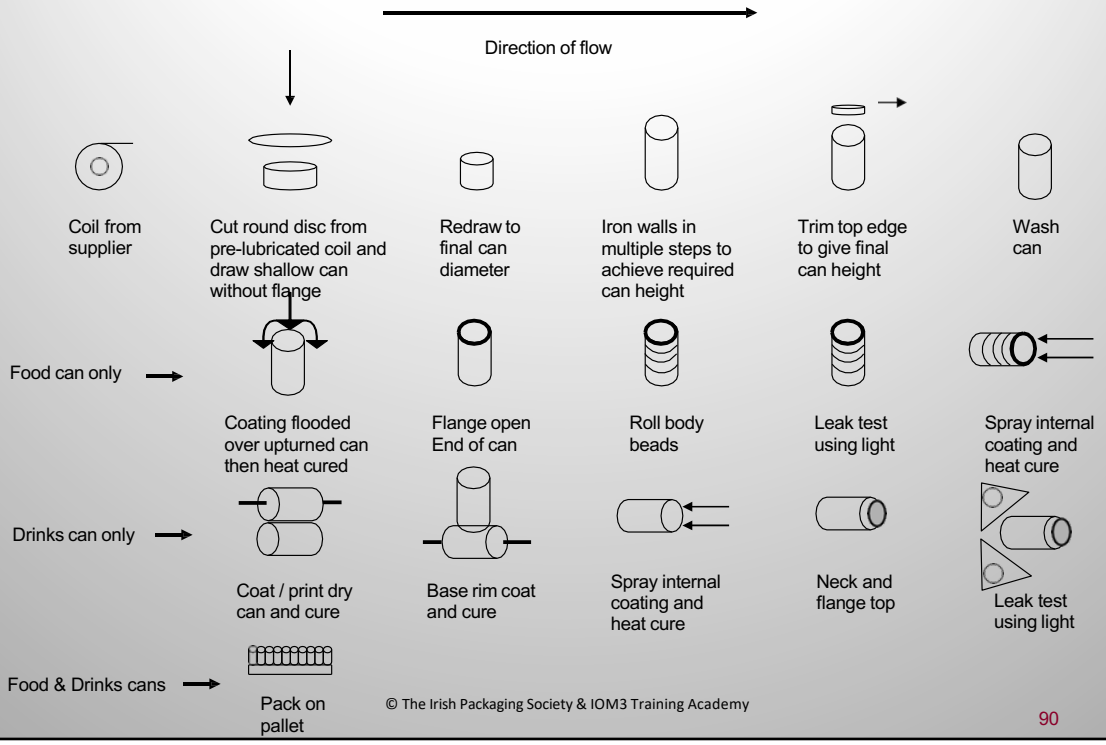
Two piece draw and wall iron can process flow diagram



Order of presentation

BODY FORMING PROCESSES

3-piece welded and built up containers

2-piece single and multiple draw

2-piece draw and iron

2-piece impact extruded

Body forming

2 piece impact extruded can

Circular slug of metal formed into closed end cylinder by impact extrusion

Top of can reformed and reduced in diameter leaving opening suitable for fitting valve head or cap

Coating applied after can is formed into a cylinder

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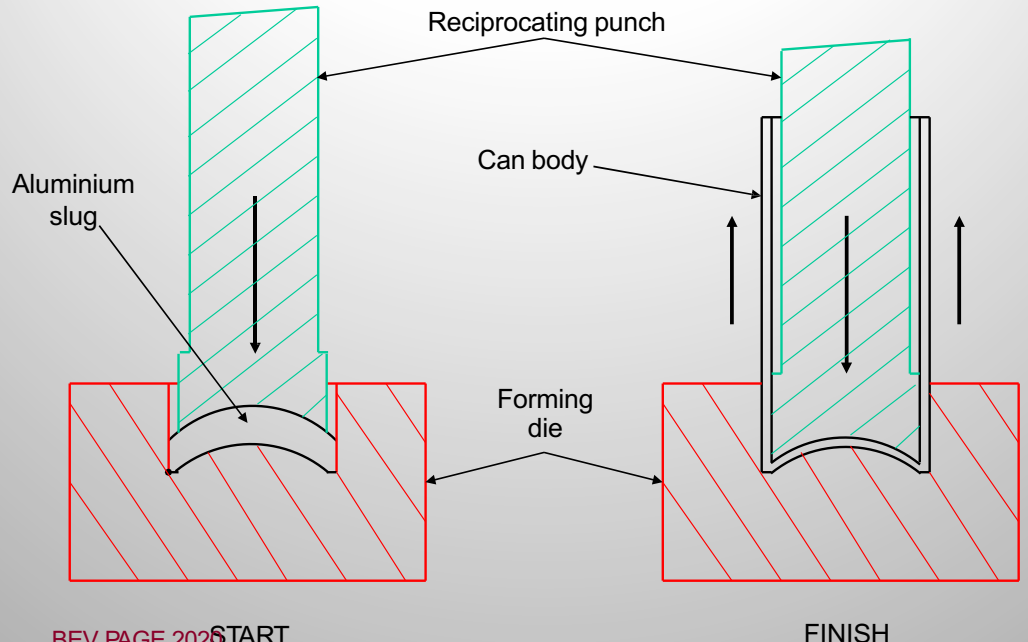
Aluminium impact extrusion



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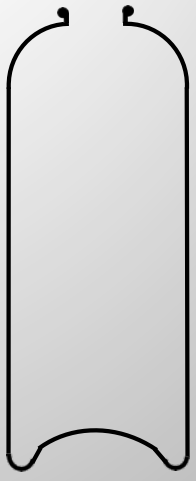
Impact extruded aerosol can

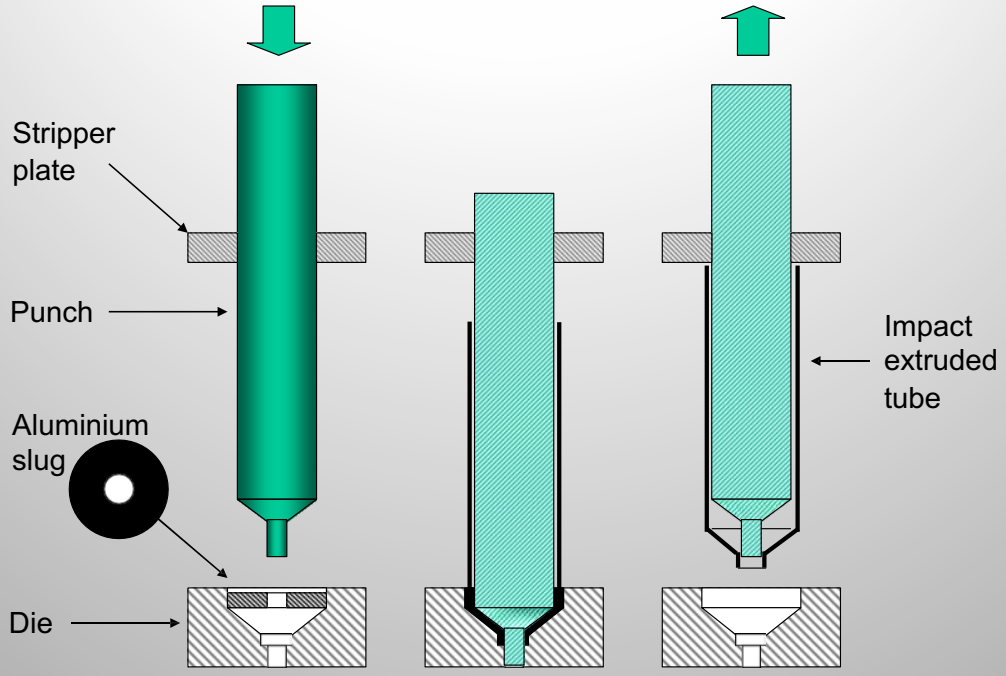
Finishing operation sequence of trimming, washing, internal coating and printing are all similar to processes used for DWI drink cans.

Conveying between processes is done by inclined pin chain.

The last process testing is to swage-in the top edge of the can, in approximately 15 steps, to form a smooth top and roll flange to accept the valve system.

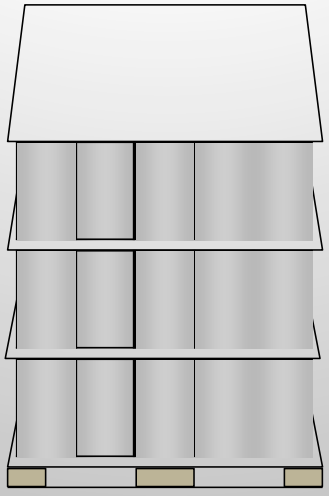


Impact extrusion - collapsible tube



Palletising of empty cans

The finished can bodies are automatically palletised before despatch to the filling plant.



Typical sequence of metal can making processes

Typical sequence of metal can making processes

Start → Finish

Can body type	Product	Metal coat / print before body forming		Internal side stripe	Trim	Wash / dry	External flood coat / cure	External cylindrical coat / cure	External cylindrical print / cure	Part into multiple bodies	Neck	Flange	Seam on base end	Seam on cone top	Bead walls	Internal lacquer spray / cure	Test (air)	Test (light)	Test (water)	
3-piece Welded	Food	Opt	↑ |	Opt						Opt	Opt[1]	Yes	Yes		Opt		Yes			↑ |	
	B & B	Yes	B	Yes							Opt[2]	Yes	Yes			Opt	Yes			P	
	Aerosol	Yes	O	Yes							Yes	Yes	Yes	Yes			Yes		Yes[6]	A	
			D																	L	
2-piece Draw/Redraw	Food	Yes	Y		Yes						Opt[3]	Yes[4]			Opt			Yes		L	
	B & B	Yes			Yes						Yes	Yes						Yes		E	
			F																	T	
2-piece Draw/Wall Iron	Food		O		Yes	Yes	Yes					Yes			Opt	Yes		Yes		I	
	B & B		R		Yes	Yes		Opt	Yes		Yes	Yes				Yes		Yes		S	
	Aerosol		M		Yes	Yes		Yes	Yes		Yes	Yes		Yes		Yes[5]		Yes		E	
			|																|	
2-piece Impact extruded	Aerosol	↓			Yes	Yes		Yes	Yes		Yes	Yes				Yes[5]		Yes		↓ |	

Notes:

Opt	Optional process
1	Option to neck in base only for stacking feature
2	Option to neck in both ends
3	Option to neck outwards only
4	DRD cans - flange may be left in place during body forming operations
5	Internal lacquering normally done immediately after washing process
6	Cans held under water at 55°C to observe any leakage after filling with product

Metal cans – Attributes v Manufacturing Route

Metal cans - Attributes - v - Manufacturing Route

ATTRIBUTE	CAN MANUFACTURING ROUTE				
	Three-piece	Two-piece			
	Welded	Single Draw	Draw - Redraw	Draw and Wall Iron Food	Draw and Wall Iron Drinks
Metal					
Tinplate	Yes	Yes	Yes	Yes	Yes
Tinfree-steel	No	Yes	Yes	No	No
Aluminium	No	Yes	Yes	No	Yes
Tapered wall	No	Yes	Yes	No	No
Can configuration	All	Shallow	Deep	Very deep	Very deep
Height / diameter ratio	All	0.3	0.3 - 1.5	1.5+	1.5+
Size change flexibility	Very Good	Good	Good	Poor	Poor
Output (typical) - millions p.a.	< 200	< 100/tool	< 100/tool lane	500 - 600	500 - 600
Location of coating operation	off-line	off-line	off-line	in-line	in-line
Location of decorating operation	off-line	off-line	off-line	N.A.	in-line
Metal cost	high	medium	medium	low	low
Decorating cost	high	high	high	N.A.	low

Overview of container construction

2 piece greater integrity than 3 piece

Three-piece

- Any can shape - easy to change
- High cost - medium to low quantity

Two-piece DRD

- Ideally max height $\leq$diameter
- Medium cost - medium quantity

Two-piece DWI

- Height > diameter
- Low cost - large quantity

Typical cross sections of metal cans (1)

- **Processed food**
- **Beer and beverage**
- **Bottle (for food and drink)**
- **Aerosol**

Can construction method

3-piece cans welded (steel only) for processed food or drink and aerosols

Rectangular flat sheet rolled into cylinder and seam made by welding or cementing

One end fixed by canmaker

One end supplied loose for attaching by the filler

Three metal to metal seams in filled can

Can construction method

2-piece drawn cans (aluminium or steel) for processed food, drinks, aerosols and bottle cans

Circular disc cut from flat sheet / coil and formed into a can by drawing (& sometimes ironing) in a power press

For food & drink, one end supplied loose for attaching by the filler

For aerosols separate cone top fitted by canmaker unless can body has an integral cone shape top.

Can construction method

2-piece impact extruded cans (aluminium only) for aerosols, collapsible tubes and bottle cans

Circular slug of metal formed into closed end cylinder by impact extrusion

Top of can reformed and reduced in diameter leaving opening suitable for fitting valve head or cap

One metal to metal seam in filled can

Sector Developments

Reveal Inks

Crown's Reveal temperature sensitive inks offer brand owners a unique opportunity to increase engagement with consumers before, during and after beverage consumption. Formulated in partnership with Chromatic Technologies, Inc. (CTI), graphics can change to 'reveal' specific imagery and messaging as the cold product inside the beverage can is consumed, fostering greater interaction between consumers and brands.

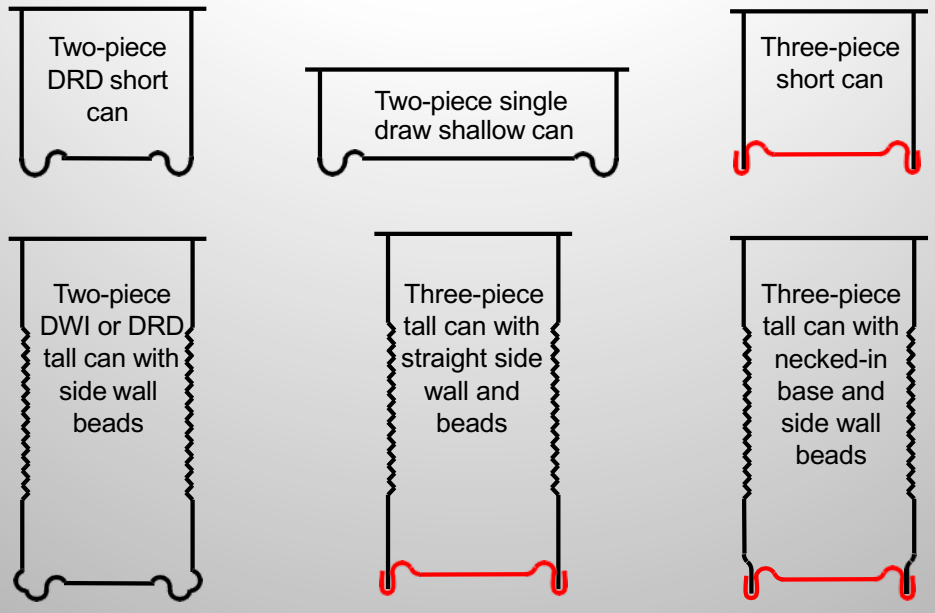
CrownSmart™

CrownSmart™ is an augmented reality packaging innovation. It allows brand owners from North America to Europe to create unique smart packaging that delivers a wide range of content and experiences via a unique AR code. See how it works.

360 End®

With Crown's 360 End®, the entire lid of the beverage can is removed, turning the metal can itself into a drinking cup and eliminating the need for separate glassware. Ideally suited for the beer industry, the 360 End® allows the full flavor and aroma of the beer to hit the drinker's senses.

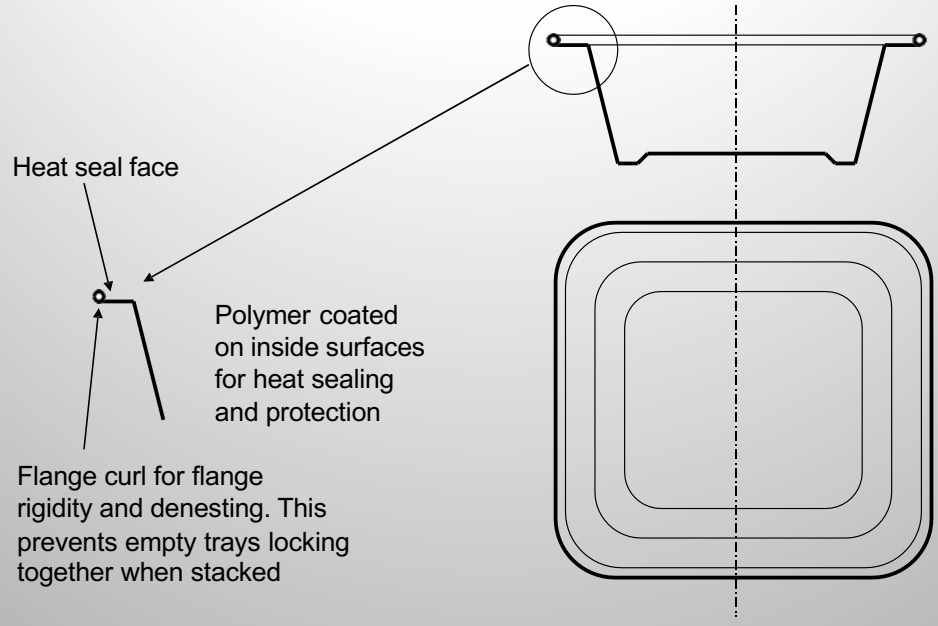
Typical processed food cans



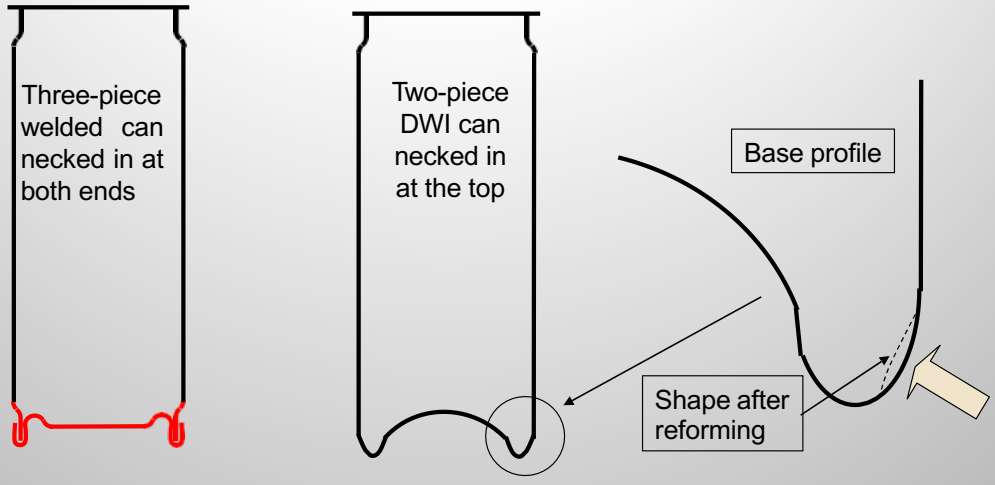
Food canning line - video

https://youtu.be/QFPbOaEo9v4

Tapered shallow drawn tray

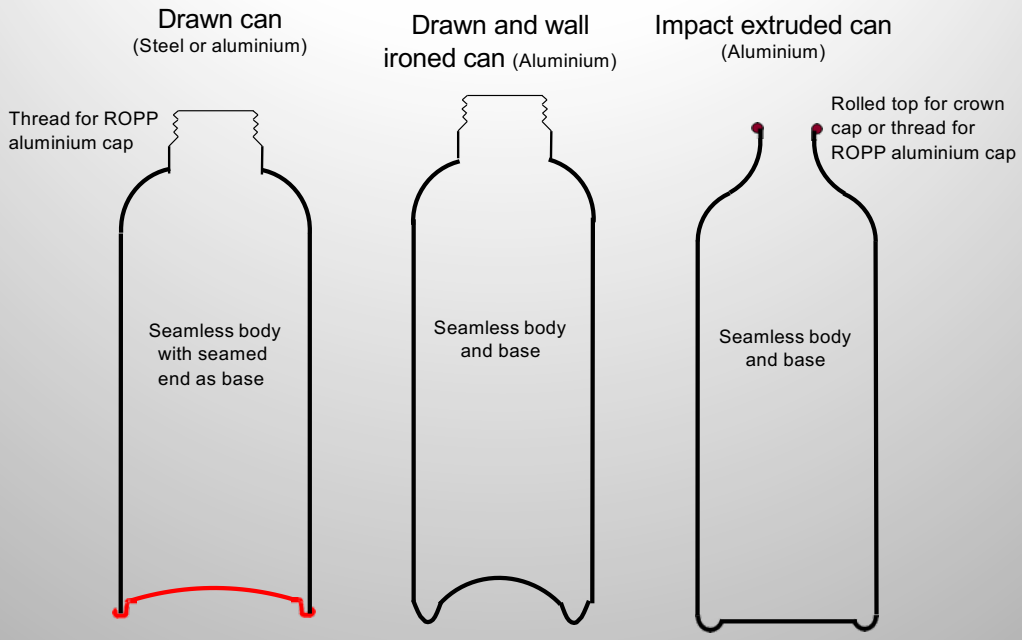


Typical drinks cans



120

Typical bottle cans

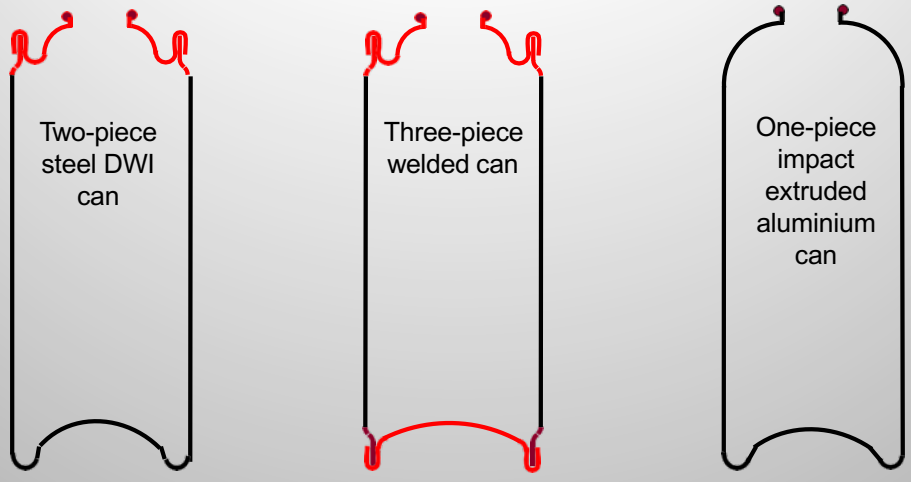


121

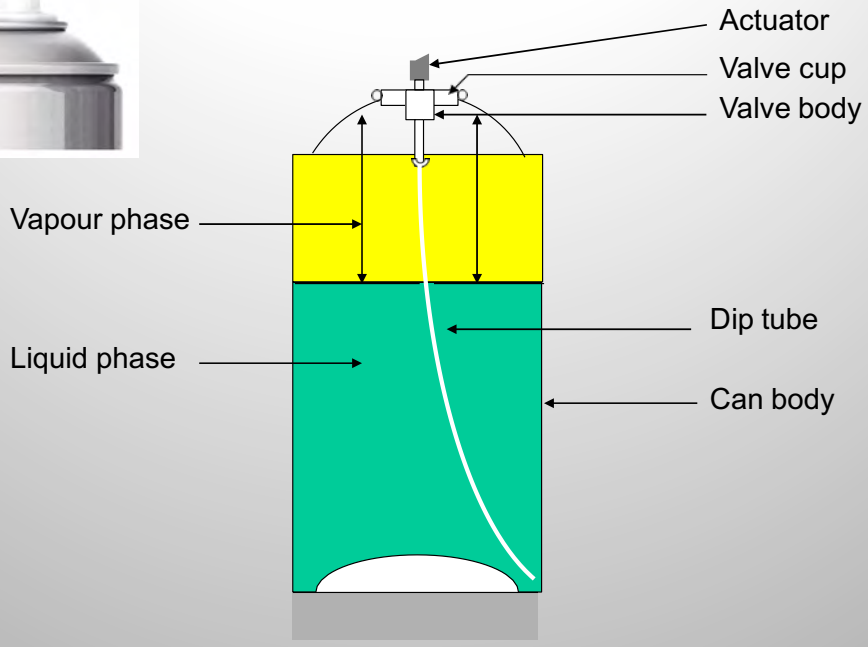
Virtual aluminium DWI bottle can manufacture - video

https://youtu.be/TZfWX7JfmLw

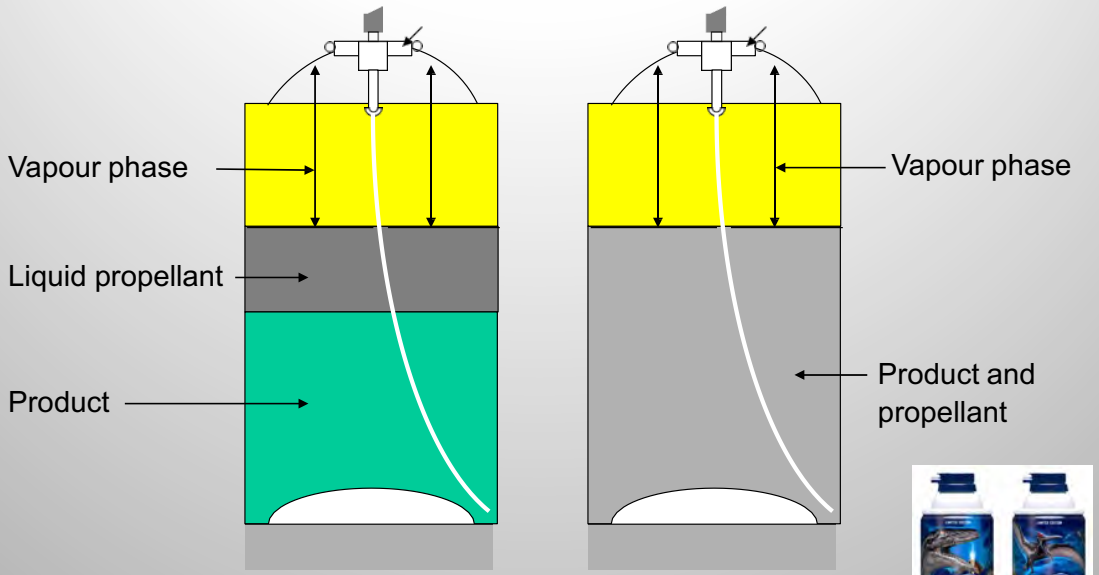
Typical aerosol cans
(shown prior to fitting of valve mechanism)



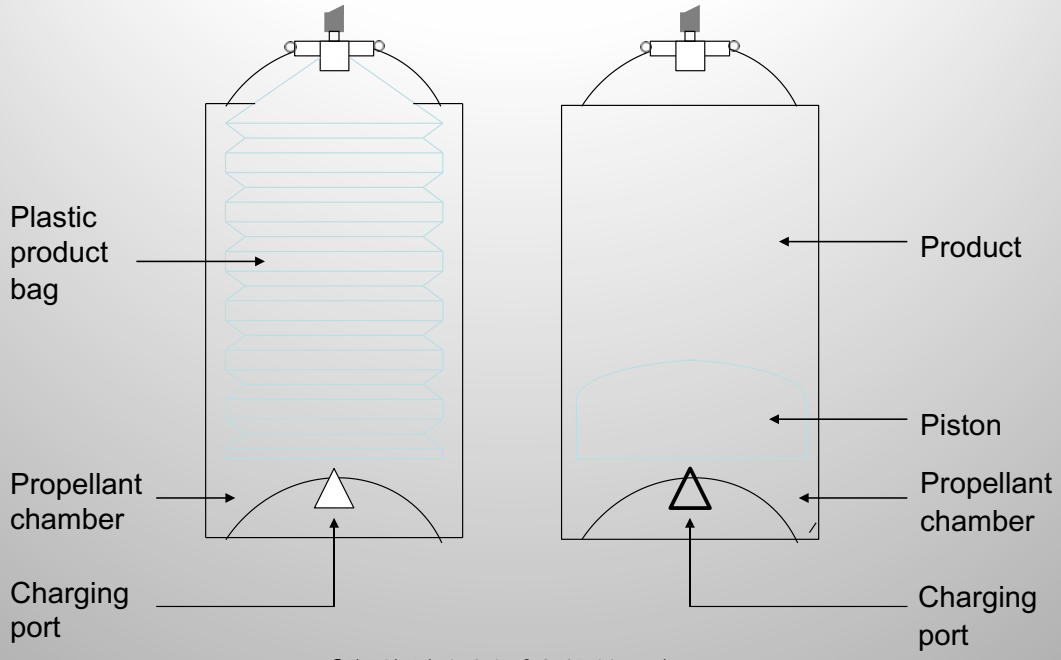
Typical aerosol system



Three-phase and Two-phase Aerosols



Aerosols with propellants in chambers separate from the product



Typical cross sections of metal cans (2)

- **General Line – performance cans**
- **General Line – non- performance cans**

Can construction methods GL performance

3-piece cans welded (steel only) for paint

Welded cylinder formed as for food cans

Both ends fixed by canmaker, one contains a lever lid

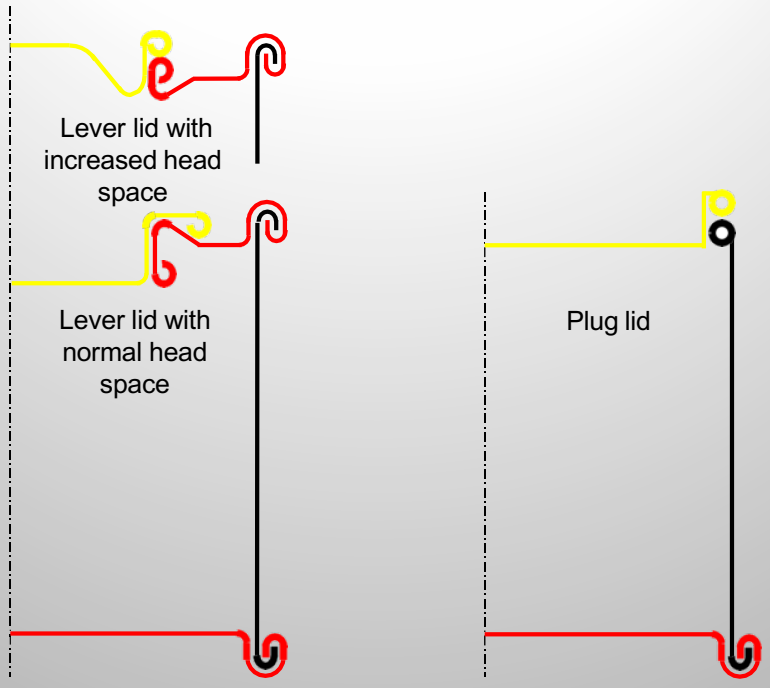
May be reformed into a taper cylinder to make a nestable pail

3-piece cans welded (steel only) for edible oils and industrial products

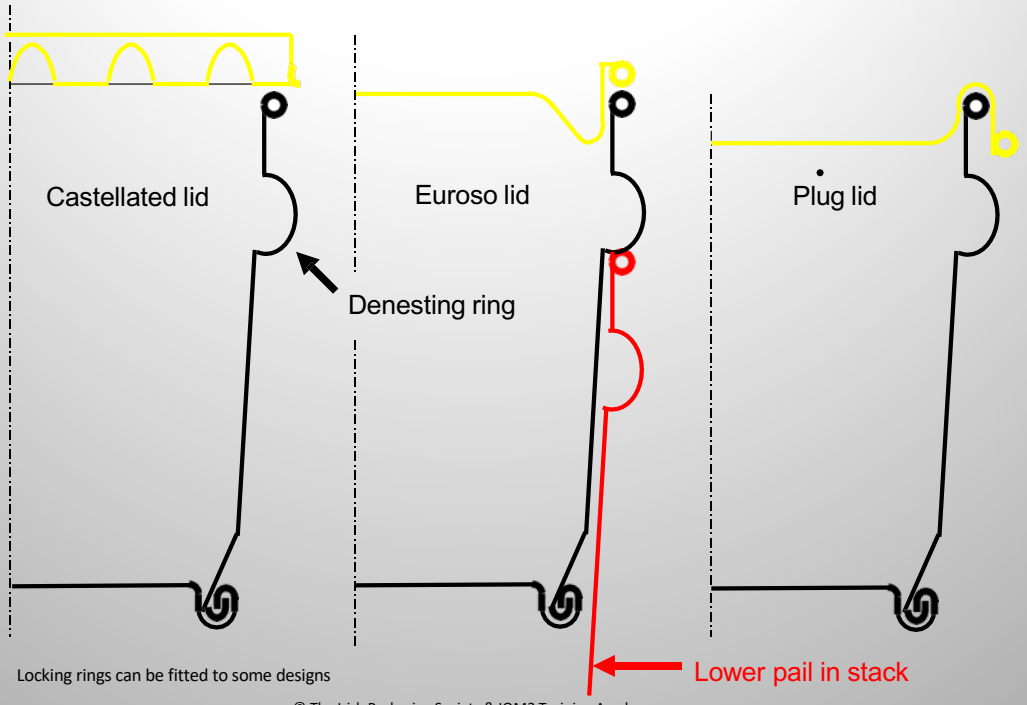
Welded cylinder formed as for food cans then reformed into square or oblong section

Both ends fixed by canmaker, one has a pour spout or other opening device.

General line performance round can with lids

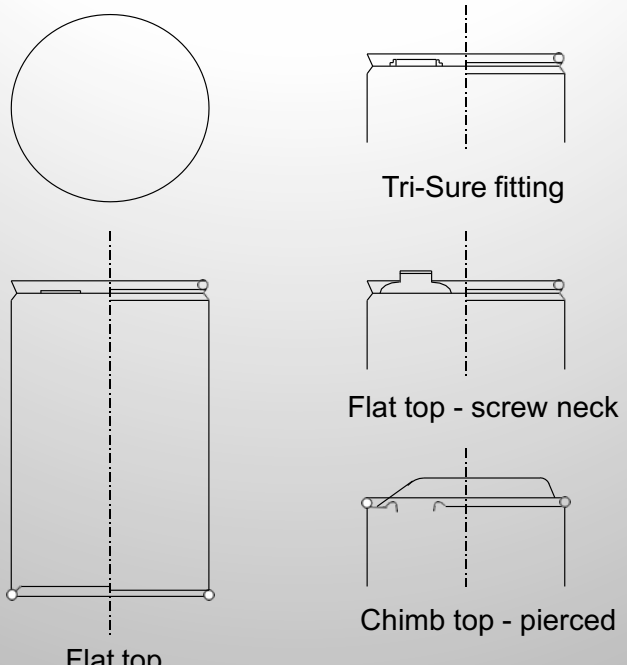


General line performance round tapered



130

Small capacity drums (< 50 litre)



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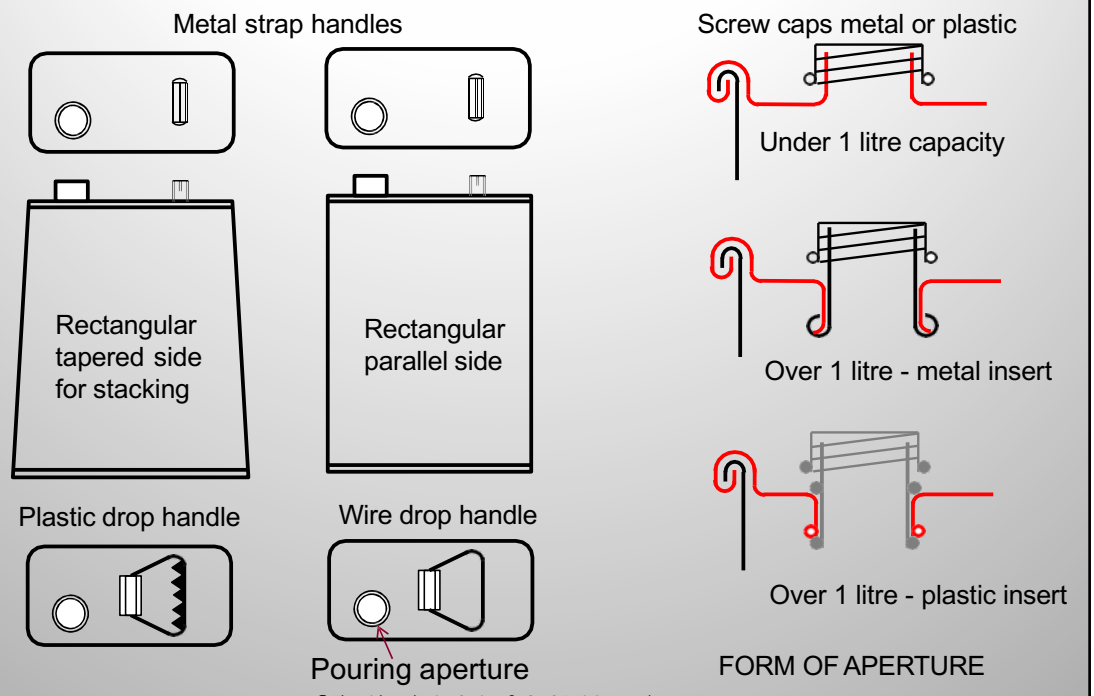
General line performance irregular cans with typical lids and handles



Can construction methods GL non-performance

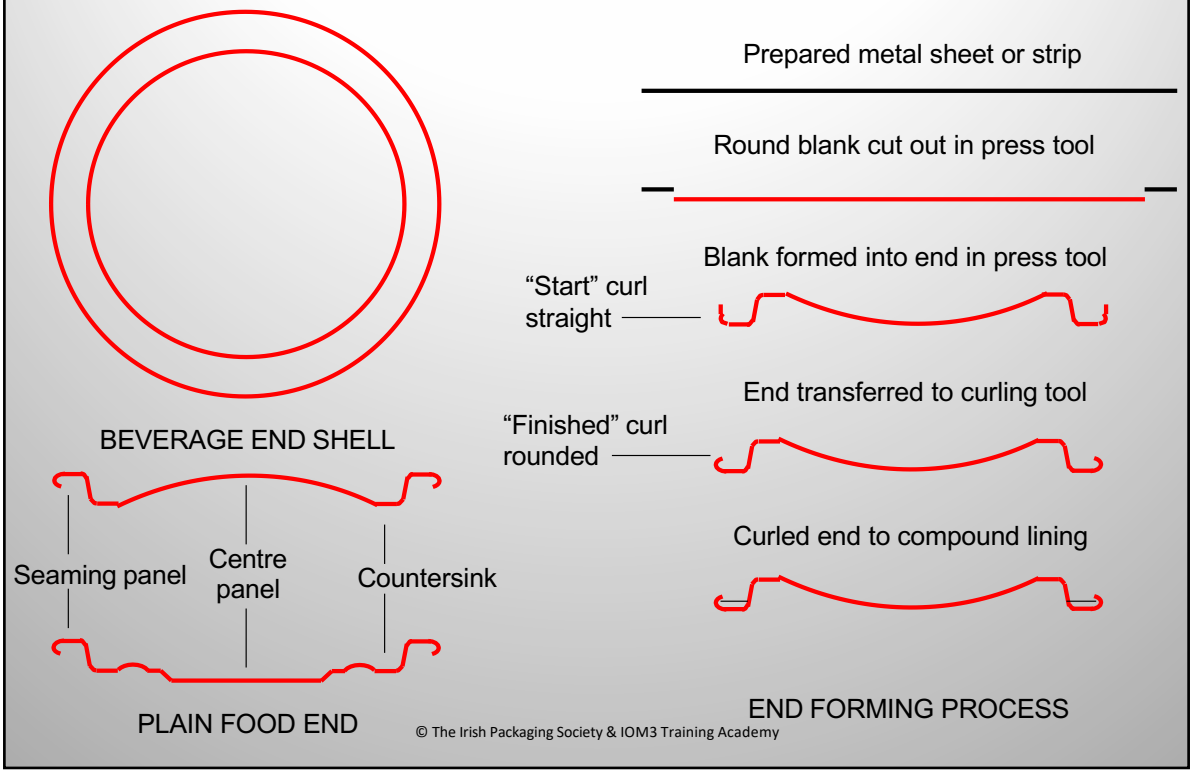
Built-up containers of many different cross-sections using the lock seam joint

Lids systems also in many different formats

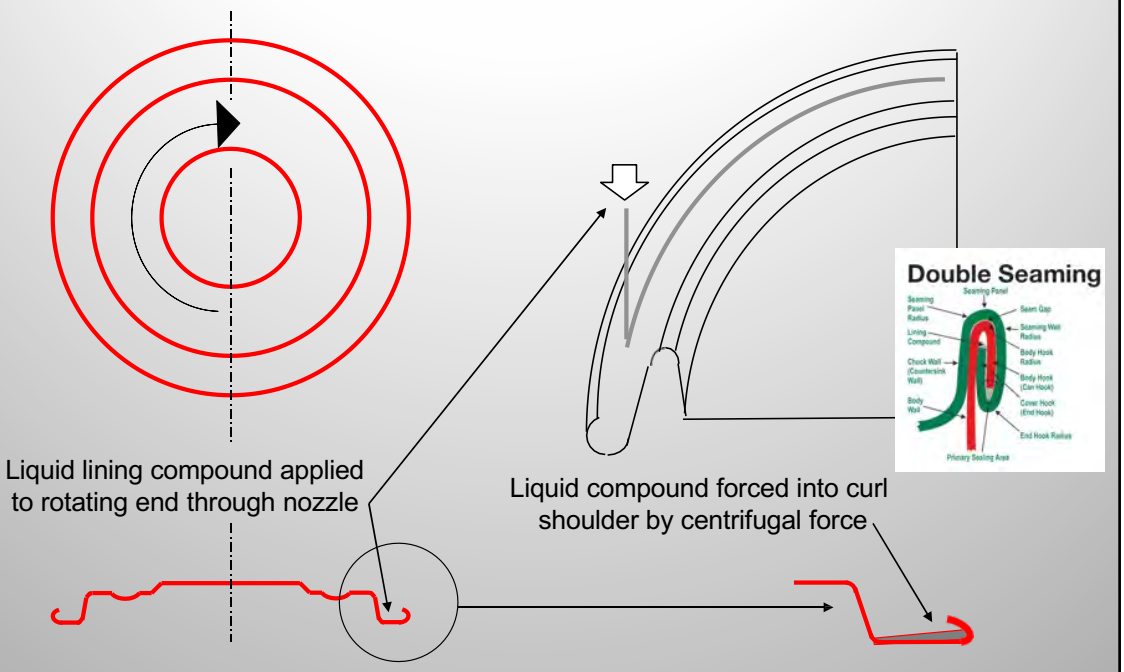
End making

- Formed from sheet (coated / printed / uncoated) as a shallow drawn can
- The edge is curled to give the correct fit to the can flange
- Liquid lining compound is piped into the inside of the curl area
- For easy open ends the panel is scored and a tab is riveted on

Can end forming and curling



End - lining compound application to hermetically seal end to can body



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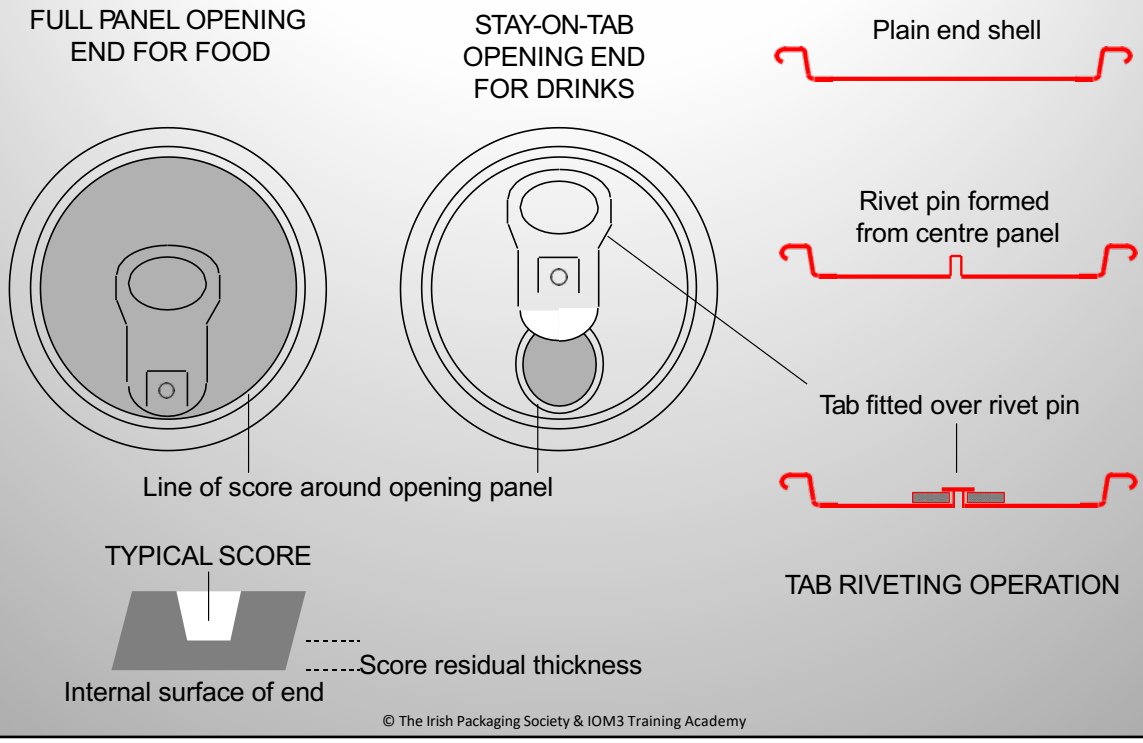
Score detail & Tab riveting - Easy open ends



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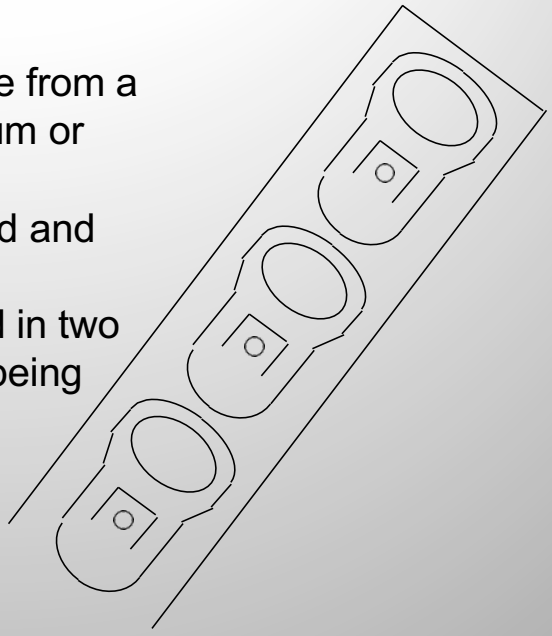
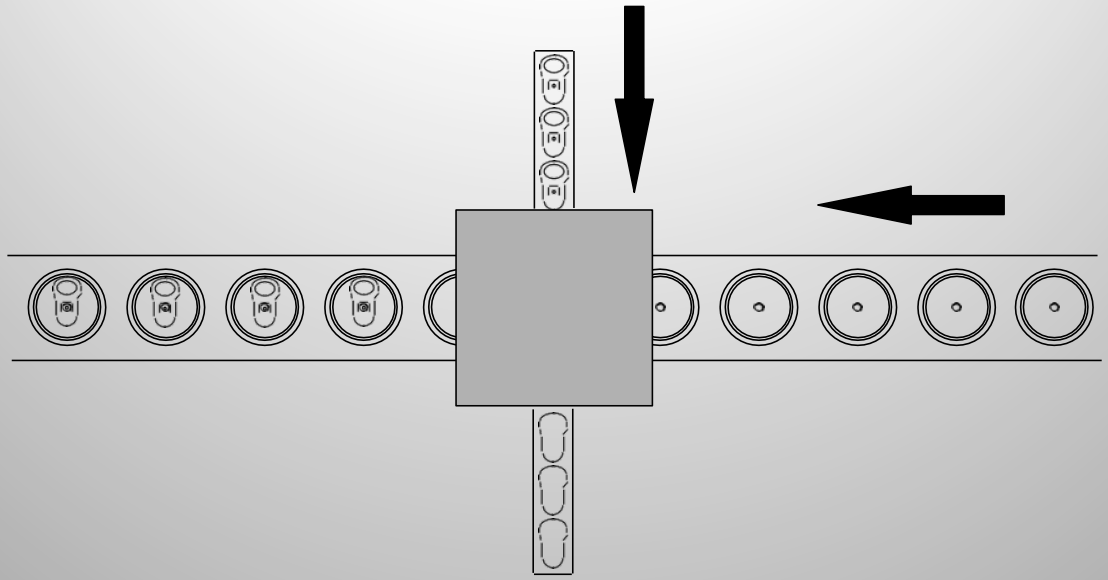
Tab forming

- The TAB.
  - The pull tabs are made from a narrow coil of aluminium or steel.
  - The strip is first pierced and cut.
  - Then the tab is formed in two further stages before being riveted to the can end.

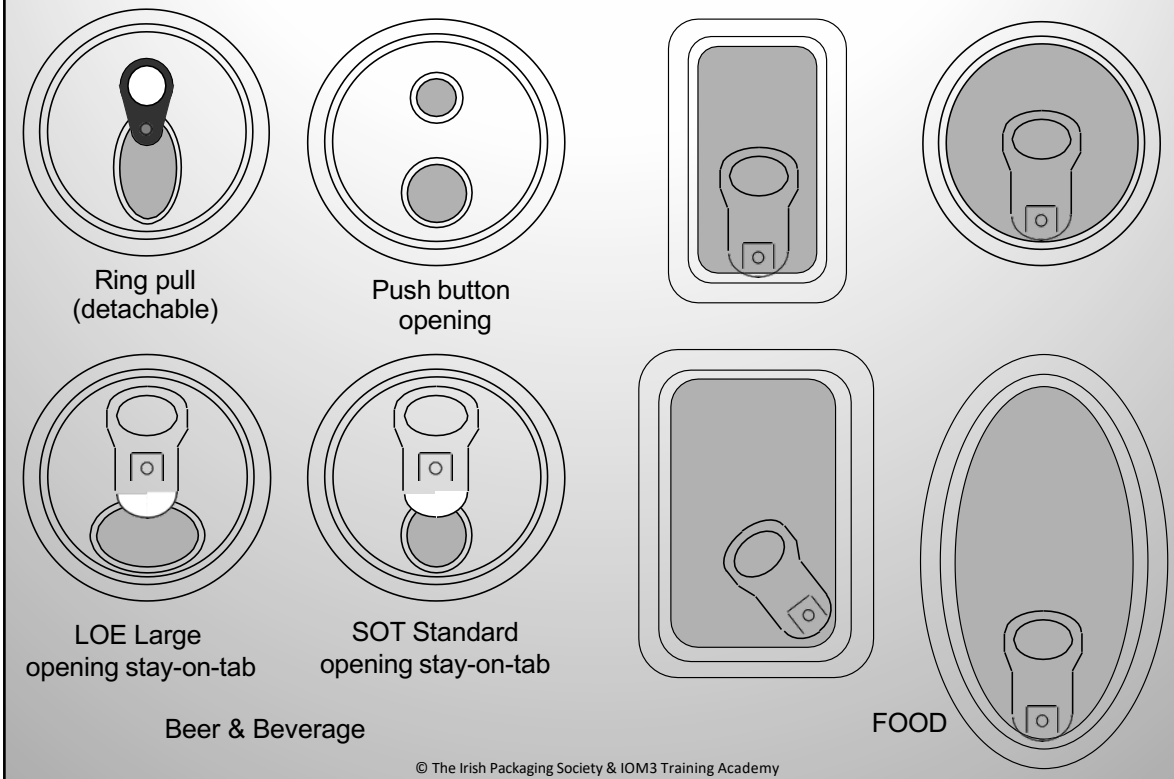


Easy-open end assembly

The ends pass through a series of dies which score them, form the rivets and attach the tabs, which are fed in from a separate source.

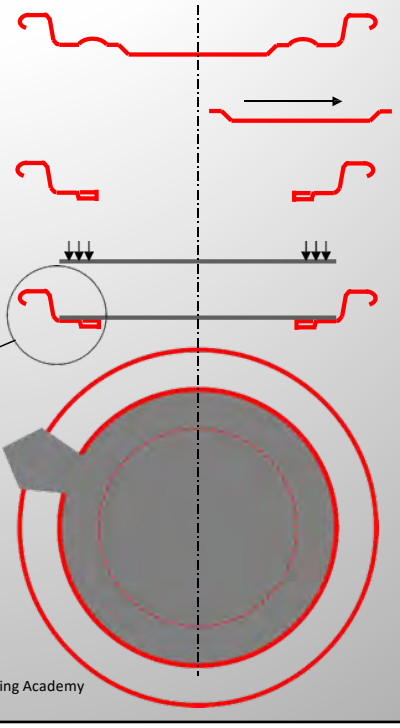


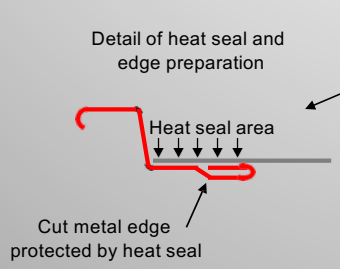
Typical easy open ends



Peelable diaphragm end

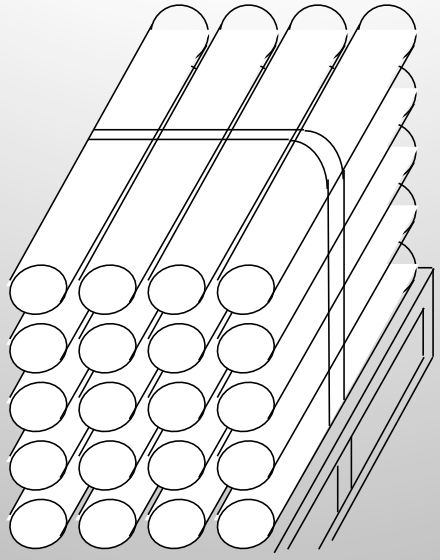
1. Standard plain end
2. Centre panel cut out and removed
3. Internal edge prepared
4. Precut aluminium foil lid heat sealed in place





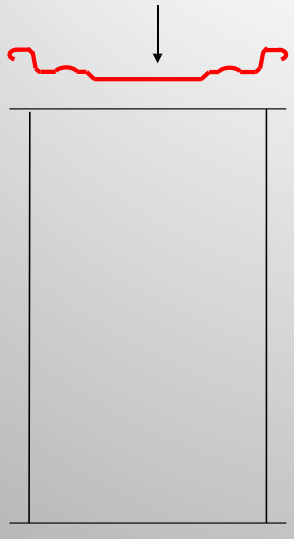
Palletising of can ends

The finished ends, ready for capping the filled cans, are packaged in paper sleeves and palletised for shipment to the can filler.

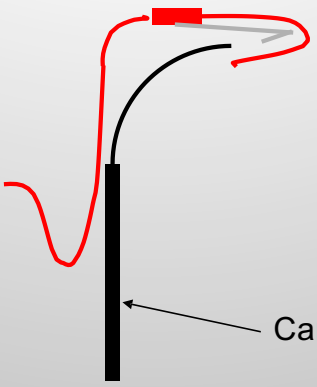


Can end double seaming

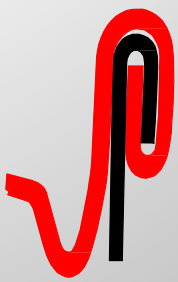
The canmaker's end is seamed onto the base of a 3-piece can



Before seaming



After seaming



Metal Closures for use on glass and plastic containers

- ROPP™ Closure – Aluminium
- Composite Closure
- Twist-off closure
- Press-twist closure
- Crown Cork

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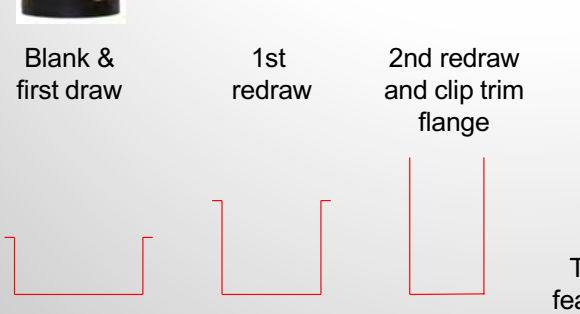
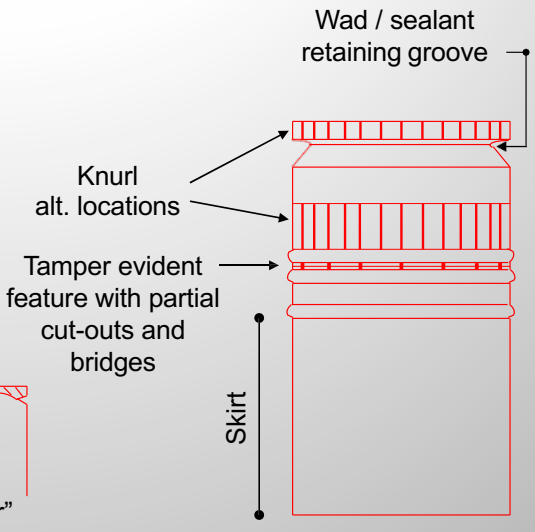
ROPP™ Closure - aluminium



CLOSURE BODY FORMING SEQUENCE

CLOSURE LINING METHODS



TYPICAL CLOSURE WITH LONG SKIRT (wadded)

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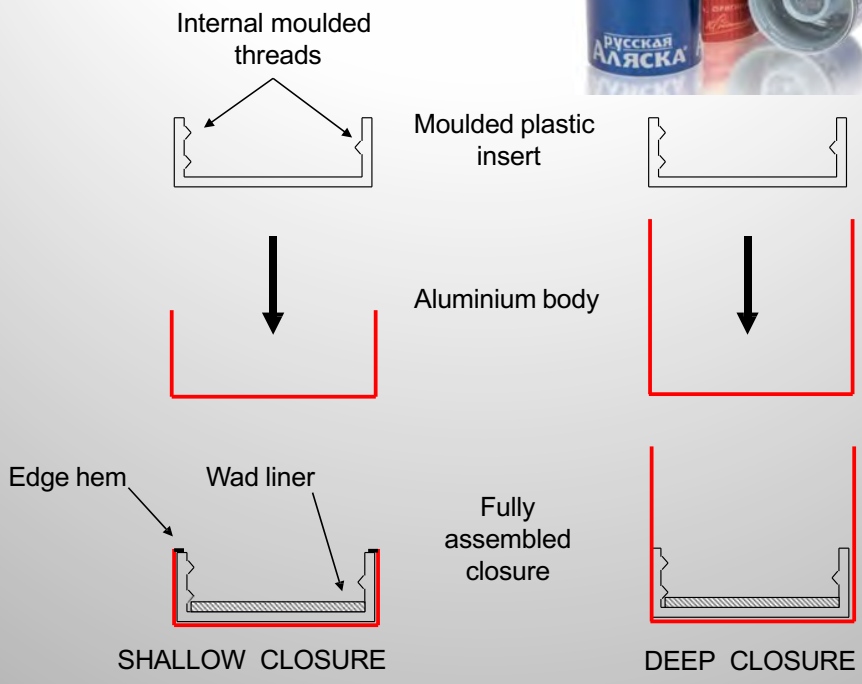
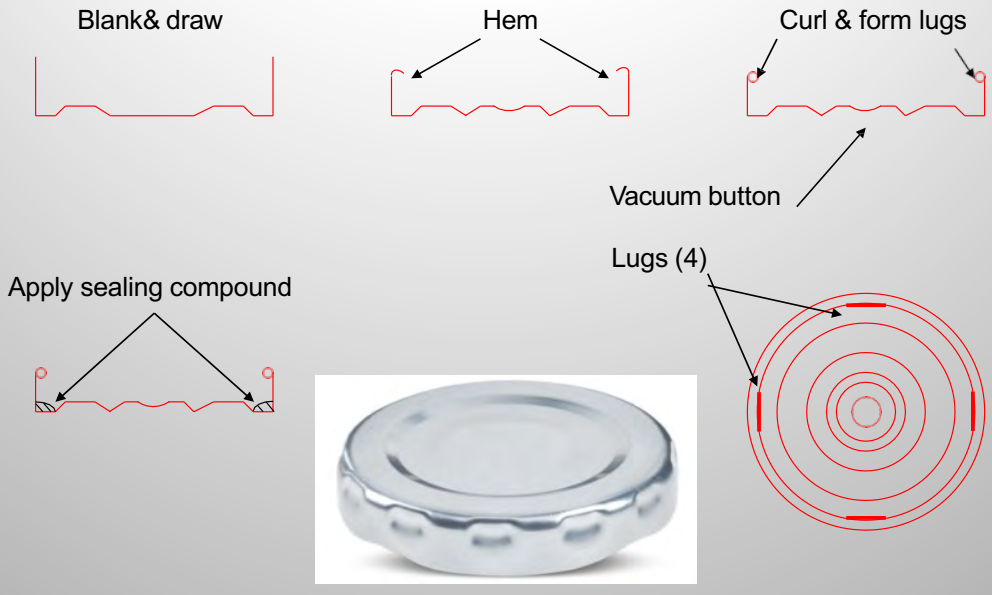
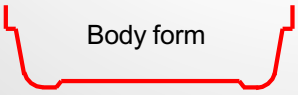
Composite closure



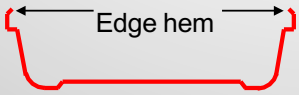
Twist-off closure (with vacuum button)



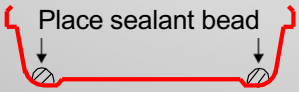
Press twist closure



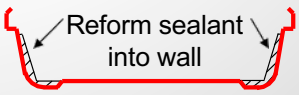
STEP 1.



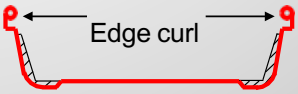
STEP 2.



STEP 3.



STEP 4.

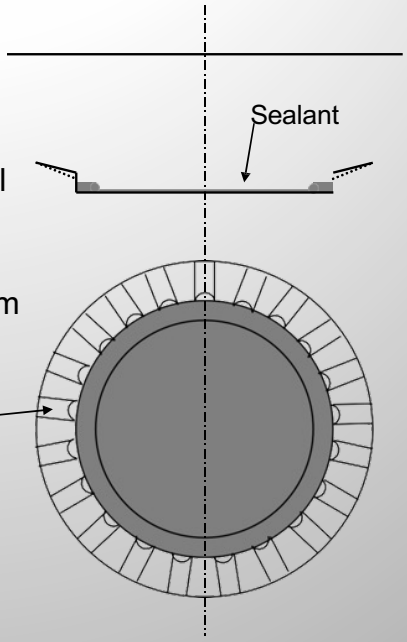


STEP 5.

(Optional vacuum button may be incorporated as in previous slide)

Crown Cork closure

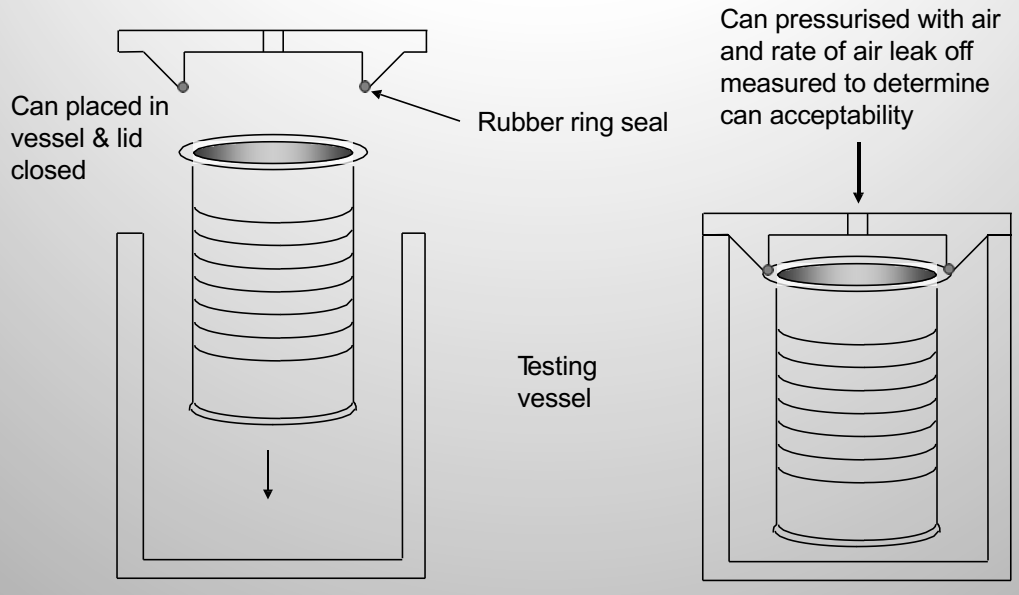
1. Circular blank cut from sheet
2. Closure with flutes formed in press tool
3. Sealant applied in liquid or hot solid form



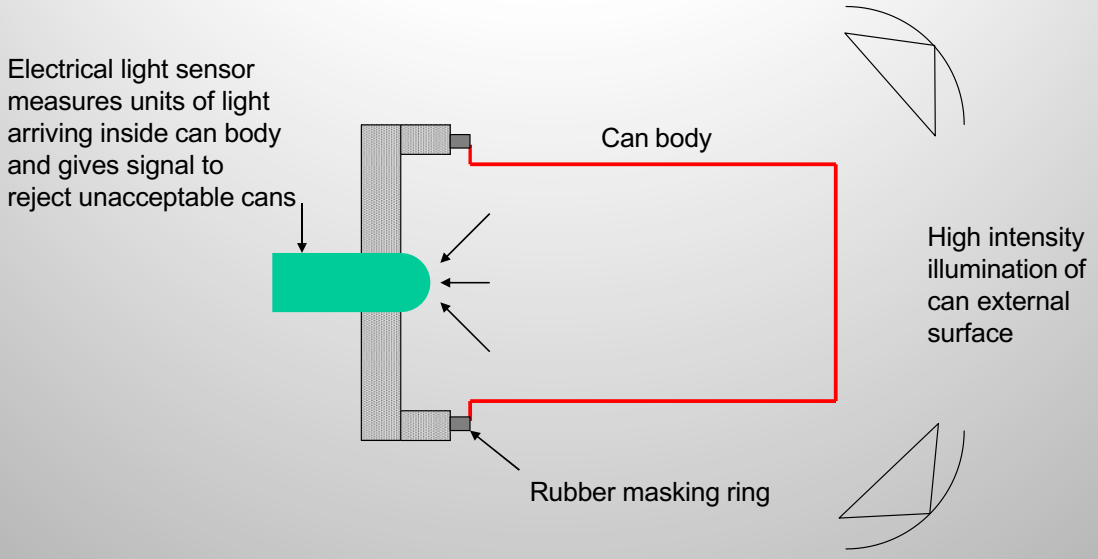
Quality assurance – In-line testing / viewing

- All can bodies pass through a tester which automatically rejects those with cracks or pinholes. The tester operation is validated regularly with cans having known defects.
- Light testing is used for two-piece cans but this system cannot be used for three-piece cans as light will not travel through the double seam on the base of this can. An air pressure leak off test is therefore used for three-piece cans.
- High speed two-piece DWI can lines usually incorporate internal video inspection systems.
- Easy-open ends pass through a leak detection system to check integrity of rivets and scores

Three-piece can – in line air testing principles



Two-piece can – in line light testing principles



Quality assurance – Off-line inspection

Cans	Various
Dimensions:	Axial compression
Strength:	Panelling resistance (collapse due to external pressure, processed food cans only)
	Base dome reversal pressure (pressurised cans only)
Coating integrity:	Internal / external coating weight, continuity, adhesion
Ends	Various
Dimensions:	Buckle resistance to internal can pressure
Strength:	Internal pressure / deflection test
	Negative internal pressure at which end reverts to normal configuration after can internal pressure / deflection test (food can ends only)
Coating integrity:	Internal / external coating weight, continuity, adhesion
Lining compound:	Compound placement
	Compound weight

Easy-open ends require additional tests to check loads to “pop” and “pull” open the tab and to check integrity and strength of the rivet

Pack labelling and traceability

- Complete packs of can bodies / ends on pallets are typically labelled with the following information:
  - Name of manufacturer
  - Specification of product
  - Number of items in pack
  - Time and date when pack has been completed
  - Serial number of pack
- For high volume products this information may be provided in the form of two bar codes:
  - Fixed information (Manufacturer, specification etc.)
  - Variable information (Serial no, time etc.)
- Cans printed in line, such as for beer or beverage, may contain a multi-digit code indicating: Manufacturer, factory, date, line no. and shift

Specifications for metal packaging

- Container / end construction method, dimensions / volume capacity
- Metal type, strength properties, dimensions, weight of metallic coating
- Protective organic coatings / lining compound, type, application weight
- Decorative coatings and inks, types, number of colours
- Performance criteria, strengths, coating continuity
- Attribute levels of acceptance
- Secondary packaging specifications

Pack Testing of cans filled with wet product

Purpose: Confirm that stated shelf life can be achieved without compromising Food safety or palatability of product

Typical issues:
Taint pick up from lacquer or metal
Metal pick up into product
Sulphur staining of light coloured product – particularly meat and fish
Corrosion of can wall / end
Actual issues will depend on specific product packed and can specification

Pack testing process:
Typical shelf life for processed food 2-3 years – need to get product to market without undue delay – use methods that accelerate duration of test
Storing filled cans at elevated temperature of 35°C accelerates rate of chemical change to 4 times that achieved at ambient temperature – 6 months at elevated temperature equivalent to 2-3 years at ambient temperature
Note: Elevated temperatures can give false indications because some live organisms react differently at these conditions.

A typical pack test protocol for processed food cans

Sample packs filled with product and processed, 75% stored at elevated temperature and 25% stored at ambient

Accelerated test opening plan:
1/3 opened in 1 month from filling
1/3 opened in 3 months from filling
1/3 opened in 6 months from filling – if no significant change between 3 and 6 month openings consider going ahead with commercial production

Ambient test opening plan:
½ opened at 12 months and ½ opened at 24 months after filling as a real time back up check

Note: for drinks cans where shelf turn round is generally under 6 months A less severe test protocol may be used

Other tests relating to can or lacquer development may employ simulants packed in cans – example - chicken soup to check performance of can end lining compound.

Coatings for cans & ends

- Functions of coatings
- Types of organic resin based coatings
- Types of resins used in coatings

Functions of coatings

- Provide inert barrier between metal and internal or external environment
  - prevent / reduce corrosion – presence of tin coating is beneficial
  - prevent taint from metal to food
  - prevent discoloration of food by tin or iron sulphide
- Provide meat release property
- Provide sulphur absorption property

Functions of coatings

- Protect can or end external decoration during seaming, processing and handling
  - no water absorption, de-lamination or discoloration of coating
  - surface tough enough to prevent damage to coating integrity during handling operations
- Provide lubricated surface to aid metal forming operations
- Provide pigmented or decorative surface

Types of resins in coatings

- Oleo resinous - low cost, mostly USA not EU
- Phenolic - to combine with other resins
- Epoxy
  - epoxy phenolic - food internal + external
  - epoxy urea - chem. resistance beverage cans
  - epoxy ester - over varnish
- Alkydes - external heat resistance
- Vinylic - beer + beverage cans
- Organosol - drawn cans
- Acrylic - colour retention

Overview of container coatings

- Very important to the performance and manufacture of most metal cans
- Coatings can be applied as liquids, laminated plastic or directly extruded plastic
- Many types of resin, coupled with complex solvent mixtures, to give wide performance range
- Industry moving to high solids solvent based or water based, where feasible, to reduce emissions of volatile organic compounds to the air

Summary of functional properties of metal packaging

The physical properties of steel and aluminium are very similar

Strength / toughness / surface & others

- Good protection of product from physical damage / external tampering
- Hold (high) internal as well as negative pressure
- Withstand heat processing
- Do not shatter on impact
- Will conform to UN regulations on Transport of Dangerous Goods
- Light weight when empty
- Good conductors of heat
- Take high quality print
- Steel is magnetic

Summary of functional properties of metal packaging

The physical properties of steel and aluminium are very similar

Product protection

- Provide hermetic seal closure systems
- Long shelf life potential (up to three years) at ambient conditions – product quality not dependant on how customer stores package
- Hold organic solvents safely
- Absolutely opaque to light / UV
- Absolutely impervious to passage of moisture / gases

Environmental

- Metals classed as permanent materials providing infinite number of re-melt cycles with no loss of properties

Additional sources of information about metal packaging

The CANMAKER magazine

Tel: 01293 435100 Fax: 01293 619988

e-mail: canmaker@sayers-publishing.com Web:

www.canmaker.com

Canning & Filling magazine

Contact details as for The CANMAKER

CanTech International magazine
Tel: 01474 532202 Fax: 01474 532203

e-mail: info@cantechonline.com Web:

www.cantechonline.com

Metal Packaging Manufacturers' Association
Tel/fax: 01273 585833

e-mail mpma.enquiries@mpma.org.uk Web:

www.mpma.org.uk

Represents manufacturers of light rigid metal packaging in the UK and Ireland

MPE, Metal Packaging Europe
Avenue des Arts 41, 1040 Brussels,
Belgium Tel.+32 2 897 04 90

Web: www.metalpackagingeurope.org

E mail: info@metalpackagingeurope.org

Umbrella organization representing producers and suppliers of rigid metal packaging across Europe

APEAL, The Association of European Producers of Steel for Packaging

Avenue Ariane 5, BE-1200

BRUSSELS Tel: +32 2

537 91 51

Webs: apeal.org & steelforpackaging.org

Text books about metal packaging

Metal Packaging – 2nd edition Author: Bev Page
Publisher Pira International
Tel: 01372 802080 Fax: 01372 802079
e-mail: publications@pira-international.com
Web: www.piranet.com (buy on line available)

Slides accredited to Bev Page through IOM3.

The following books are available through The CANMAKER magazine:

Can Basics (fundamentals of filling cans with food products) Two Piece Beverage Canmaking

Design and technology of packaging decoration for the consumer market Canmaking: The technology of metal protection and decoration

The Wiley encyclopedia of packaging technology Food canning technology

Canmaking for can fillers