

# Diploma in Packaging Technology

## Flexible Metal Packaging Unit 2

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## Content

- Aluminium
- Aluminium Foil
- Properties of Aluminium Foil in flexible packaging
- Foil Coatings
- Decorative Effects
- Foil laminations
- Foil Pinholing and Flex Cracking
- Vacuum Metallising
- Wrinkle Wall Trays
- Environmental aspects
- Metal packaging component specifications

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## Metals (recap!)

- Properties of all metals:
  - Metal offers 100% gas, moisture and light barrier
  - Metal packaging has good stiffness, strength, ductility and has attractive appearance.
  - Disadvantages of metal packaging are weight, high noise levels and cost fluctuations.
  - Metal cans are cheap, thermally stable, strong, rigid, opaque, easy to process on high speed lines and readily recyclable.

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## Manufacturing terms (recap!)

- Temper
  - The greater the degree of draw required, the softer the steel must be. Metal is work hardened, if rolled while cold, thus producing a much stiffer steel. Double reduced steel is rolled once, annealed, then rolled again
- Annealing
  - Heat treatment to change properties in a material. Used to induce ductility.
- Ductility
  - Ductility describes the extent to which materials can be deformed without fracture.

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# Aluminium manufacture

- Bauxite + Sodium hydroxide (NaOH) -> Aluminium Oxide ( $\text{Al}_2\text{O}_3$ )
- Electrolysis converts Aluminium Oxide (Alumina) to Metallic Aluminium + Oxygen
- 4kg bauxite -> 2kg Alumina (+8kW electricity) -> 1kg Aluminium
- "Rolling Ingots" reduced to re-roll stock 3-6mm thick on regular sheet
- Pure aluminium is a soft, silvery white comparatively light material (1/3 the weight of steel)
- Ductile and malleable at normal temperatures, but loses strength at temperatures above 150°C
- Good conductor of heat and electricity

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## Supported / Unsupported Aluminium

- Advantages
  - Ductility of material for forming
  - Tearing character for developing easy openings
  - Light weight (density 1/3 of steel)
  - Recyclable
- Disadvantages
  - Price fluctuations
  - Not suitable where high pressure or heat required

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# Material & process developments

[www.alufoil.org](http://www.alufoil.org)

- 1960s – Thickness of foil < 0.0065mm
  - High purity steel rollers
- 1970s – Rolling line improvements
  - Rolling lines and integrated transport / storage.
  - Strip thickness hydraulic adjustment and control
- 1980s – Rolling mill technology
  - 2,200m/min
- 1990s – Plant automation
  - Rolling widths up to 2,150mm
  - Thickness 0.006mm
  - Rolling speeds 2500m/ min.

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# Uses in different markets

- As an effective barrier to light, aluminum foil is used extensively to package photographic materials and other light-sensitive products.
- Long life packs for dairy products, drinks, and many other sensitive foods.
- Aluminum foil trays and containers to bake cakes and pies.
- Takeaway meals, ready snacks and long life pet foods.
- Aluminum foil wrap for food in order to preserve it in refrigerator.
- Candy-bar and chewing gum wraps.

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## Uses in different markets

- Beverage cans.
- Toothpaste.
- Cigar holders.
- Aerosols.
- Pharmaceutical blister packages.
- Aseptic drink boxes.
- Medicinal oils.
- Ointments, grease-based cosmetics.

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## Challenge from metallised materials

- Metallised materials less prone to pinholing and flex cracking
- Deposition of metal can be as low as 0.05 micron
- Laminated or metallised films combine best properties of metal and film

*But*

- Can have environmental issues due to combination of materials, making them difficult to recycle.

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# Aluminium Foil

- Rolled aluminium less than 150 $\mu$  thick is called foil
- When being rolled to foil, aluminium hardens and must be re-annealed
- Foil gauges less than 25 $\mu$  are passed through work rollers two sheets at a time
- Foil to foil faces have matt finish. Foil to roller faces are bright
- If single web is run through the rollers, both faces are bright
- Strong mineral acids corrode bare foil
- Mild alkaline compounds (such as soaps and detergents) have some effect on foil
- Mild organic acids (i.e. in food) have little or no effect on foil

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# Hot Rolling vs Cold Rolling

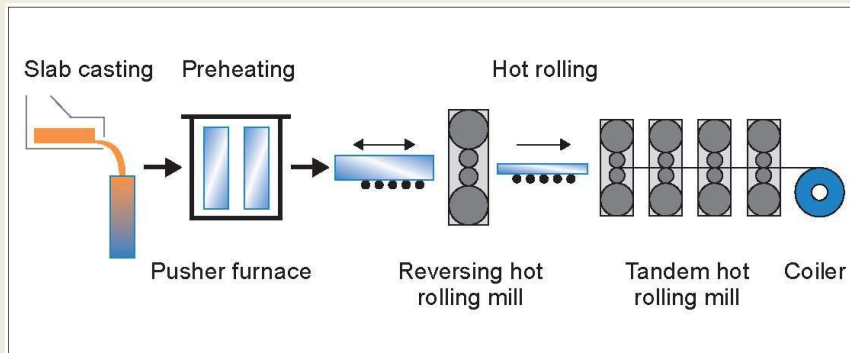
- Hot rolling: rolled above recrystallisation temp. of metal (500°C+)
  - Can be fed directly from casting operation
  - Large reductions in thickness
  - Simple cross sections and sheet metal
- Cold rolling: rolled below recrystallisation temp. of metal
  - Increased strength (via strain hardening)
  - Improved surface finish
  - Improved tolerances
  - Various conditions: full-hard, half-hard, quarter-hard, skin-rolled
  - Sheets, strips, bars and rods
- Normally hot rolled followed by cold rolled

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## Step 1. Hot strip production

[www.alufoil.org](http://www.alufoil.org)

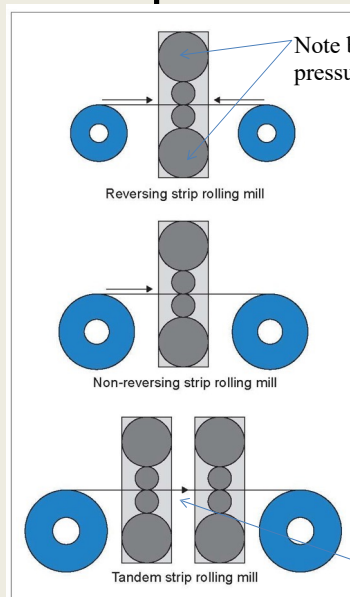


- Heated to over 500°C (Hot rolling)
- Thickness down to 6 mm

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## Step 2. Cold strip rolling [www.alufoil.org](http://www.alufoil.org)



- Still heated to 100°C
- Material hardens after each pass
- **Annealing** step after each pass
- Coils:
  - <5 tonnes: reverse strip rolling
    - Reel ends up on same core
  - 10-15 tonnes: non- reverse strip rolling
    - Reel ends up on new core
  - 15-25 tonnes: tandem rolling mills

No annealing here because strip is in tension. Strip work hardens when it relaxes on the reel.

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## Step 3. Thin strip and foil rolling

[www.alufoil.org](http://www.alufoil.org)



- Thin strip for cans, foil for foil sheet
- Double web of foil rolling
- Thickness down to 6 micron

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## Step 4. Slitting and winding [www.alufoil.org](http://www.alufoil.org)



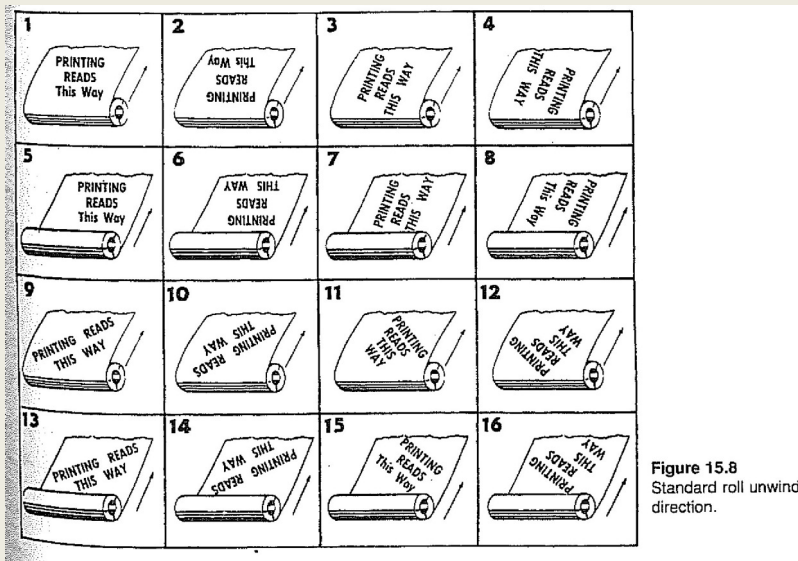
- Carried out at high speed
- Slitters / winders must match operation speeds
- Winding configuration depends on surface finish requirements

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## Unwind directions for reel fed material



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## Qualities of Aluminium Foil in Flexible Packaging

- See 'Properties of Foil in Flexible Packaging'
  - (slides 22-23)
- Foil prone to pinholing / flex cracking
- Protected by foil coatings / laminations
- Or by using vacuum metallising instead.

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## Properties of Aluminium Foil in Flexible Packaging

1. **Appearance** – Bright, specular metallic gloss
2. **Barrier properties** – Foil greater than 17 $\mu$  gives 100% barrier to all gases
3. **Dead-fold property** – Ability of material to hold geometry of fold. (Good for wraps and tubes)
4. **Friability** – Easily punctured and torn. (Good for blister packs and tamper evidence)
5. **Stability** – Aluminium oxide forms as hard transparent layer when exposed to air

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## Properties of Aluminium Foil in Flexible Packaging

6. **Hygienic Properties** – Easily sterilised and non absorptive to contaminants. Inert, or forms no harmful contaminants with most food, cosmetics or other chemicals.
7. **Conductivity** – Good ability to conduct electricity and heat. Used in microwave susceptor films, electrostatic shielding and induction heat seals
8. **Recyclability** – Aluminium (and alloys) are reclaimed at 5% of original energy consumption
9. **Formability** – Ductile metal. Can be moulded into trays or cups, drawn into cans or impact extruded into tubes/ aerosols
10. **Printing, embossing, coating** – Foil available as low as 6 $\mu$

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# Foil Coatings

Reasons for coating include:

- To make foil surface heat sealable
- To increase scratch or scuff resistance
- To increase tensile or burst strength
- To add slip, non-slip, release lacquer, decorative surface etc.
- To improve adhesion of other coatings or inks (primer)
- To enhance water vapour or gas barrier properties of lower gauge foils
- To increase resistance to corrosive agents or products
- To impart high gloss or 3D depth to foil decoration or printing
- To lubricate during converting or processing operations
- To improve UV resistance of a printed surface

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# Foil Coatings

Coatings generally classified as:

1. Decorative,
  2. Protective, or
  3. Heat Sealing
- Low viscosity coatings are **gravure** applied.
  - Heavier coatings are **roll coated**.

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## Printing on Foil

- Does not require special artwork preparation
- Inks:
  - Gloss
  - Opaque
  - Transparent
- Co-operation between printer and ink maker
- Same presses and plates used as per printing on paper or film.

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## Primers

- Primer (or wash coat) provides key for the ink
- Also protects foil surface before printing or coating
- Gravure and Flexo printing :
  - > shellacs and vinyls
- Lithographic printing:
  - > vinyl copolymer or nitro cellulose
- Second coating can be added over ink to prevent scuff resistance and to reduce surface friction.

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## Graphic Design

- Can be decorated by the usual printing processes:
  - Gravure
  - Flexographic
  - Lithographic
  - Digital
- Consider the effect of the foil before finalising print.
- Foil can also be embossed.

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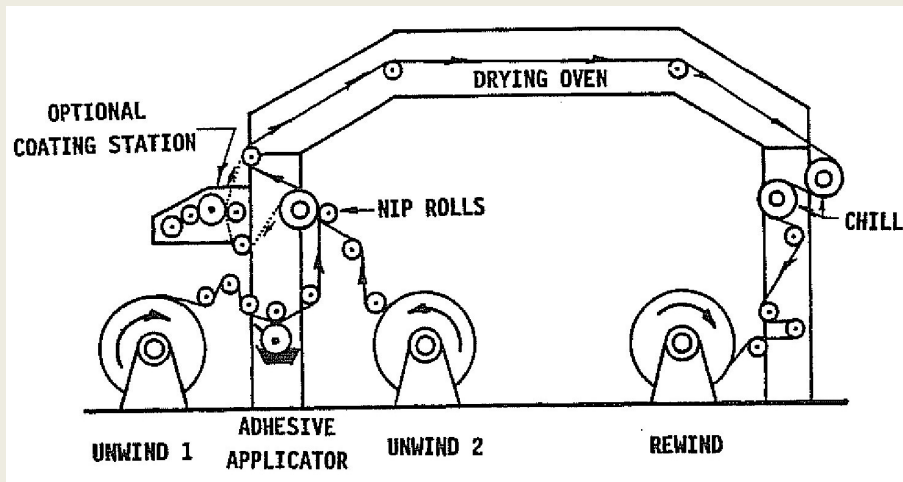
## Foil Laminations

- Wet bonding
- Dry bonding
- Hot Melt or Solventless lamination
- Extrusion Bonding
- Wax lamination

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## Wet Bonding

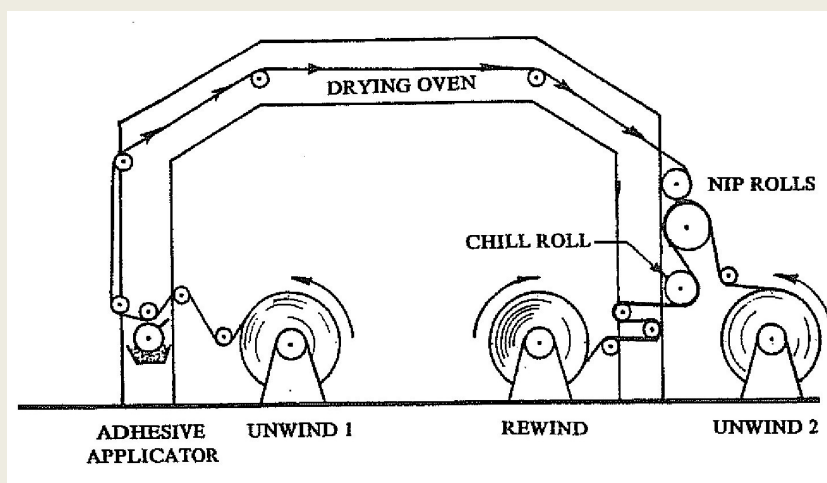


Needs porous layer such as paper to release moisture from adhesive

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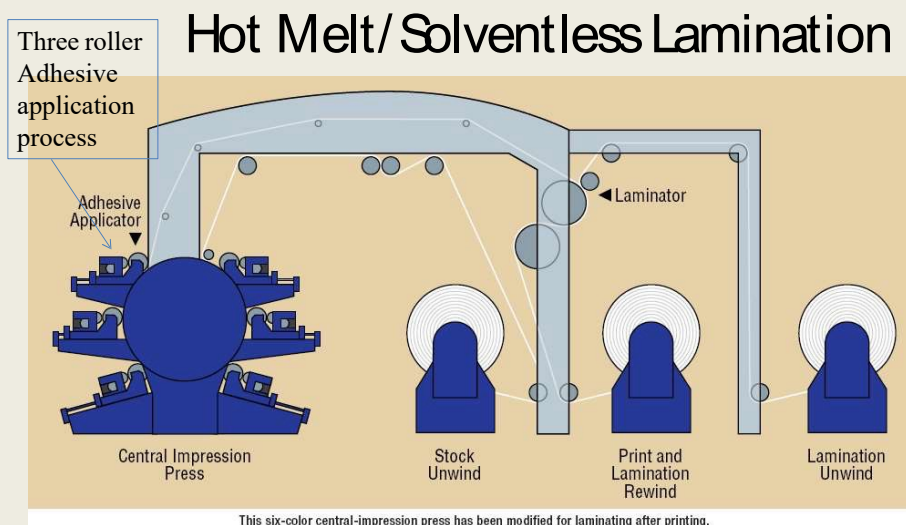
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## Dry Bonding



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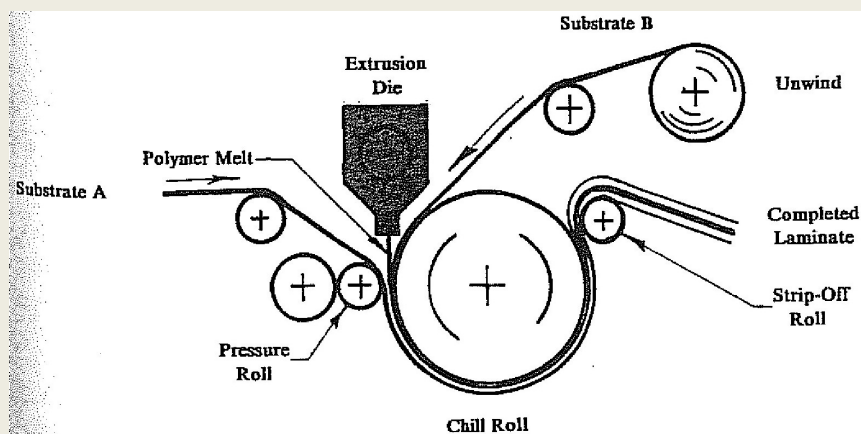
Solventless laminating is the process of metering a **low viscosity** adhesive onto a **multiple-application roll** configuration (i.e. 3 roller metering process) that applies the adhesive to a first substrate, which is then mated to a second substrate via a heated nip. Adhesive is made from **100% solids** (nothing to evaporate).

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## Extrusion Bonding

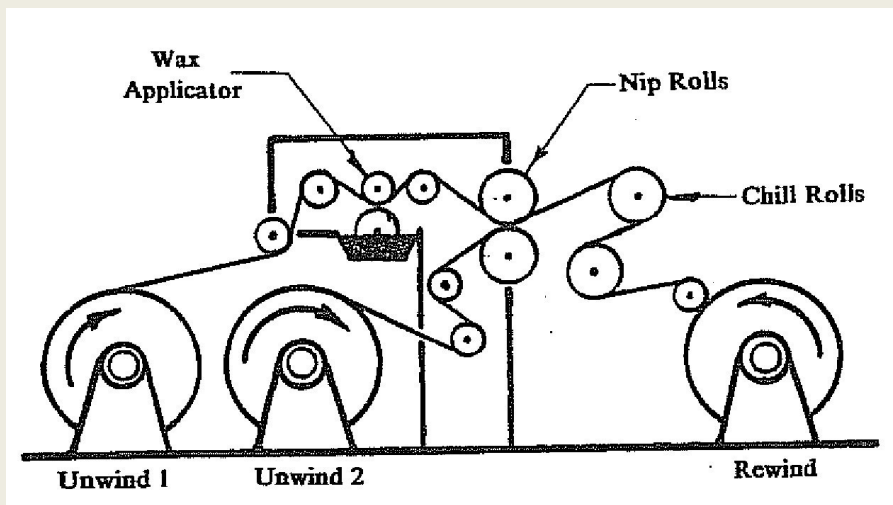


**Figure 15.4**  
Extrusion laminating uses an extruded melt to bond two materials.

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## Wax lamination



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## Foil Lamination Examples

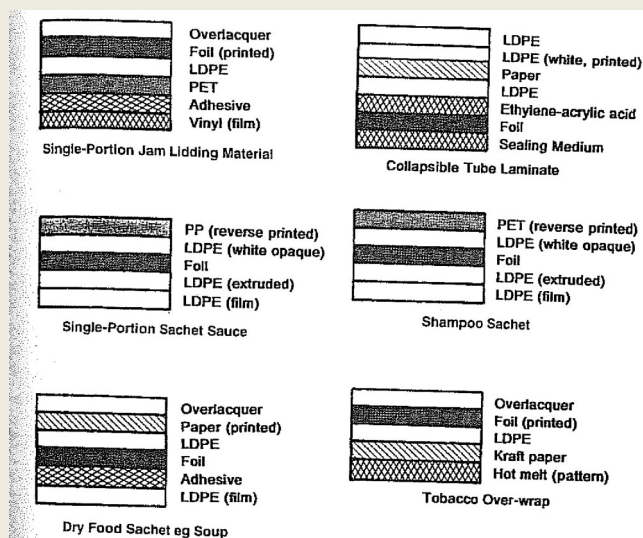


Figure 15.10  
Examples of laminate constructions containing aluminium foil.

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## Pinholing

- Most foils used for packaging are in gauges  $<12\mu$
- Minute holes occur in this foil due to metallurgical impurities and variations
- Gaspenetration through pinholes is reduced when foil is coated or laminated with polymeric material
- With heavy laminations, or heavy gauge foil the effect of pinholing is negligible

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## Flex cracking

- The splitting of aluminium foil when it is worked
- Heavy laminates reduce the tendency to flex crack (and let gases in)
- Barrier properties should be evaluated on finished packs, as well as on the flat.

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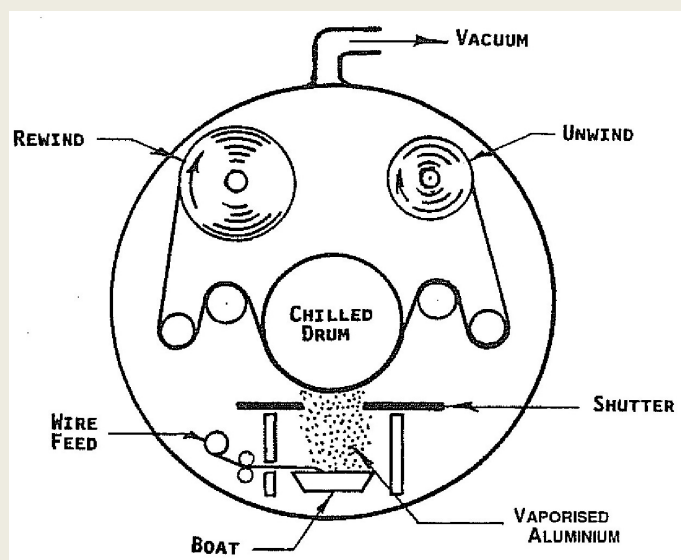
## Vacuum metallising

- Aluminium is the only metal vacuum deposited for packaging.
- Metallising:
  - Improves gas and light barrier properties
  - Provides heat and light reflectance, and
  - Provides good electrical conductivity

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## Vacuum metallising



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## Vacuum Metallising **Paper**

- Paper is high quality virgin stock, clay coated on 1 or 2 sides.
- Paper stock must always be lacquer coated before being metallised.
- Lacquer seals the surface, enhances surface smoothness and promotes consistent adhesion.
- Lacquer is normally water based or solvent based and gravure applied.
- Paper must be re-moisturised after metallisation to stop curling.
- Papers are now being developed specifically for metallising.

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## Vacuum Metallising **Films**

- Plastic does not need to be smoothed, sealed or dried like paper
- OPP, PET or Nylon (PA) are normally used for packaging
- Metallised PVC is used for fire retardant properties
- Metal deposition is measured by electrical resistance and optical density

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## Vacuum Metallising **PP**

- Excellent moisture barrier and good UV light barrier
- Limited oxygen barrier (much better when metallised)
- Can be used at temperatures up to 150°C
- Is economical
- Produces fair metal to film bond

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## Vacuum Metallising **PET**

- Produces the best metal to film bond
- Gives the best combination of oxygen, moisture and UV light barriers
- Has good printing properties
- Can be used up to 205°C

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## Vacuum Metallising **BON** (Biaxially Oriented Nylon)

- Is a good oxygen barrier
- Has excellent tear, abrasion and puncture resistance
- Has good flex crack resistance
- Is hygroscopic (Nylon attracts moisture)

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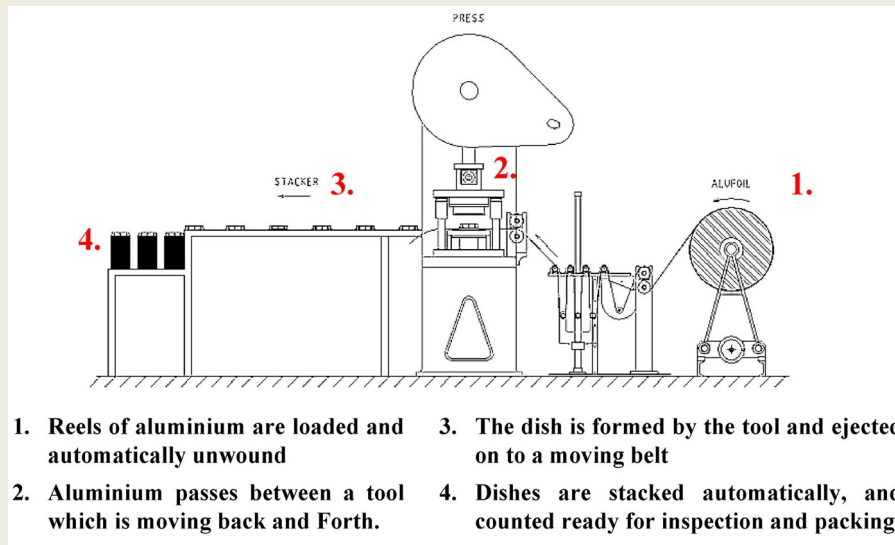
## Measuring Metal Deposition

- Aluminium foil thickness can be as low as 6 microns
- Vacuum metalized film can be as low as 0.05 microns
- Metal deposition thickness affects barrier properties
- Indirect measurement due to very low thickness
- Can be measured by:
  - Electrical Resistance
  - Optical density (preferred for plastic film)
- **Densitometer** measures amount of light that penetrates through metalised material.
- Results expressed as percentage of light transmission

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# Wrinkle Wall Aluminium Trays



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# Wrinkle Wall Aluminium Trays

## • Uses

- Take away foods
- Ready to bake desserts
- Pre-prepared chilled meals
- Frozen foods
- Baked cakes and tarts
- Pet food, Meat, Jam, Pate
- Milk portions
- Sterile surgical instruments
- Growpots for seeds
- Fireproof barbecues

## • Advantages

- Used as vehicle for product in production
- Simple effective lidding
- Heat conductivity (Product can be frozen or cooked in container)
- Lightweight (airline meals etc.)
- Typical thicknesses of 70 to 100 micron

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## Differences between smooth wall and wrinkle wall aluminium trays

- **Price:** smooth walled more expensive as they are thicker and made of an alloy
- **Speed:** Wrinkle wall trays can be made twice as fast as smooth wall, but smooth walled can be filled with product faster (automated)
- **Range:** Wide variety with each, but get more control with smooth wall. Both limited by depth of tray.
- **Lid method:** Generally cardboard lid with wrinkle wall and sealed flexible plastic with smooth wall
- **Printing:** Can pre print on smooth wall. Very limited options with wrinkle wall (Normally printed on lid, or wraparound cardboard sleeve)
- **Strength:** Better with smooth wall (thicker and well formed). May allow for reduction in secondary packaging.
- **End Use:** Wrinkle wall good for small runs, hand packed, or where hermetic seal is not required (e.g. frozen product) Smooth wall good for large production runs (higher speeds), and for environment controlled product requiring a hermetic seal (e.g. chilled ready meals).

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## Environmental considerations

- **Reduction**
  - improvements in casting and rolling techniques,
  - more sophisticated measuring controls and equipment
- **Reuse**
  - Difficult, due to tearing, pinholing etc. easier to recycle
- **Recycling**
  - Re-melting aluminium to return it to 'new' metal takes only 5% of the original energy required.
- **Heavy metals legislation**
  - Lead, chromium etc.

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## Metal Foil specification (USmilitary QQ-A-1876)

1. **Chemical composition** (%Al, heavy metals etc.)
2. **Temper** (flexibility and strength)
3. **Surface finish** (matt, shiny etc.)
4. **Thickness and covering area** (m<sup>2</sup>kg)
5. **Burst strength** (in psi for different thicknesses)
6. **Size** (nominal, standardised sizes)
7. **Dimensional tolerances** (NB thickness)
8. **Interleaving** (How sheets are packed, pH of paper)
9. **Toxicity** (can refer to other standards, legislation)
10. **Workmanship** (quality defects etc)

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