Design, Print & Packaging Skillnet

www.dppskillnet.ie

Welcome

The Design, Print & Packaging Skillnet is funded by member companies and the Training Networks Programme, an initiative of Skillnets Ltd. funded from the National Training Fund through the Department of Education and Skills.

1

David Little

Print Technologist (DIT)

Packaging Technologist (Institute of Packaging)

30 years' experience in the Print/Packaging sector.

International Lecturer in Print / Packaging Technology courses.

Head Trainer IOM3 (Packaging)

Chair of TPS Education & Training Committee.

Chair of The Irish Packaging Society

Board Member of The Packaging Society – a division of IOM3.

Substrate experience:

Corrugate, Cartons, Flexible film, laminates, labels , rigid plastics, pre-press / repro and print production capital equipment.

Print experience:

Across all processes, Repro, brand colour control, supplier audits, training, QC problem solving and press passes.

Sector experience: Food & Drink, Pharmaceutical and Industrial.

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2

The Irish PACKAGING SOCIETY
Affiliated with I·M3

PAPERBOARD Manufacture

LECTURER
DAVID LITTLE

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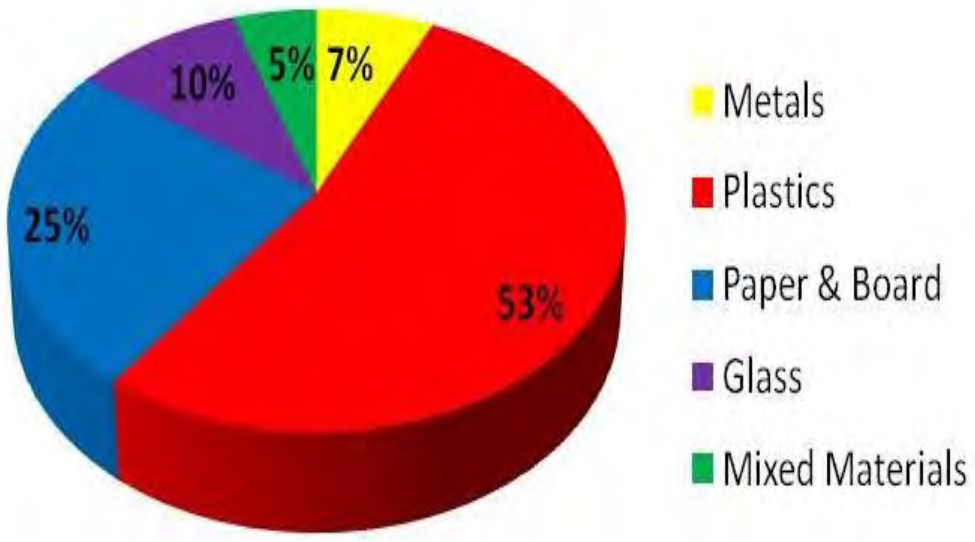
Global Packaging Materials



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Types of Board Packaging

- Name different types of Print & Packaging that use paperboard as a substrates.

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TYPES OF PAPER & BOARD PACKAGING

- Wrapping and packaging papers eg.carrier bags, sachets, tea bags, paper.
- Multi-wall paper sacks
- Folding cartons and rigid boxes
- Corrugated and solid fibreboard cases
- Liquid packaging for milk, fruit juice etc
- Fibre tubes, pots, drums
- Moulded pulp containers
- Labels
- Sealing tape
- Cushioning material

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Paper and Board Packaging

4.1%	5.9%	56.1%	33.9%
Paper Sacks / Bags	Wrappings	Corrugated Cases	Folding Cartons

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The Forest Stewardship Council is an international non-profit, multi-stakeholder organization established in 1993 to promote responsible management of the world's forests. The FSC does this by setting standards on forest products, along with certifying and labelling them as eco-friendly.

FSC
www.fsc.org
FSC® C134635

The mark of responsible forestry

The Programme for the Endorsement of Forest Certification is an international, non-profit, non-governmental organization which promotes sustainable forest management through independent third-party certification. It is considered the certification system of choice for small forest owners.

PEFC
PEFC/XX-XX-XX

PEFC Certified

This product is from sustainably managed forests and controlled sources

www.pefc.org

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FACTS

Paper was first made in China around 105AD. Using cellulose fibre from flax, cotton and other vegetable sources.

Half of all forestry harvested worldwide is used for fuel. Just 12% is used for Paper & Board.

Nearly 40% of packaging used in Europe incorporates paper or board.

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ECOLOGICAL BENEFITS OF FORESTR MANAGEMENT

- Ensures replenishment of trees
- Provides habitats for animals
- Promotes biodiversity
- Protects water courses
- Preserves landscapes
- Maintains employment in rural areas
- Creates recreational facilities

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FORESTRY

Reverses the greenhouse effect

Stabilises climate and water levels

Prevents soil erosion

Stores solar energy

A large proportion of the wood used for pulping comprises thinnings – tops of large trees felled for timber- which otherwise would have no commercial value.

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PACKAGING CHAIN

PAPER/BOARD MANUFACTURER

CONVERTER/PRINTER

PACKER/FILLER

WHOLESALE/RETAIL

END USER

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Forestry management

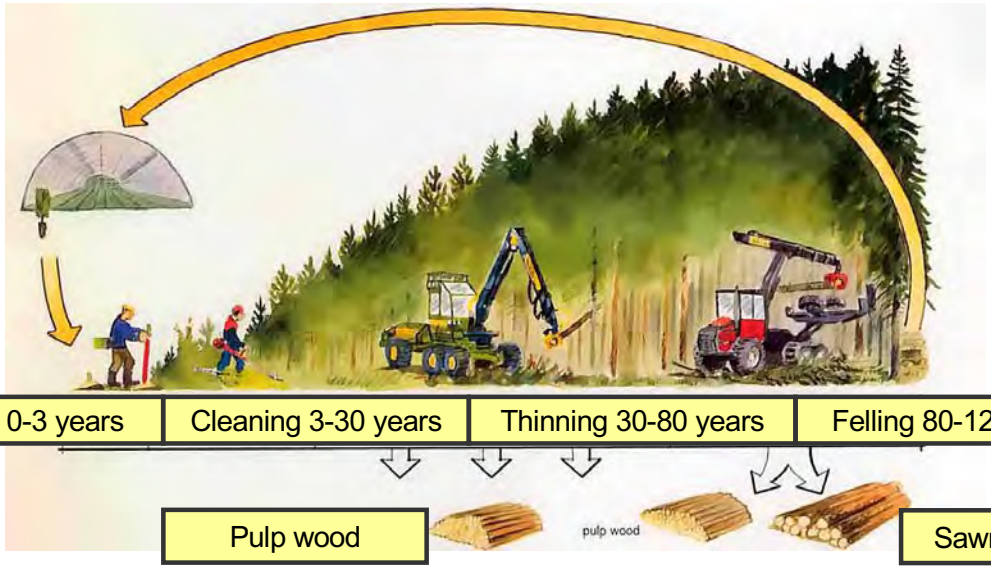

Image taken from Iggesund Paperboard AB
Paperboard Reference Manual

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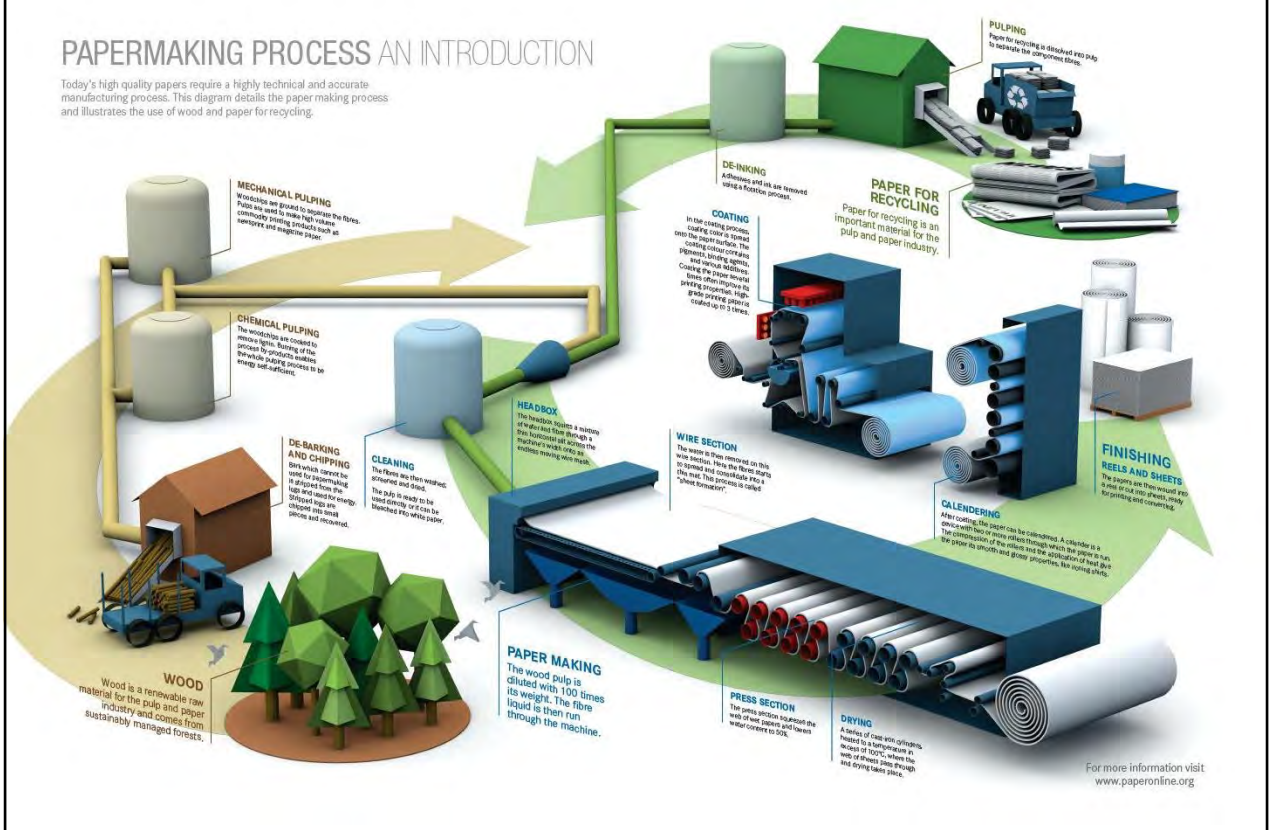

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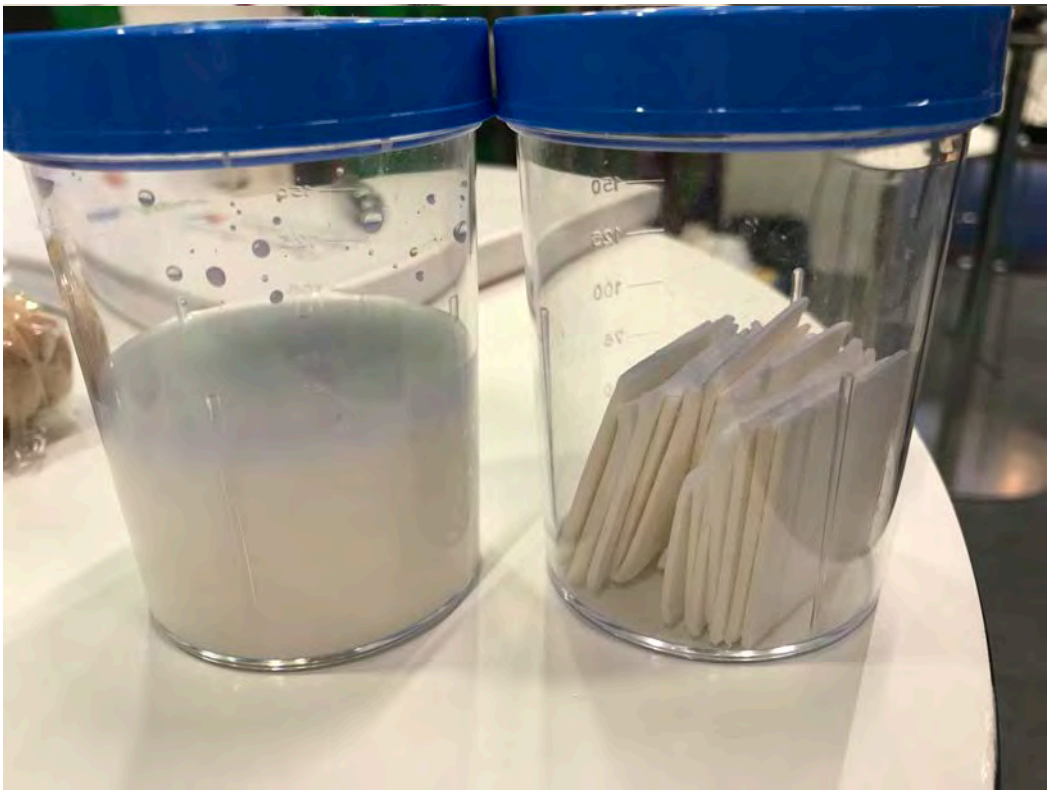

Paper Mill Video

Video

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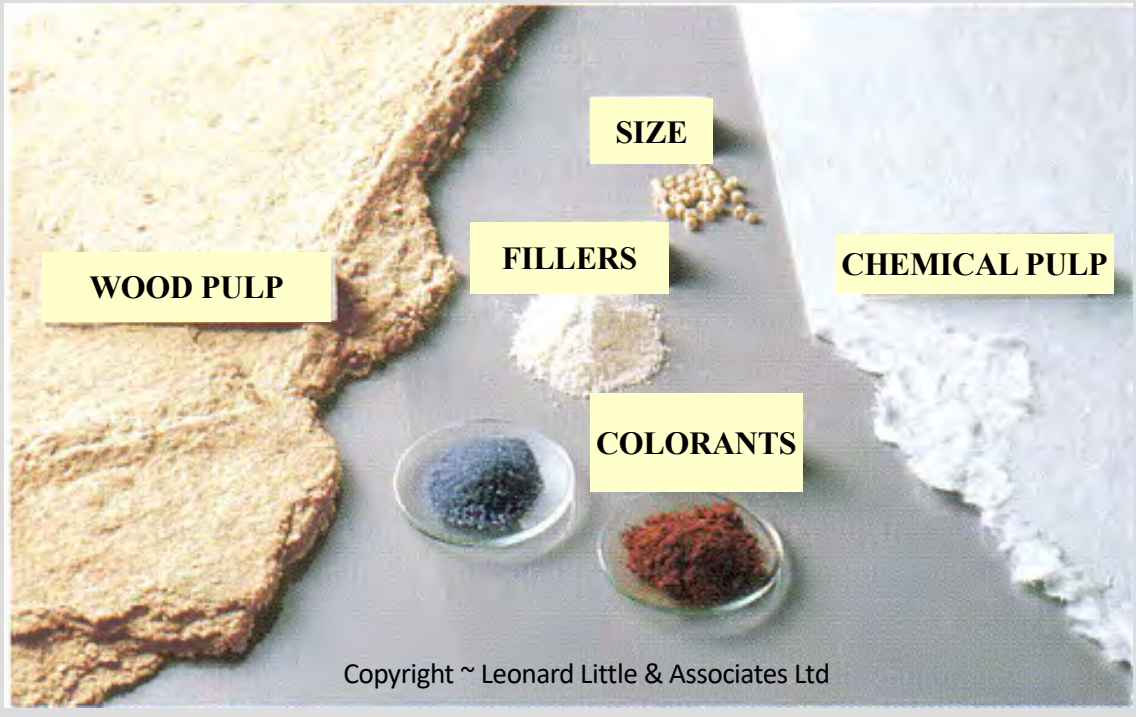

PAPER & PAPERBOARD PROCESS

FORESTRY

PULPING

STOCK PREPERATION

FORMING (pressing/drying/coating)

FINISHING (slit/sheet/wrap/count/label/weigh/palletise)

CONVERTING/PRINTING

PACKING/DISTRIBUTION

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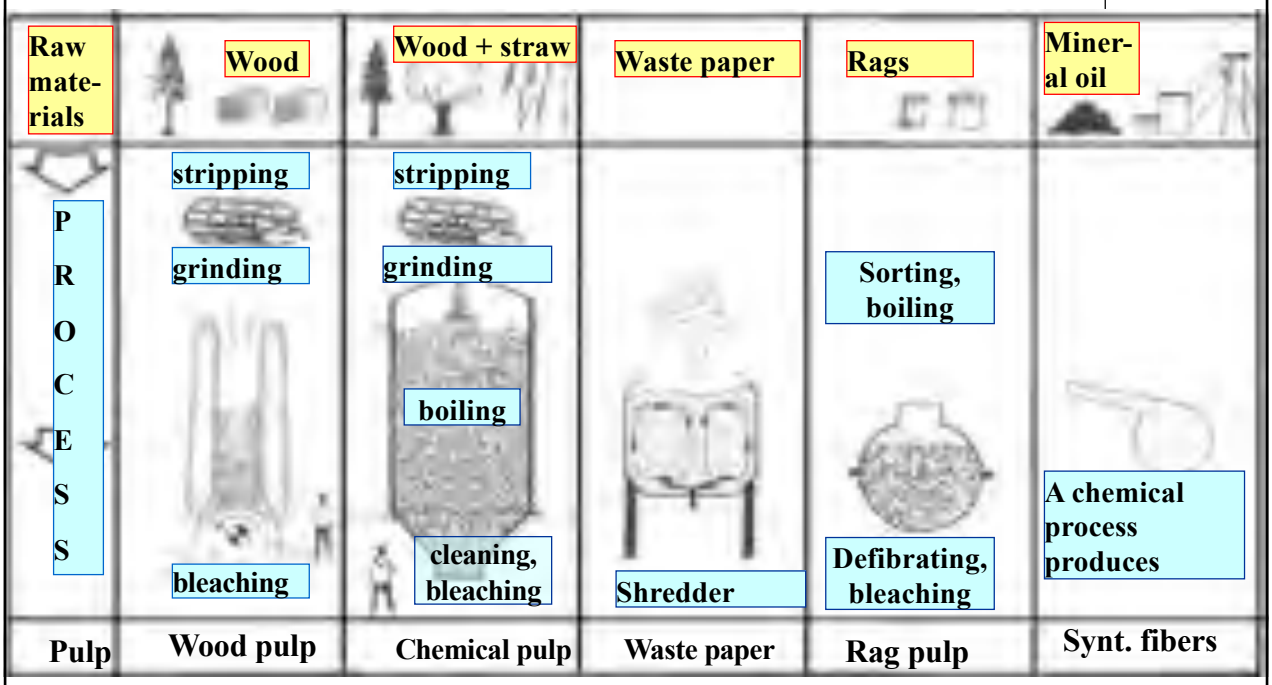
Overview of Pulp making



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FIBRE SOURCE

- **IN THE PAST**

RAGS(linen), BAGASSE(sugar cane), COTTON, STRAW.

- **NOW ADAYS**

CELLULOSE FIBRE FROM WOOD.

NON-WOOD ESPARTO GRASS, LINEN

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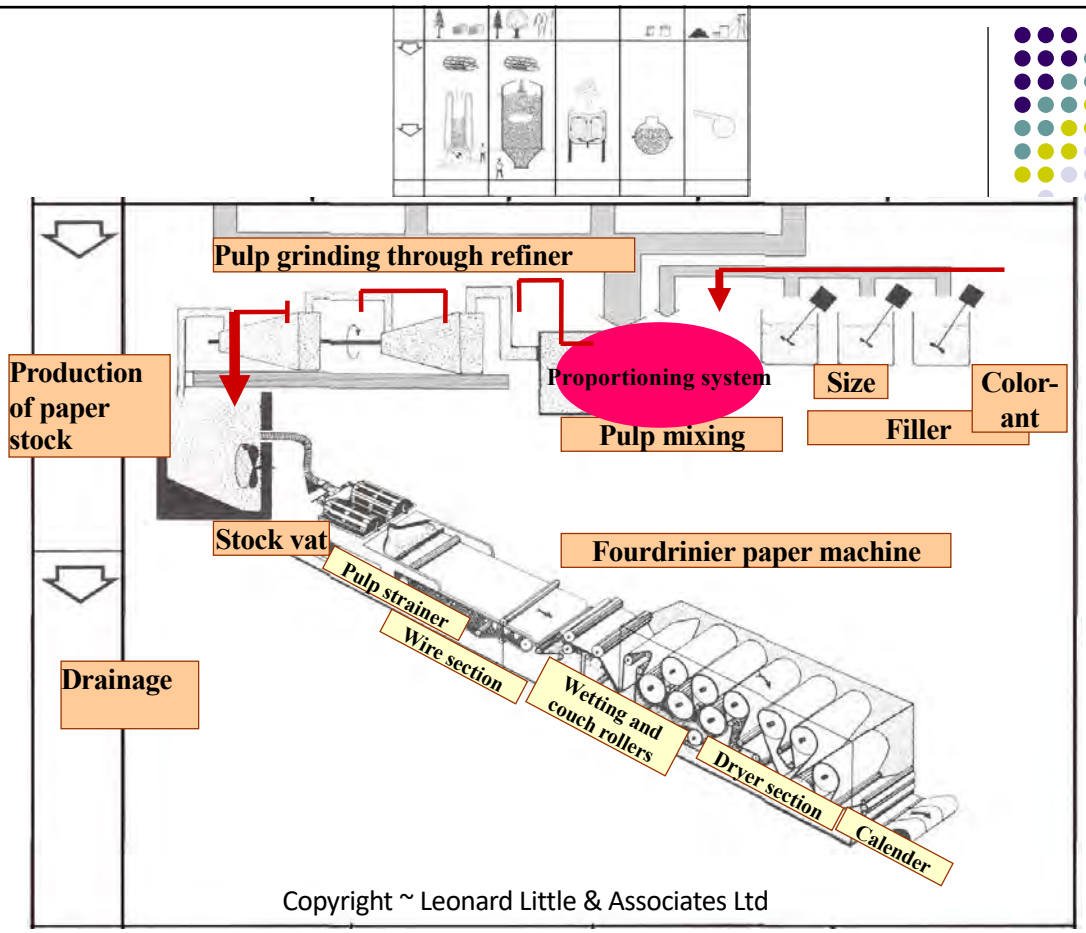

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Raw materials

Cellulose fibre, from managed forests:

FSC - Sustainable Forest Certification – www.fsc.org

FSC stands for FOREST STEWARDSHIP COUNCIL

Virgin softwoods
coniferous trees
eg Spruce, Pine

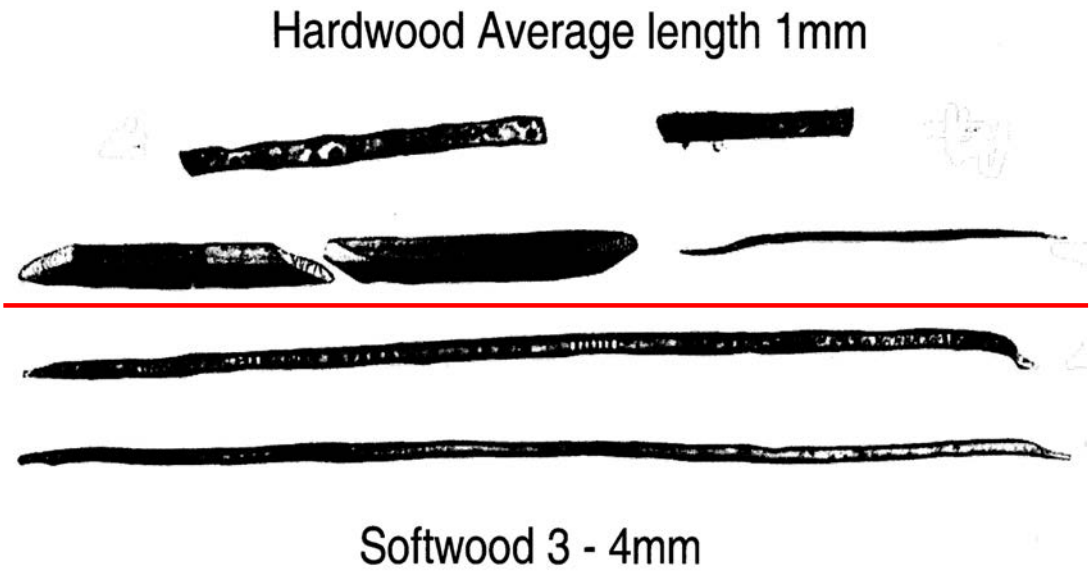
long fibres
high strength papers due to matting of fibres
uneven surface papers - poor printing quality

Virgin hardwoods
deciduous trees
eg Eucalyptus, Acacia, Birch, Maple.

short fibres
low strength papers
smooth surface papers - good printing quality

23

Raw Materials



24

FIBRE LENGTH

The longer the fibre the better the matting and the stronger the paper.

Coniferous trees - Spruce & Pine have long fibres of 3mm or so. High tear strength.

Deciduous trees – Aspen & Birch have short fibres 1mm-1.5mm. Smooth paper.

Esparto grass 1.5mm/Linen (flax) 55mm.

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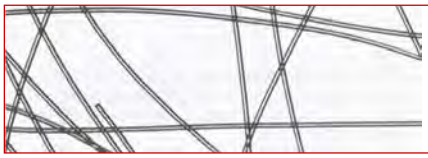
Pulp composition



Synthetic fibers
are very strong, do not absorb water and do not decay.

Rag fibers (linen, cotton, etc.) are long , supple, and very strong. Used for high-grade papers.

Cellulose fibers – fine, supple, not as strong as rag fibers.
Cellulose from deciduous trees = soft with short fibers
Cellulose from conifer trees = hard with long fibers

Groundwood pulp (mechanical pulp) – contains all components of the wood (turns yellow over time).
Wood pulp is not so strong but increases opacity (non-transparency).

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A Pine Tree

- 41% Cellulose
- 30% Hemi cellulose
- 24%+ Lignin
- 4% Extractives

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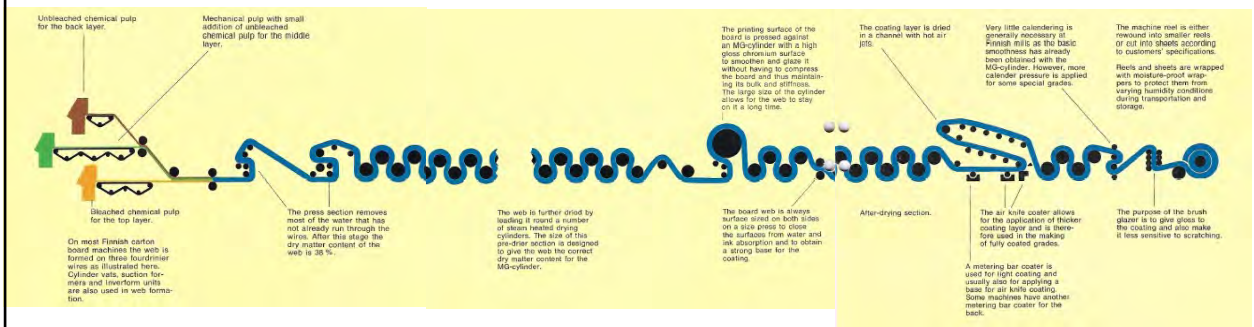
Manufacturing Process for Cartonboard



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Wet End

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Pulping Methods

Summary

Pulp preparation	Yield	Process
Mechanical	95% +	Grinding
Thermo-mechanical	95% +	Steam heating and grinding
Semi-chemical	65 - 85%	Cooking with chemicals + grinding
Chemical	45 – 65%	Cooking with chemicals
Chemical + bleaching	45 – 55%	Plus bleaching agents
Dissolving	45 – 50%	Plus sodium hydroxide (cellulose film)

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Bleaching

Pulp in different bleaching stages

Pulp in different bleaching stages

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Bleaching

ECF - Elemental Chlorine Free:

- uses chlorine dioxide
- reduced environmental effects vs using chlorine gas (Dioxins/Furans)

TCF - Total Chlorine Free:

- uses oxygen (O2) or ozone (O3)

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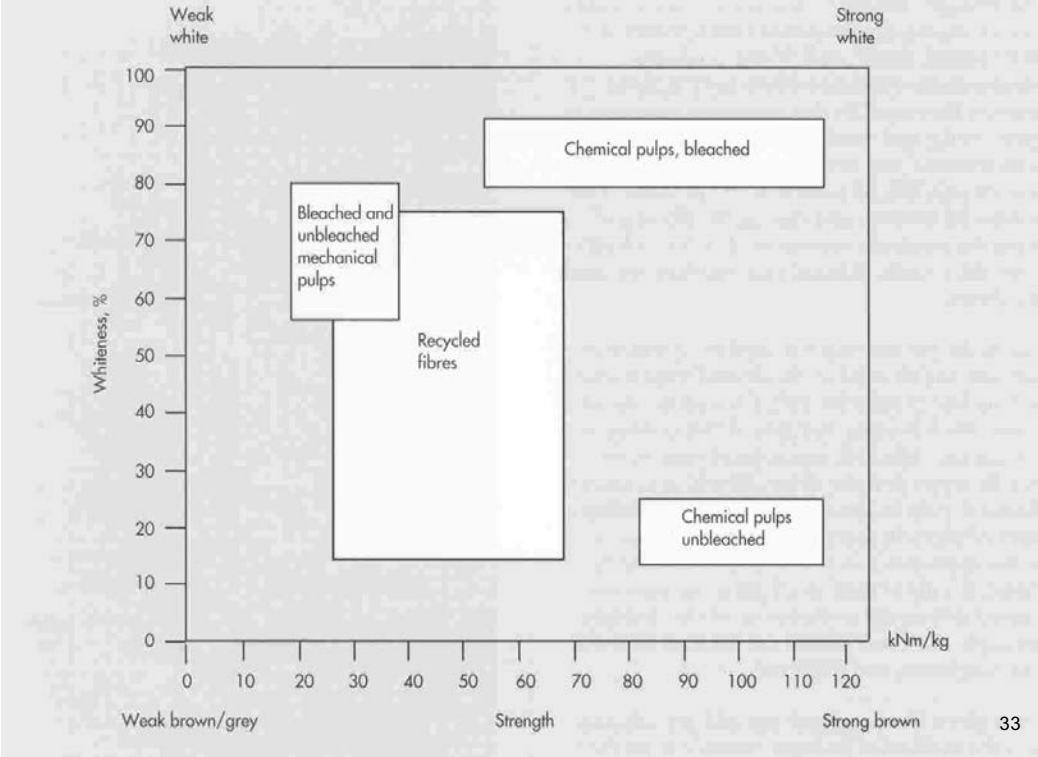
Effect of pulp on paper/paperboard properties



Refining treatment

(Before refiners were invented, used to use Beaters)

Mechanical action on cellulose fibres:

- bruises/splits fibres, fibrillation
- increases surface area of fibre (H-Bonding)
- Increases fibre length distribution (fines)

Dramatic effect on performance properties of finished paper and paperboard

Refining treatment

(Before refiners were invented, used to use Beaters)

An example of an old-fashioned Beater, still in use at Wookey Hole, Somerset, where they make Hand Made Paper using rag pulps.

Making Handmade Paper with a Forme.

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Refining

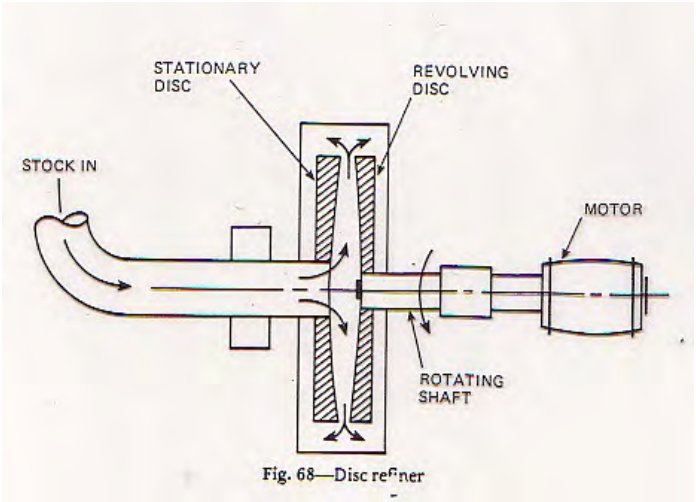

Fig. 68—Disc refiner

Disc refiners are used for the Primary refining, i.e. Refining the woodchips.

Refiners may be as much as 1.5 metres in diameter.

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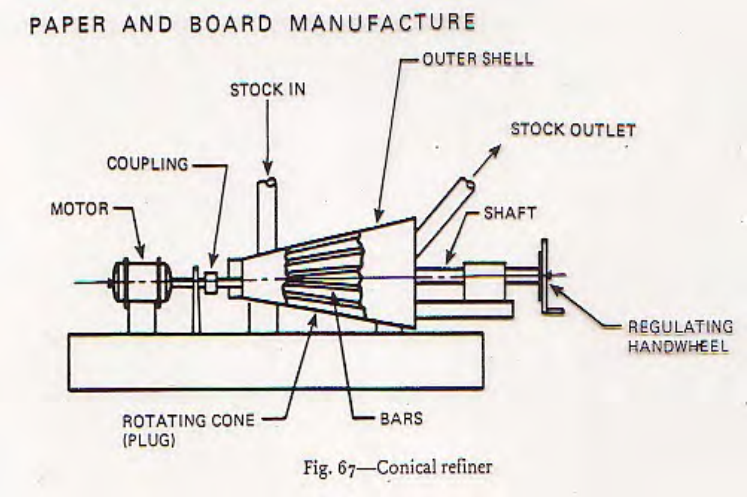
Refining



Conical refiners are usually used as secondary or trim refiners.

Good fibrillating action.

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Refining treatment

Increased flexibility means fibres can be brought closer together:

- Density of the paper is increased
- Bulk is decreased
- Air permeability is decreased
- Grease resistance is increased

Increased surface area means better inter-fibre bonding:

- Burst strength is increased
- Tensile strength is increased
- Folding resistance is increased
- Tear strength may be decreased if over-refined.

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Refining treatment

Increased surface area means better inter-fibre bonding:

- Burst strength is increased
- Tensile strength is increased
- Folding resistance is increased
- Tear strength may be decreased if over-refined.

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Refining treatment

Increased fibre length distribution means:

- Uniformity of paper is improved
- Surface printability is improved
- Better appearance - ‘formation’

To optimise these characteristics, the pulp stock is often put through **Fractionators** to make sure only fibres of the right length are used, especially for recycled fibre furnishes.

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Refining treatment

3 Stage Effects of Refining

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Refining treatment

- Final preparation
- Blending of pulp types for optimum performance and cost (the Furnish)
- Mixing with additives
- Cleaning/Screening
- Dilution to required consistency:
  - 0.5-1.0% for paper
  - 2.0-3.0% for paperboard
- 'Furnish' is now ready for paper/paperboard making

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Raw Materials

Cellulose fibre, from recycled papers:

- paper properties vary according to source
- need for control of source
- reduction in fibre length during recycling
- reduced strength papers vs virgin fibres

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PULPING

- MECHANICAL PULPING.

The fibres are separated mechanically. Debarked logs are chipped and passed between rotating metal discs. This is known as Refiner Mechanical Pulp – RMP

Alternatively debarked logs are pressed against a grindstone. This is known as Groundwood pulp.

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1 - MECHANICAL PULP

Does not remove Lignin which results in a high yield, but fibres are broken, hard and rigid. Therefore bonding will not be as good. However it does provide resilience, dimensional stability and stiffness. Also good smoothness for printing.

USED: Newspapers, low-quality paper and for blending, also to improve surface formation

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Mechanical contd

Thermo-mechanical pulp –TMP

Chips are pre-heated to help soften fibres and assist separation.

Chemi-Thermomechanical Pulp-CTMP

Chips are also given a limited amount of chemical treatment.

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2 - CHEMICAL PULP

Debarked logs are chipped and treated with chemicals to dissolve non-cellulose components, most of which are used as an energy source in the mill.

Two types:

- Sulphate (KRAFT) process
- Sulphite process (now not widely used)

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Sulphate (KRAFT) process

- Kraft means strong in German.
- This process is mostly used today.
- Has ability to process all wood types of commercial importance.
- Separating using chemicals preserves fibre length which helps with inter-fibre bond.
- Yield 50-65% brown pulp (unbleached).
- Fibre is flexible and soft, good for creasing, folding, cutting with low dust levels.

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Sulphate pulp contd.

- BLEACHING

Whitening the pulp is achieved by bleaching.

Environmental concerns were raised in the past as the by- product a complex organochlorine compound found to be persistent in the environment.

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Sulphate contd.

Two new bleaching methods used now adays

Elemental chlorine free – ECF

Totally chlorine free - TCF

Neither process generate complex organo-chlorine compounds.

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3 - REYCLED PULP

- Collected waste paper and board
- Logistical, cost and environmental implications
- Recycling leads to some fibre loss and loss of fibre length.
- Virgin fibre is added regularly to maintain quality
- De-inking by flotation separation and mild bleaching (tissue/office products not packaging)

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Recycled fibre

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STOCK PREPARATION

Pulp immersed in water by a Batch, refining or continuous process.

Pulp in bales or straight from pulp mill is dispersed in water (1-2% ratio).

Fibres are beaten in Hydrapulper to breakdown bundles and hydrate.

Fibre surface is roughened FIBRILLATION

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ADDITIVES

Bleach

Sizing – controls water repellancy, ink penetration

Starches – improves burst strength,stiffness pick resistance

Wet-strength resins** – improves tensile strength

Clay, talc, titanium dioxide – improves optical brightness and printing quality.

FURNISH is pulp (complete blend) and additives that goes to the paper machine.

** Impacts on recyclability or some may contain environmentally harmful long life plastics…(PFAS)

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Additives

Fillers	**Kaolin and calcium carbonate fill the spaces between the fibers**
Size	**Sizing is done using resin size or synthetic sizes.**
Colorants	**Adding blue makes the paper appear whiter, red makes it appear warmer.**
Optical brighteners	**are agents that transform the invisible UV radiation into visible radiation.**

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FORMING

The FURNISH is “formed” in an even layer on to a moving belt of plastic or wire mesh (or a mesh covered cylinder).

The entangled fibres are left in a layer after the water drains away.

The wire side of the paper has a different appearance to the top side.

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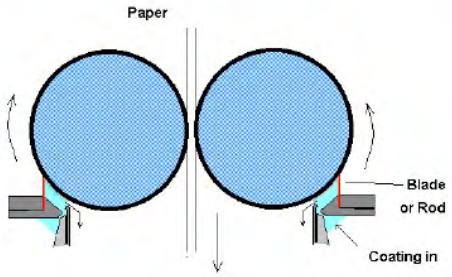
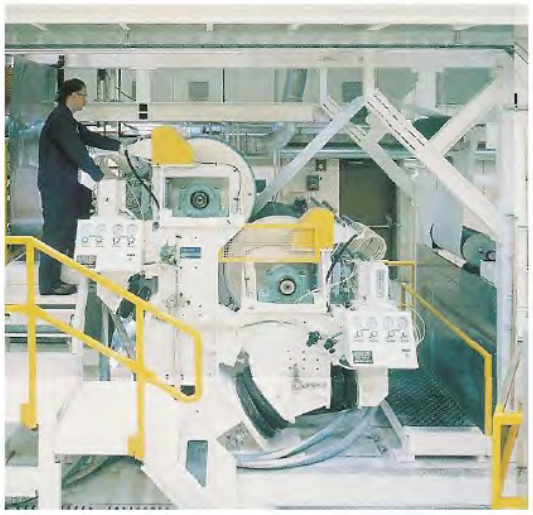
Size

Size Presses:



To act as a protective filler or glaze and change the absorption and wear characteristics of paperboard



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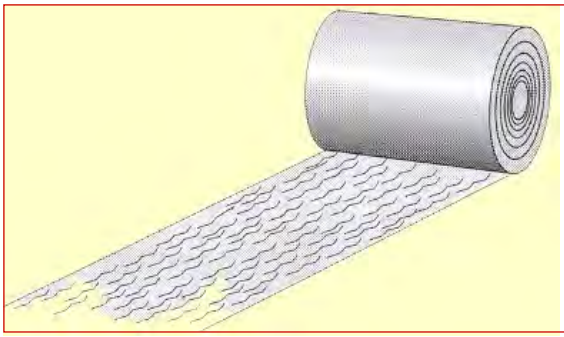
Paper grain direction



In a finished paper reel most of the fibers lie along the length of the reel.

Also called:
machine direction,
longitudinal direction

This is because the fibers settle predominantly along the direction of flow on the wire mesh in the paper machine.

- **Fiber content 1-2%**
- **Water content ca. 98%**

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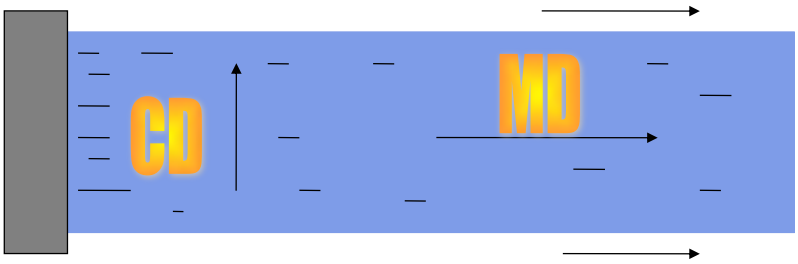
GRAIN DIRECTION

- MACHINE DIRECTION (MD)
- CROSS DIRECTION (CD)

The watery pulp deposited on a moving belt tends to align mostly in one direction. However this happens twice as much on a Cylinder machine



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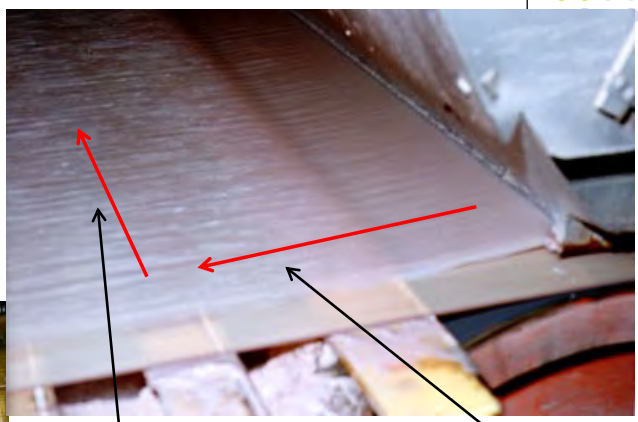
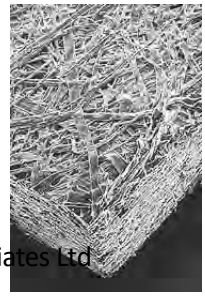
Paper and Board Production

Fibres aligned

in machine direction





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MD & CD

- Paper tears easiest along MD.

ie. Newspaper in one direction

- Paper folds easiest along MD.
- Stiffer across CD
- Stronger folds across CD. (better wear ie. hinged lid)

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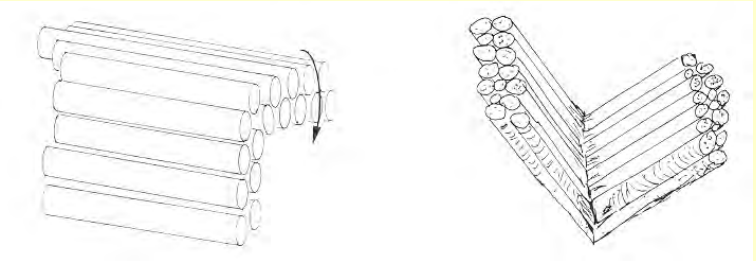
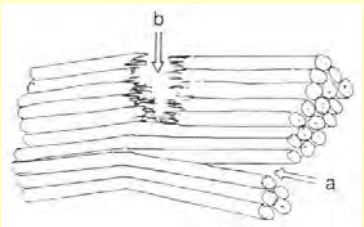
Paper grain direction



Paper is easier to bend and fold parallel to the grain direction than across the grain direction.



Paper can be torn more easily and evenly along the grain direction than across it.

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PRESSING

- Paper layer travels from wire to absorbent blanket and on to press section under its own support.
- Pressed between rollers, with vacuum assistance it reduces to about 60-65% moisture content.

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PAPER MAKING MACHINES

1. FOURDRINIER MACHINES
2. CYLINDER MACHINES
3. TWIN WIRE MACHINES

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FOURDRINIER MACHINES

Invented 1820

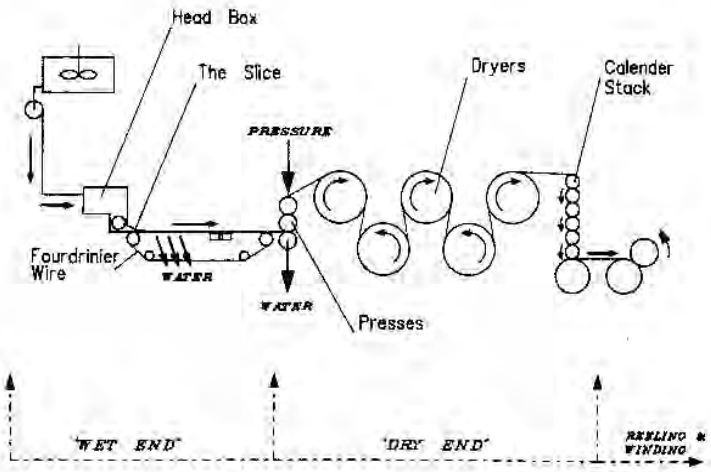

Figure 5.1
A Fourdrinier machine – wet and dry ends.

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CYLINDER MACHINE

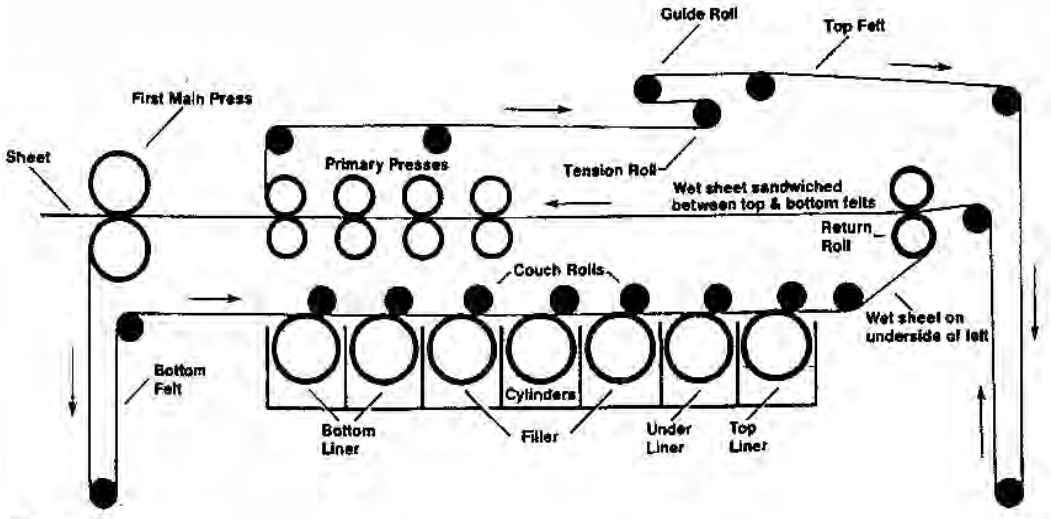

Figure 5.3
A cylinder machine.

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Single Cylinder Station

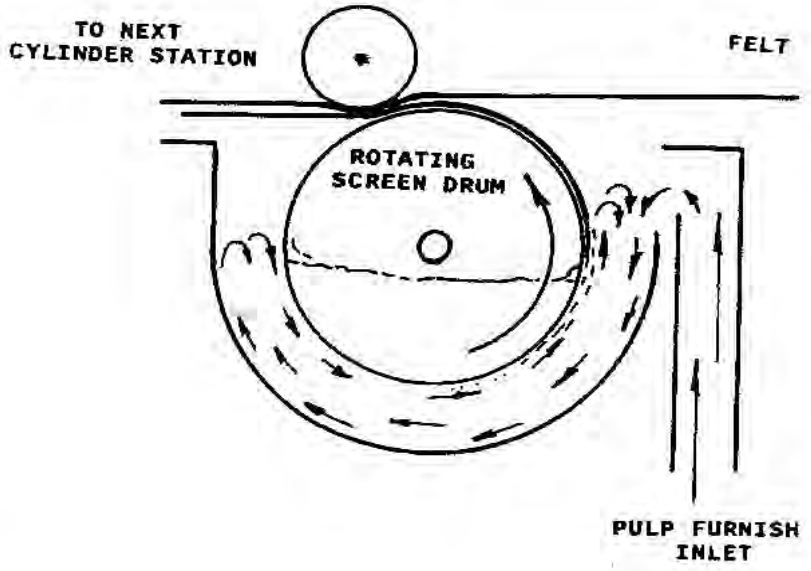

Figure 5.4
A single cylinder station on a cylinder-type machine.

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Multi-ply section of Board from a Cylinder Machine.

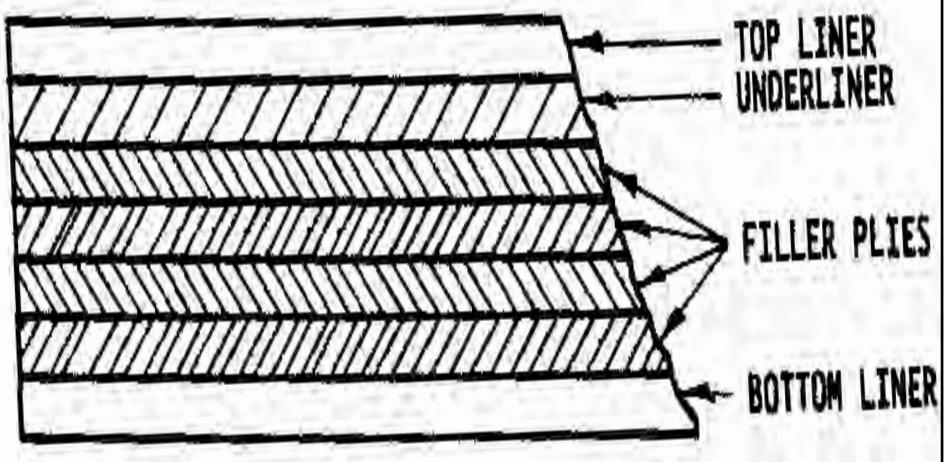

Figure 5.5
Cylinder boards are multi-ply boards.

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TWIN WIRE MACHINE

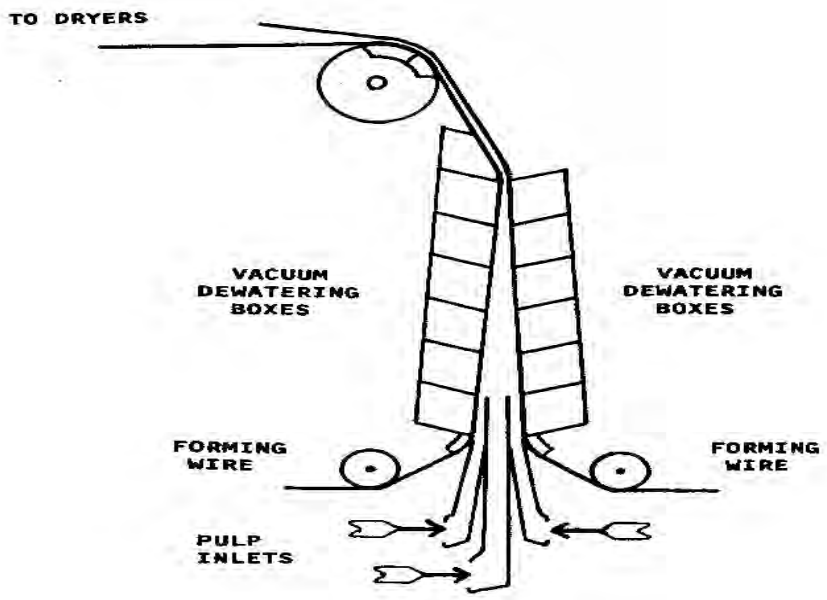

Figure 5.6
A twin-wire paper former.

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TYPES OF PAPERBOARD

- Solid Bleached Board - SBB
- Folding Box Board – FBB
- White Liner Chip – WLC
- Solid Unbleached Board – SUB

See examples provided.

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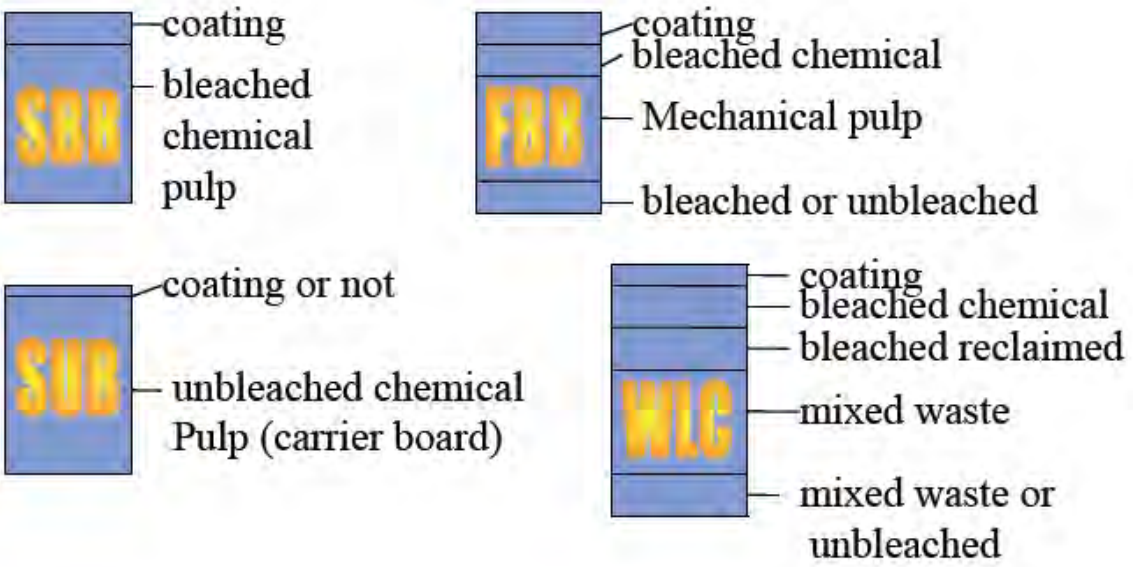
Board Make -up



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Overview of paperboard nomenclature

Definition (DIN 19303)		Type	Description	Pulp stock
uncoated	coated			
	AZ	SBS	Cast-coated solid bleached board with white reverse	Fully bleached chemical pulp
	AC1	FBB	Cast-coated solid boxboard with white reverse	Chemical and mechanical pulp
	AC2	FBB	Cast-coated solid boxboard with cream reverse	Chemical and mechanical pulp
UZ	GZ	SBS	Solid bleached board	Fully bleached chemical pulp
	GN1	SUS/SUB/CNK	Solid unbleached board with white reverse	Unbleached chemical pulp
	GN4	SUS	Solid unbleached board with brown reverse	Unbleached chemical pulp
UC1	GC1	FBB	Folding boxboard with white reverse	Chemical and mechanical pulp
UC2	GC2	FBB	Folding boxboard with cream reverse	Chemical and mechanical pulp
UTI	GT1	WLC	White lined chipboard with white reverse	Secondary fibres
UT2	GT2	WLC	White lined chipboard with cream reverse	Secondary fibres
UT4	GT4	WLC	White lined chipboard with brown reverse	Secondary fibres
UDI	GD1	WLC	White lined chipboard high bulk ≥ 1.45 cm^3/g	Secondary fibres
UD2	GD2	WLC	White lined chipboard high bulk < 1.45 cm^3/g, > 1.3 cm^3/g	Secondary fibres
UD3	GD3	WLC	White lined chipboard high bulk ≤ 1.3 cm^3/g	Secondary fibres

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Four Main Types of Board

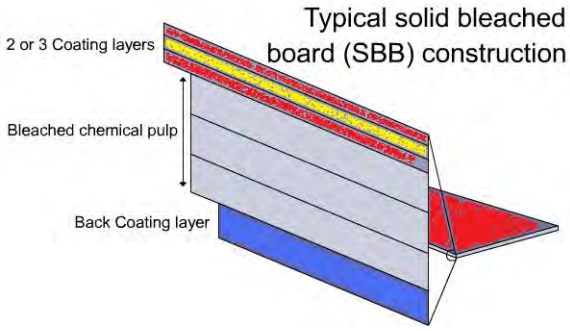
Solid Board – A laminate structure

Solid Bleached Board (SBB)

Bleached chemical pulp

Can be clay coated for printing

Aroma/Flavour sensitive products

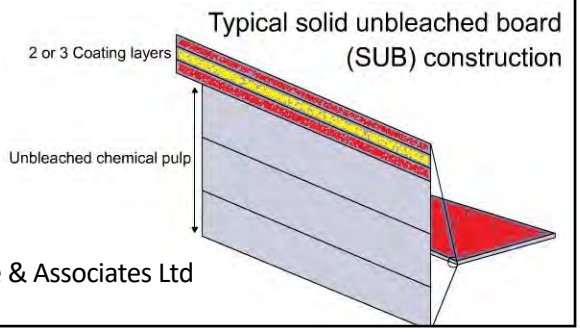


Unbleached Board (SUB)

Clay coated

Unbleached chemical pulp

Carrier sleeves or liquid packaging



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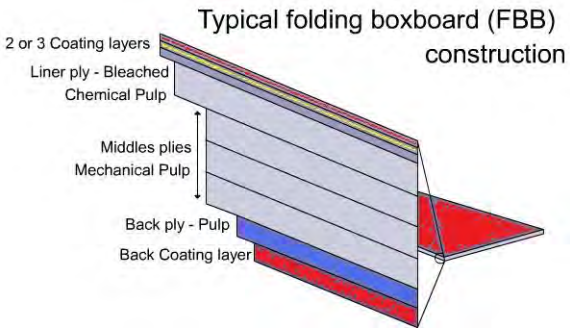
Four Main Types of Board

- Folding Boxboard (FBB)

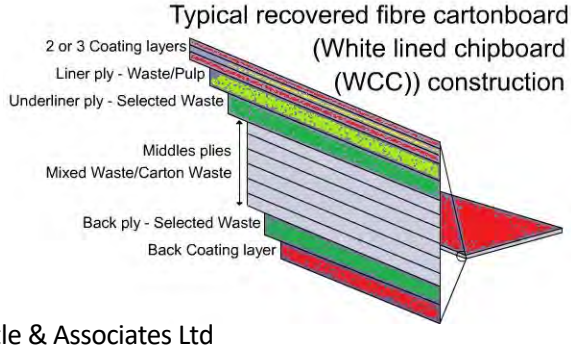
  Layers of mechanical pulp sandwiched between layers of chemical pulp

  Low density, high stiffness



- White-lined Chipboard (WLC)

  Coating – for printing
  Centre is recycled fibre
  Top layer bleached chemical pulp
  Wide range qualities
  General packaging



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SBB SUB FBB WLC can all be modified

- Clay Coated Board

  SWL or DWL which is coated to improve brightness

  Used in cosmetic and food applications where appearance important

- Test.Chipboard

  100% recycled fibre

  Colour - Brown – recycled (Test) to Light Grey – very recycled (Chip)

  Poor printing

  Used where appearance is not critical

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Paper and Board Properties

Deadfold characteristics

Stiffness

Tensile, tear and burst strength

Porosity

Grease resistance

Printability

Moisture absorbance

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Deadfold and Stiffness

Deadfold - resistance to 'unfolding' after creasing

- Important in box manufacture
- Will be higher in CD than MD – (creasing damages fibres)

Stiffness – resistance to crush

- Important for structural design
- Will be greater in MD than CD
- However MD often runs around a carton to reduce bulging

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Tensile, Tear & Burst Strength

Tensile, Tear & Burst Strength are important in the final end use
eg. damp environment/ freezer

Burst Strength - Mullen Burst test

Long fibres – higher burst

Tensile strength – resistance under stretch

Long fibres higher tensile?? – which direction?

Tear Strength – in both MD and CD – Elmendorf Tear Test

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Porosity, Grease Resistance Printability & Moisture Absorbance

Importance of each depends on final use of the Paper/Board

- Porosity – important with vacuum handling
- Grease resistance – depends on the product inside
- Printability – Affects quality of the final pack
- Moisture absorbance – where pack will be stored and used

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Dry End

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DRYING

Paperboard passed over steam heated cylinders

Moisture reduced to 10%

Multiple rollers Callender material to iron smooth and compress paper.

MG-Machine Glazed- Large heated cylinder (Yankee Cylinder) gives glossy shiny surface but preserves thickness.

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Surface treatments and coatings

Coating are added to add gloss, opacity, brightness or smoothness.

They consist of mineral pigments China Clay/Calcium Carbonate or synthetic binders (adhesives).

Applied with excess removed by meter bar/ air knife or blade coating.

One, two or three layers may be applied on of off line.

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PAPER & PAPERBOARD CATEGORIES

- Tissue paper 12-20gsm
- Newsprint 60-70 gsm
- Sugar bags, Labels 60-120gsm
- Photocopy paper 80-85 gsm
- Tetrapack 160gsm
- Board category 200gsm +(ISO 250gsm+)

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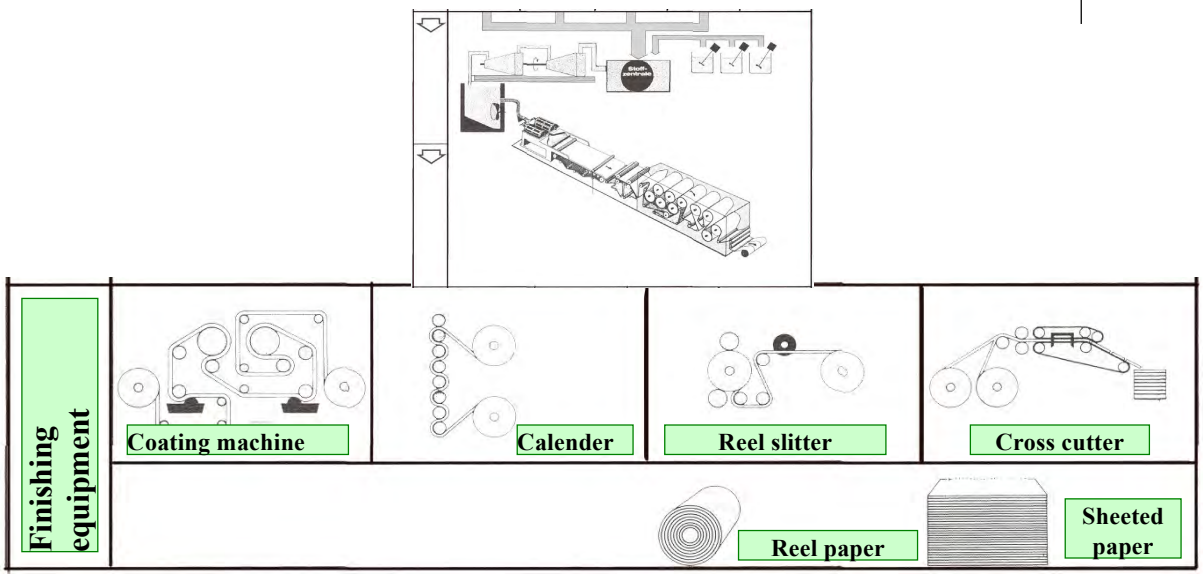

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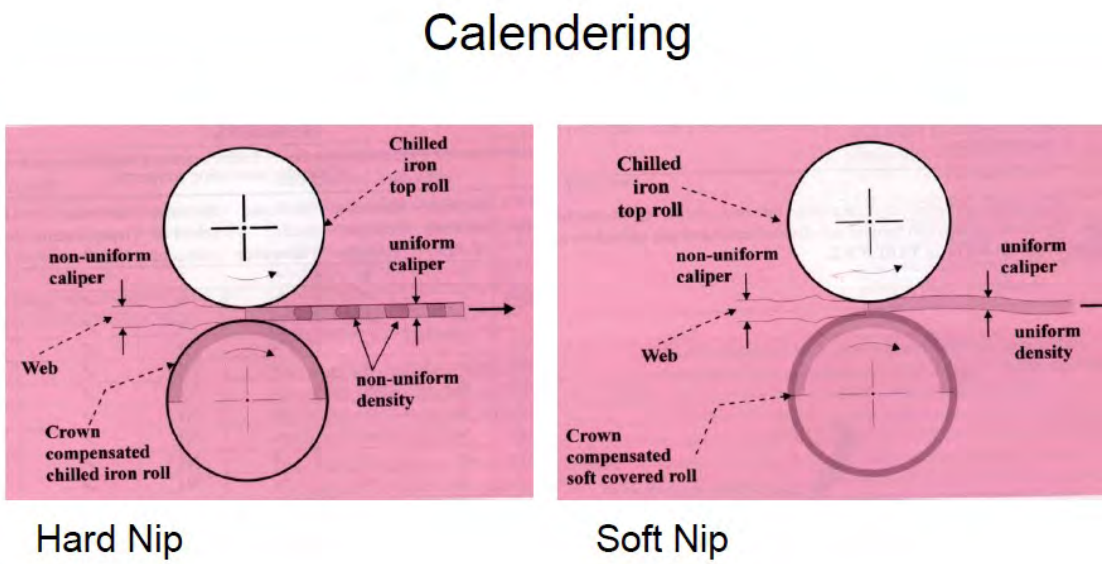
Calendering



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Scale of measurement

WEIGHT-Measured in grammes per square metre. gsm or gm2.

THICKNESS-Measured in microns.

=1/1,000 of a mm Mu or u.

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MARKET NEEDS

- *APPEARANCE*
- *PERFORMANCE*
- PROMOTION
- PROTECTION
- PRODUCTION

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APPEARANCE properties

- Whiteness
- Surface structure/smoothness
- Printability and varnish
- Absorption and Drying
- Rub resistance

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PERFORMANCE properties

- Strength & toughness
- Stiffness
- Compression strength
- Crease ability & 'Foldability'

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Paper and Packaging Boards

Wet strength paper-paper sacks added formaldehyde to waterproof fibres

Micro-creeping - built-in invisible crimp to help paper withstand dynamic strength.

Greaseproof - Fibres are heavily beaten at batch hydration stage. Become gelatinous

Glassine - supercalendered greaseproof, produces dense sheet of high finish

Vegetable parchment - bleached chemical pulp is passed through a vat of sulphuric acid. Surface cellulose is gelatinised and deposited between fibres creating grease resistance and wet strength

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Paper and Packaging Boards contd.

Tissue - Neutral pH low chlorine and sulphate residue

Paper Labels – MG machine glazed, MF Machine finished.

Bag Papers - Coated or uncoated bleached Kraft. Imitation Kraft is either a blend of Kraft with recycled or 100% recycled.

Sack Kraft – Unbleached Kraft 100% sulphate pulp

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Paper and Packaging Boards contd.

- Impregnated papers – mould inhibitors for soap wrapping, rust inhibitors, siliconised, grease resistant
- Laminating Papers- Coated or uncoated.Laminated to foil, extrusion coated with PE or laminated to film or wax laminated to chipboard
- Solid Bleach Board-bleached chemical pulp
- Folding Box Board-middle layer of mechanical pulp between layers of chemical pulp

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Paper and Packaging Boards contd.

White Lined Chip-Middle layer of recycled pulp. Top layer bleached chemical pulp. Underliner may be bleached chemical or mechanical pulp.

Solid Unbleached Board- Unbleached kraft pulp. Contains wet strength resins.

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Quality and Test Measures

On-Machine

- Grammage
- Thickness
- Moisture content

Laboratory (monitored on machine)

- Colour, Coating, Weight, Opacity, Gloss, Stiffness

See book page 97.

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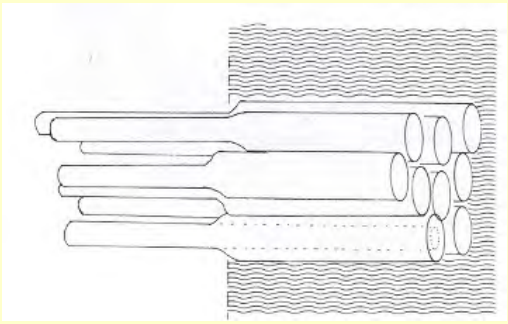
Paper moisture



Dry paper fibers – damp paper fibers

Paper fibers absorb moisture and swell in diameter.

This happens when paper is exposed to the air and during printing.

Paper always balances its moisture content with that of the air.

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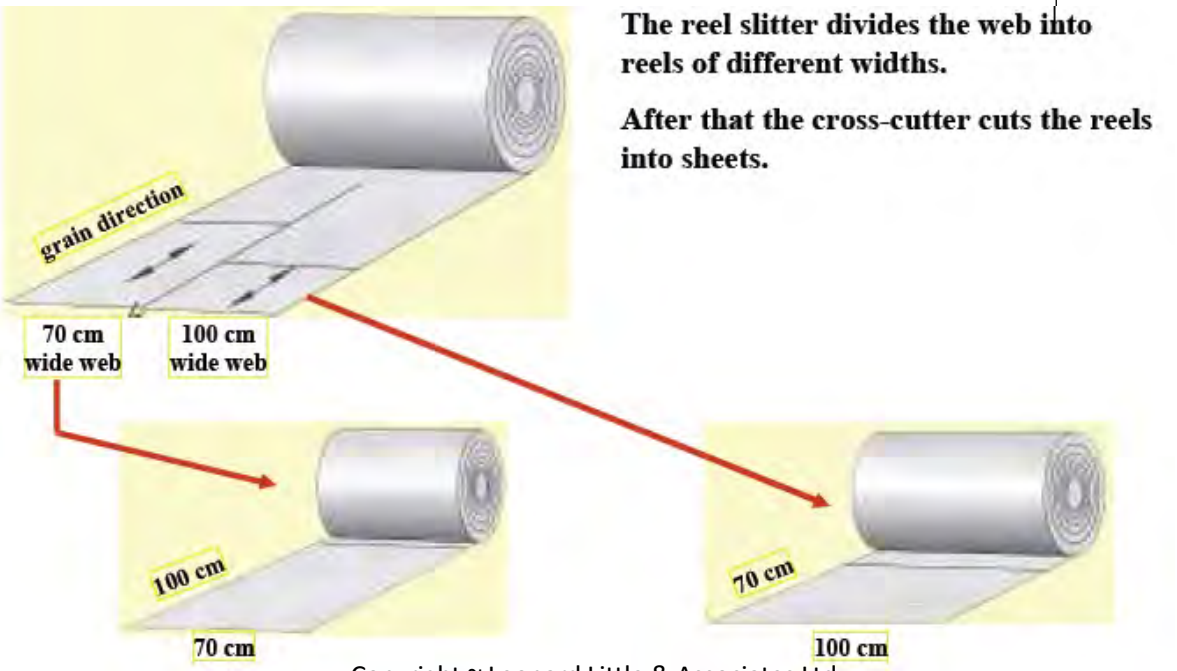
Paper grain direction



The reel slitter divides the web into reels of different widths.

After that the cross-cutter cuts the reels into sheets.

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How to determine the grain direction:

The tearing test – paper is hard to tear across the grain direction.

The moistening test – the paper curls parallel to the grain direction.

The bending test – resistance is greater in the grain direction than in the cross-grain direction.

The fingernail test – hold the sheet between the thumbnail and the fingernail of the index finger and pull it. One edge becomes very wavy, the other only slightly.

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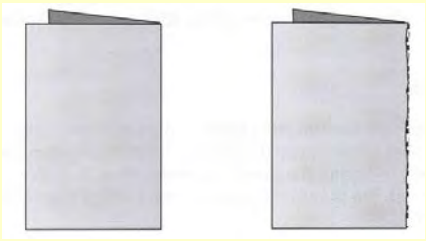

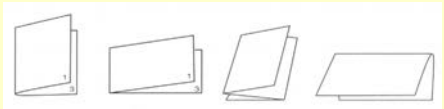

Take the grain direction into account for print products.

Not ideal to fold across the grain direction for digital print, without creasing.

Pre-creasing or water scoring often used for Pharm leaflets.

Index cards and displays need a "firm footing". Fibers run vertically.

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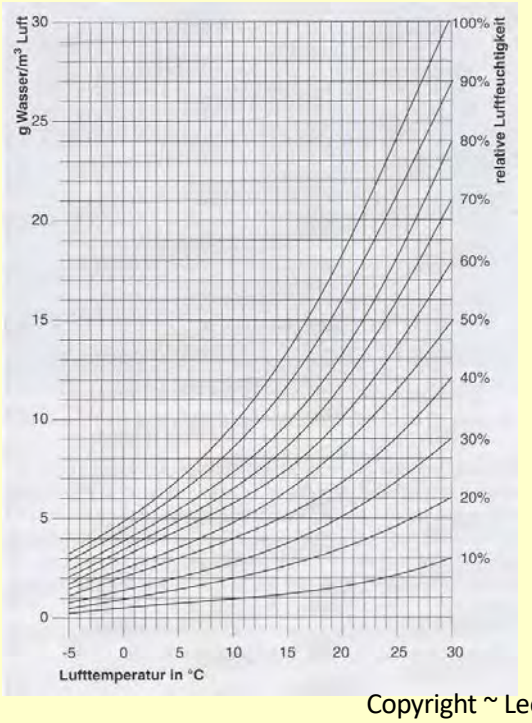
Humidity of the air

The capacity of the air to absorb moisture is limited and dependent on the temperature.

When the maximum humidity is exceeded the moisture precipitates in the form of fog or rain.

The most favourable climate in a printing plant is a temperature of 20° C and a relative humidity of 50 – 55%.



This is measured with a hygrometer.

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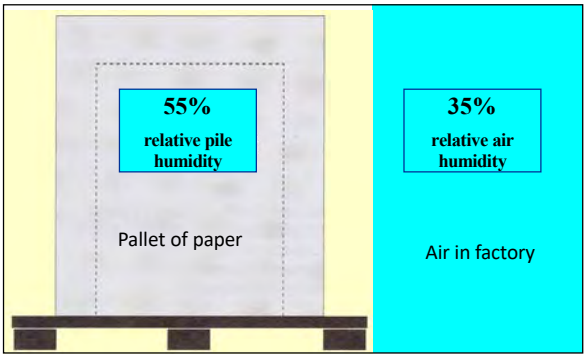

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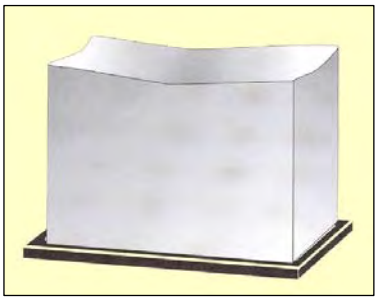

If moisture exudes from the outer edges of a paper stack to the drier ambient air, theses edges shrink and cause the stack to warp or "cockle".

Paperboard products "breath", so they, and the environment need to be managed.

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Performance Properties

Stiffness
Strength and toughness
Creasing and foldability
Water absorption - Cobb
Porosity – air and moisture
Grease resistance
Taint and odour

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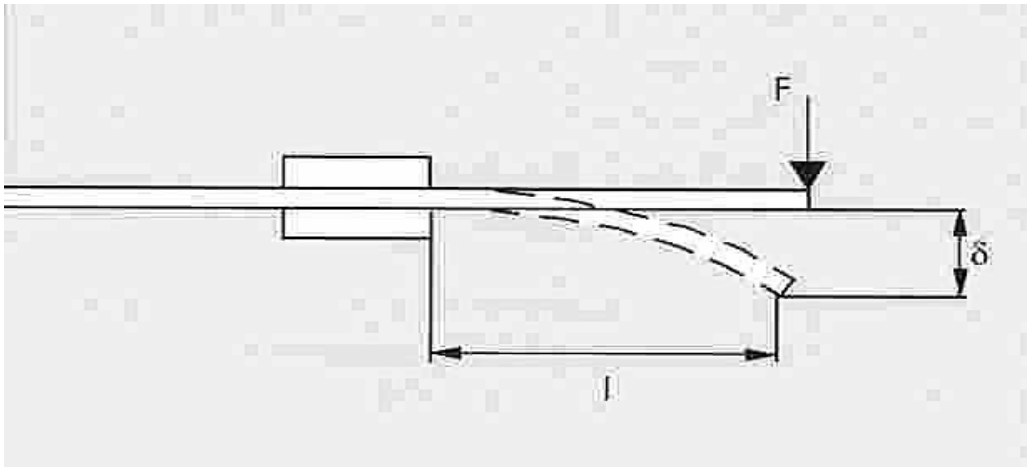
Bending stiffness



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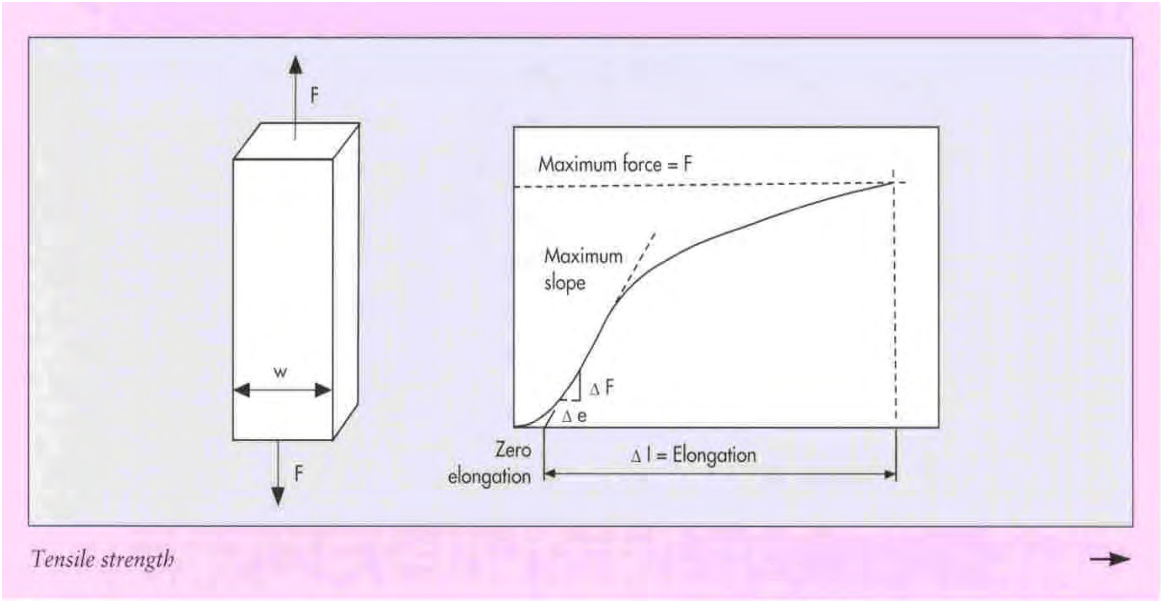
Tensile strength



Tensile strength

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Tearing resistance

Tearing resistance tester

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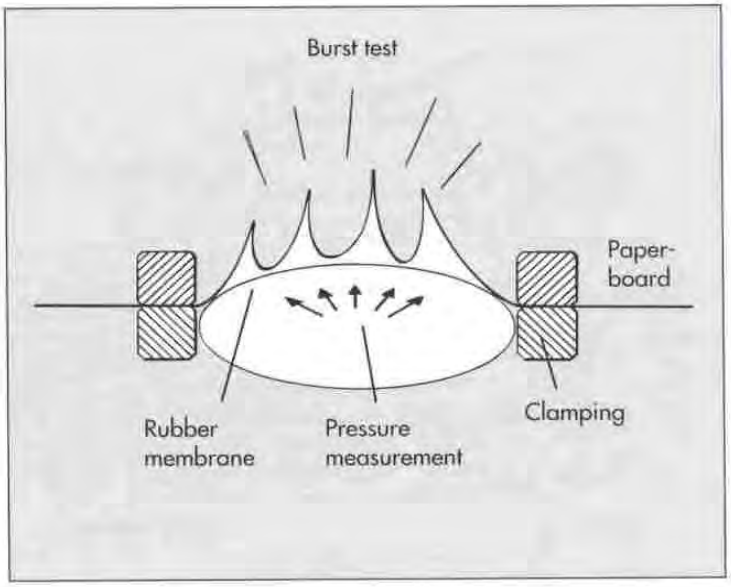
Burst strength



Principle of burst strength

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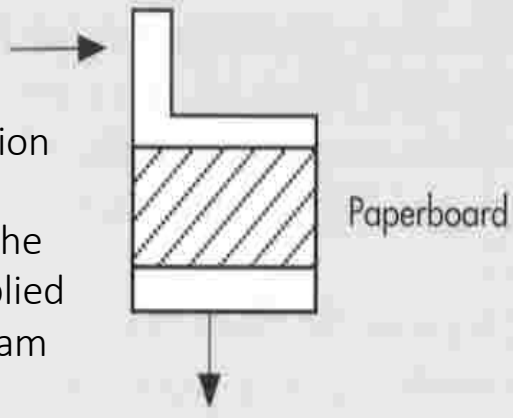
Ply Bond Strength
Scottbond Method

Levering action better assimilates the Stresses applied on a glue seam joint.



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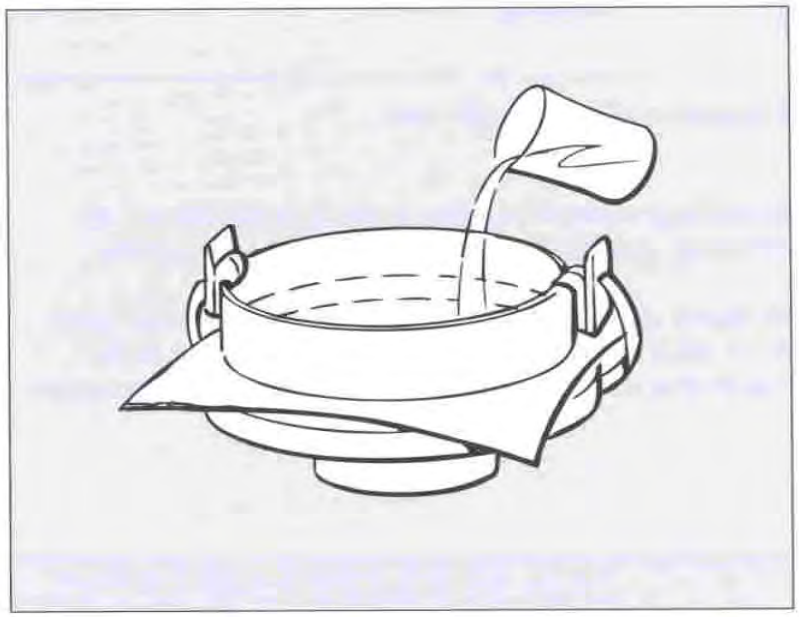
Water absorption



Cobb test method

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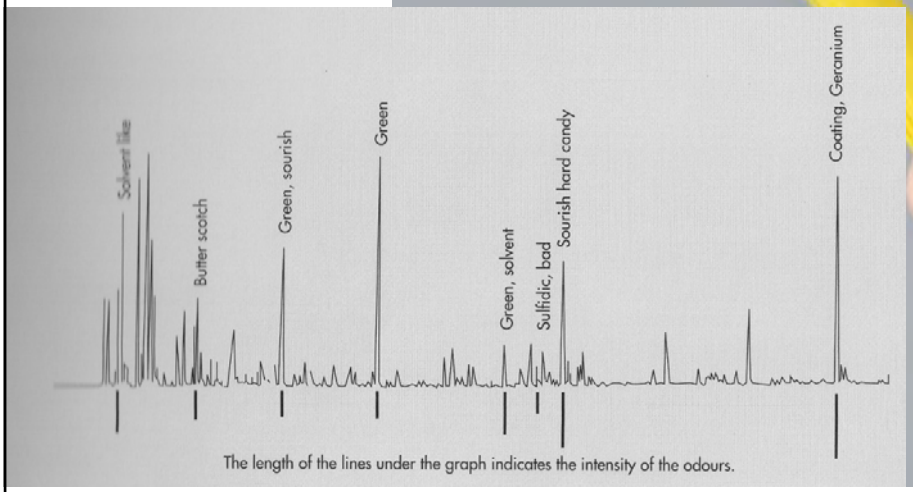
Taint and odour



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Performance Properties

Printability:

- Surface smoothness
- Surface strength
- Surface absorption
- Surface tension
- Whiteness
- Opacity

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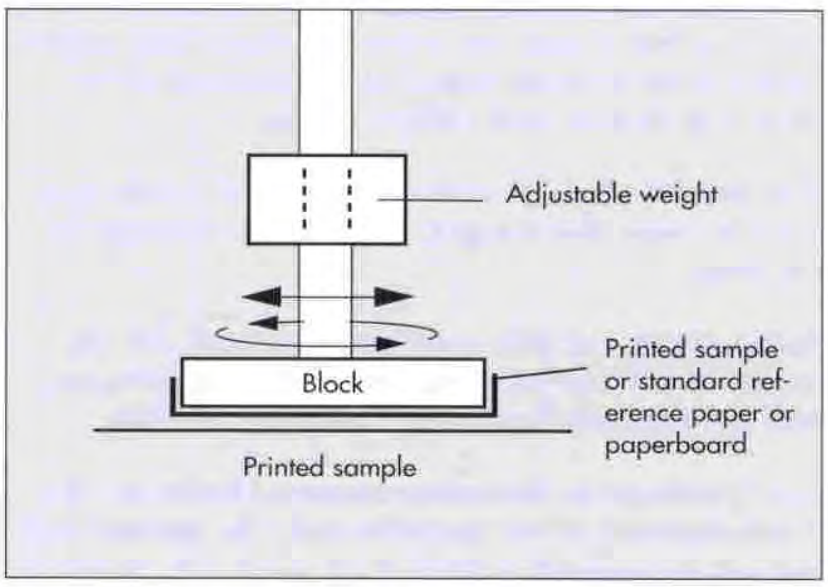
Rub Resistance of Print



Measuring equipment with printed sample

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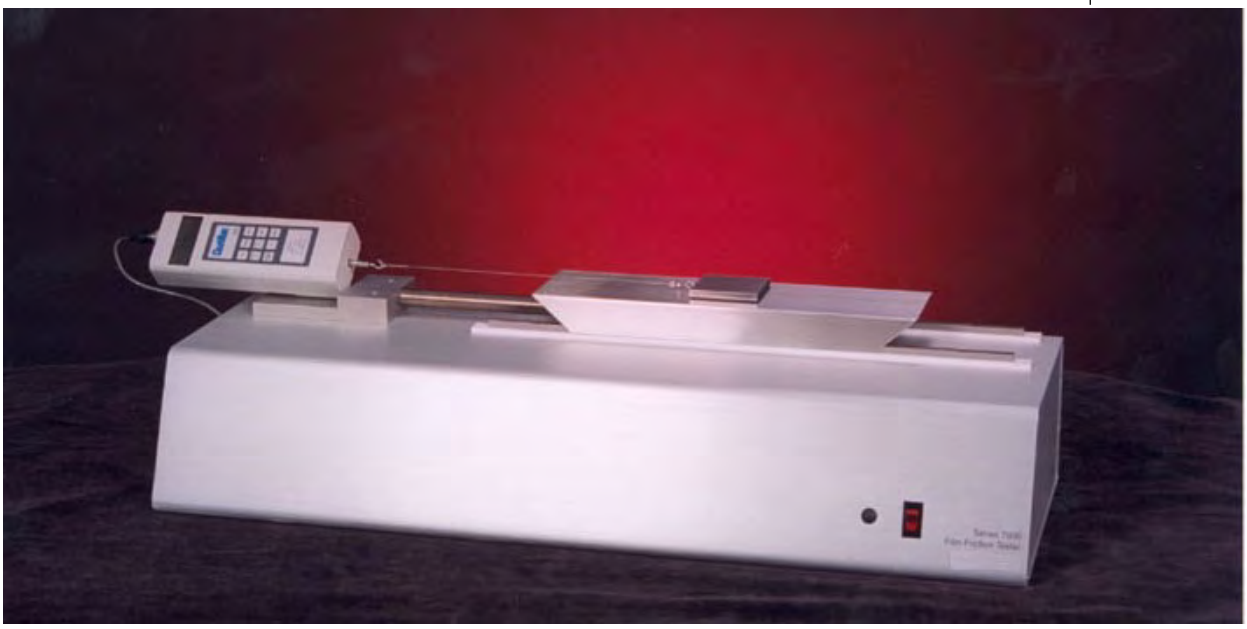
Coefficient of Friction (slip)



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Further Info

- Greif – www.greif.com
- Paper Machinery Corporation – www.papermc.com
- Weidenhammer – www.weidenhammer.de
- Sonoco – www.sonoco.com
- Robinson Packaging – www.robinsonpackaging.com
- Cullen Packaging – www.cullen.co.uk
- Huhtamaki – www.huhtamaki.com
- Association of European CartonBoard and Carton Manufacturers - www.procarton.com/home
- Corrugated Packaging Alliance - www.corrugated.org.uk/
- Confederation of Paper Industries – www.paper.org.uk/
- PIRA – www.smitherspira.com/
- FEFCO – www.fefco.org
- Billerud - www.billerud.se
- Mondi – www.mondi.com
- PITA – Paper Industries Technical Association - www.pita.co.uk

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Thank you

Any questions?

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Thank you for attending.