Fuji Seal Foundation Fuji Seal BK TP.HCM HCMUTE

SUSTAINABLE PACKAGING SOLUTION & WORKSHOP

DESIGN MONO-PE SUSTAINABLE POUCH FOR LIQUID DETERGENTS IN FLEXIBLE PACKAGING

GROUP 2

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Global Flexible Packaging Market

170,5 $B

Market value, 2023

~4%

Compound annual Growth rate

Source: FMI report

Pouch Market outlook to 2033

50,5 $B

Market value, end of 2022

~5,3%

Compound annual Growth rate

84,6 $B

Sales of pouches in 2033

Source: FMI report

Vietnam Hand sanitizer market

11,61 $M

Amounted Revenue, 2023

~9,21%

Compound annual Growth rate

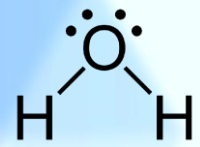
~500%

Growth after the outbreak of COVID-19 pandemic

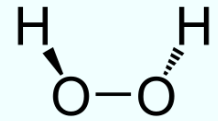
Source: Statista

Liquid detergent – Hand sanitizer

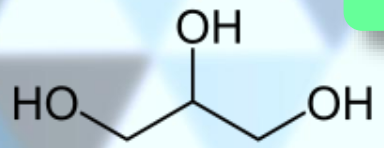
Water



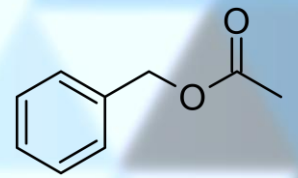
Peroxide

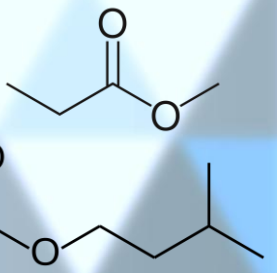


Alcohol



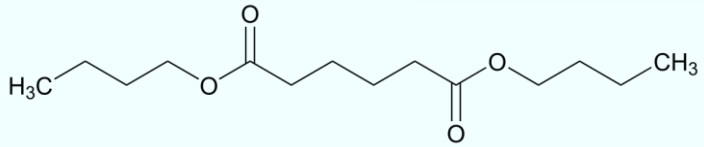
Fragrance

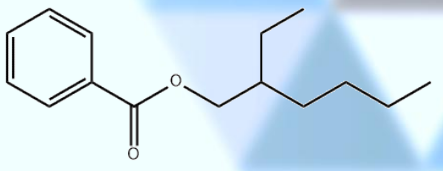




Humectant

Emollients





Product

Manufacturer: Unilever

Vendor: Aeon

Specification:
- **Liquid detergent**
- **Bag form (spout pouch)**
- **Volume: 1 liter**

Commercial hand sanitizer liquid

Source: Aeon mall

Conventional package for liquid detergent

Sealant Layer

Example

Polyethylene (PE), Polypropylene (PP)

Middle Layer (Barrier)

Example

Aluminum based film, Nylon

Outer Layer

Example

PET, Nylon

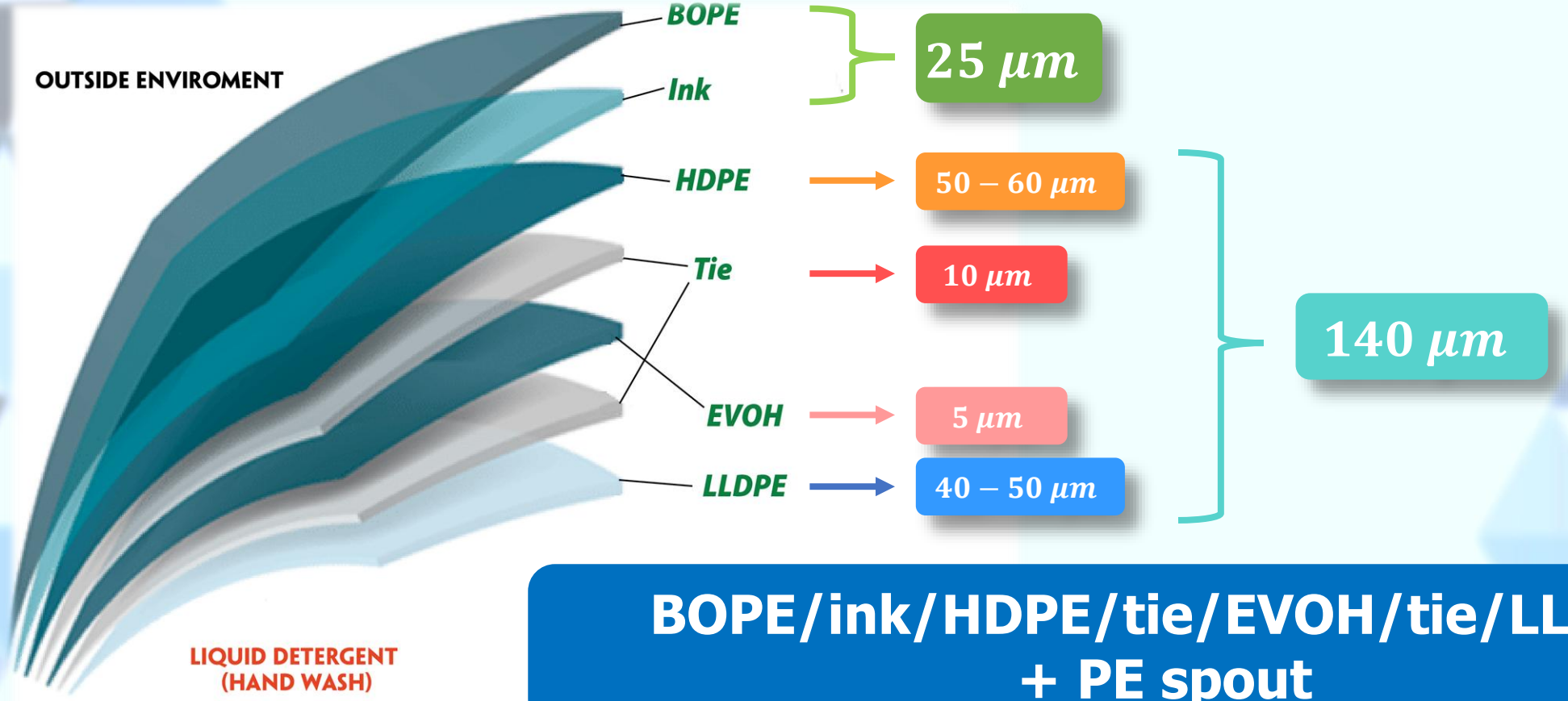
Technical Parameters

Application	Packaging volume	500-2000gram
	Packaging content	detergent
	Pouches style	laundry detergent plastic bag
Spout pouches material structure		PET/Nylon/LLDPE
Spout pouch thickness		120-140micron
Spout inner diameter(Φ)		9.6mm/10mm/15mm
Spout step(gap)		Non-step/single
Can it to be withstand	hot filling?	No
	pasteurization?	No
	retorting?	No

PET/Nylon/LLDPE

Source: Zarcos America

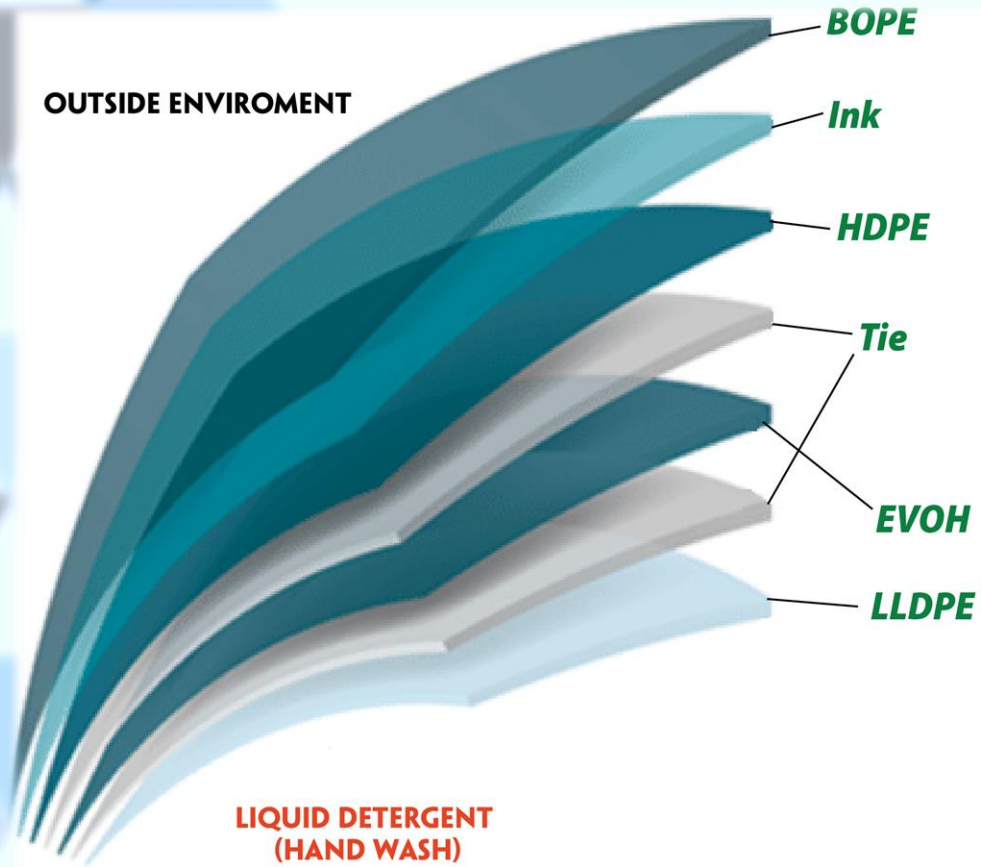
Our proposal



BOPE/ink/HDPE/tie/EVOH/tie/LLDPE + PE spout

Reference: The Science and Technology of Flexible Packaging (Book, 2022) ISBN: 978-0-323-85435-1

Concern Properties



Tensile strength

LLDPE (40 – 50 μm): 8 – 12 Mpa

HDPE (50-60 μm): 8 – 35 Mpa

BOPE (25 μm): 84 – 181 MPa

Young Modulus

LLDPE (40 – 50 μm): 0,011 – 0,413 GPa

HDPE (50-60 μm): 0,02 – 1,35 GPa

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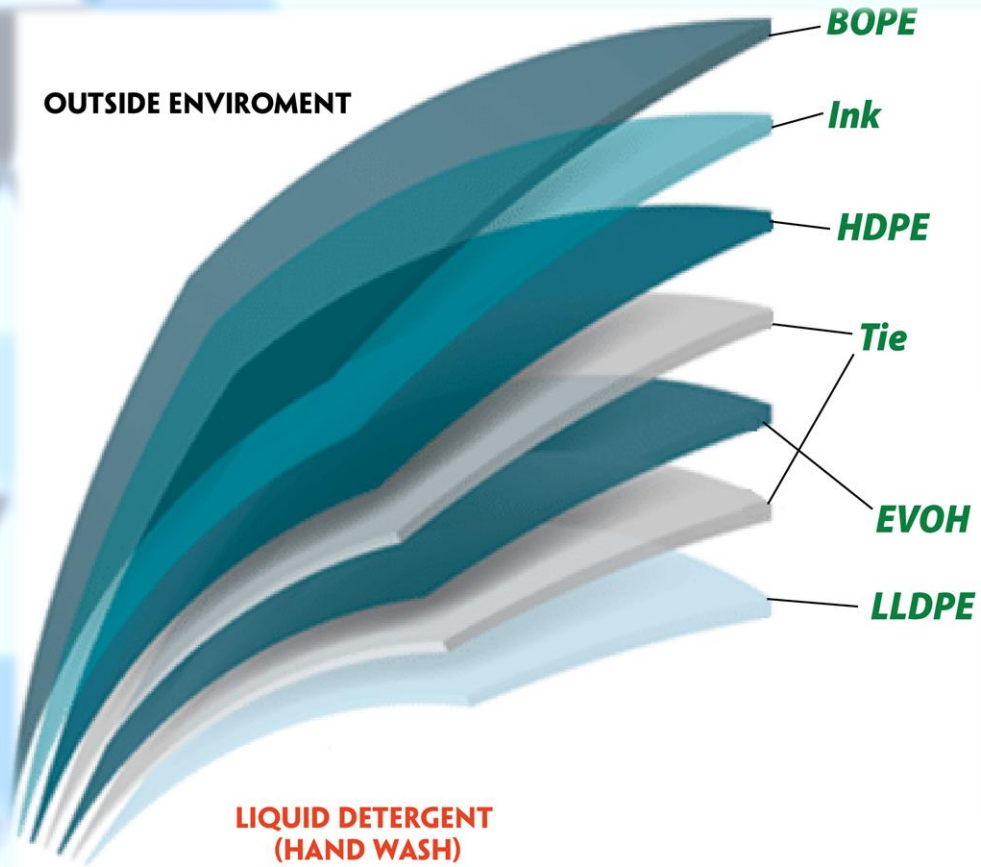
Concern Properties



Elongation at break

LLDPE (40 – 50 μm): 0,8 – 1000%

HDPE (50-60 μm): 350 – 1700%

BOPE (25 μm): 58,4 – 231,7%

Oxygen Permeation value

EVOH (5 μm): 0,3 – 1,2 $\frac{cc.mm}{m^2.day.atm}$

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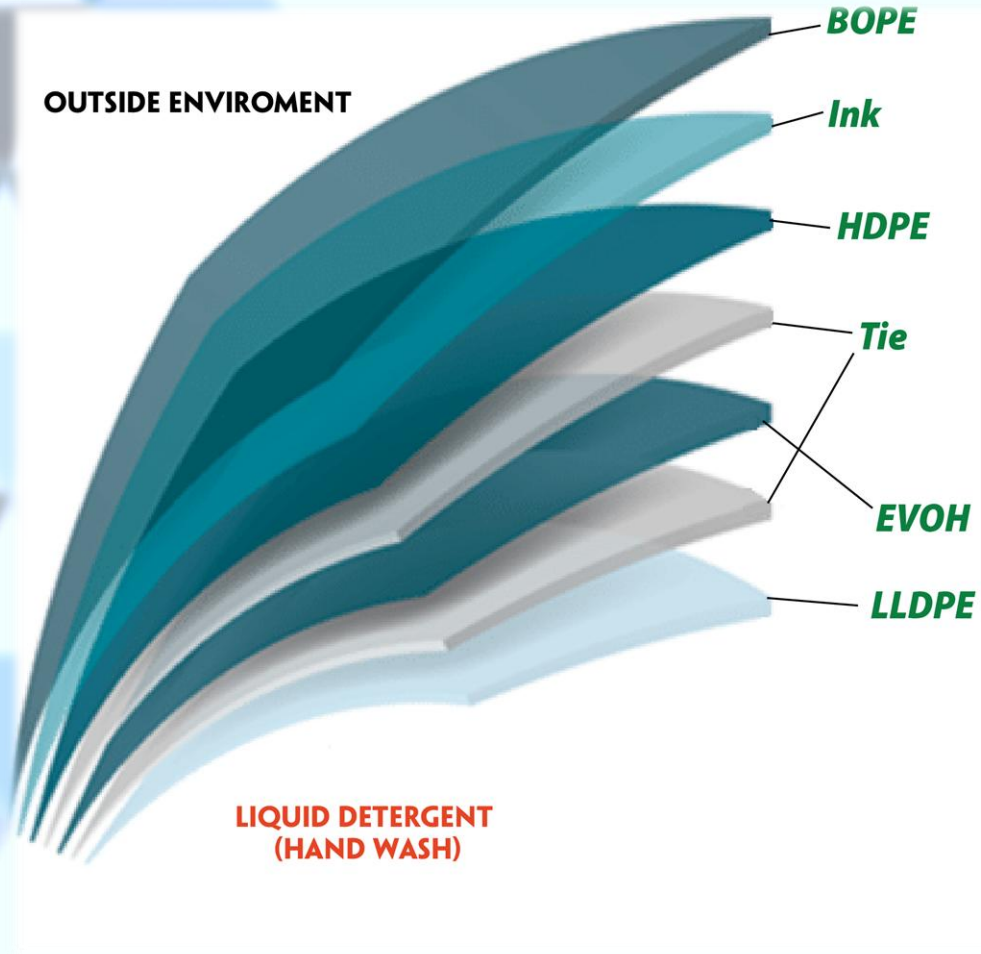
Concern Properties



Vapor Transmission rate

LLDPE: 12 – 19 $\frac{g.mm}{m^2.day}$

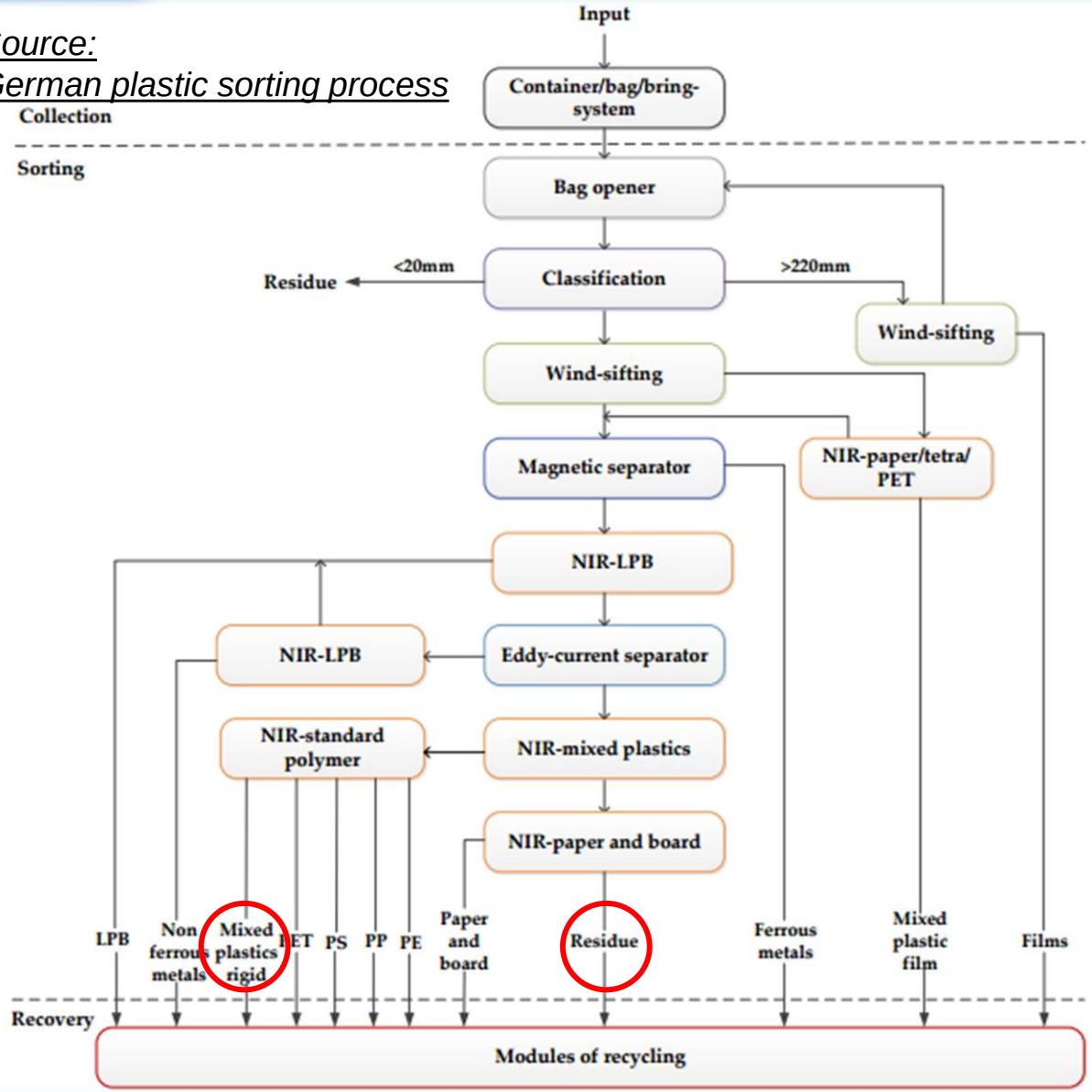
HDPE: 1.5 – 12 $\frac{g.mm}{m^2.day}$

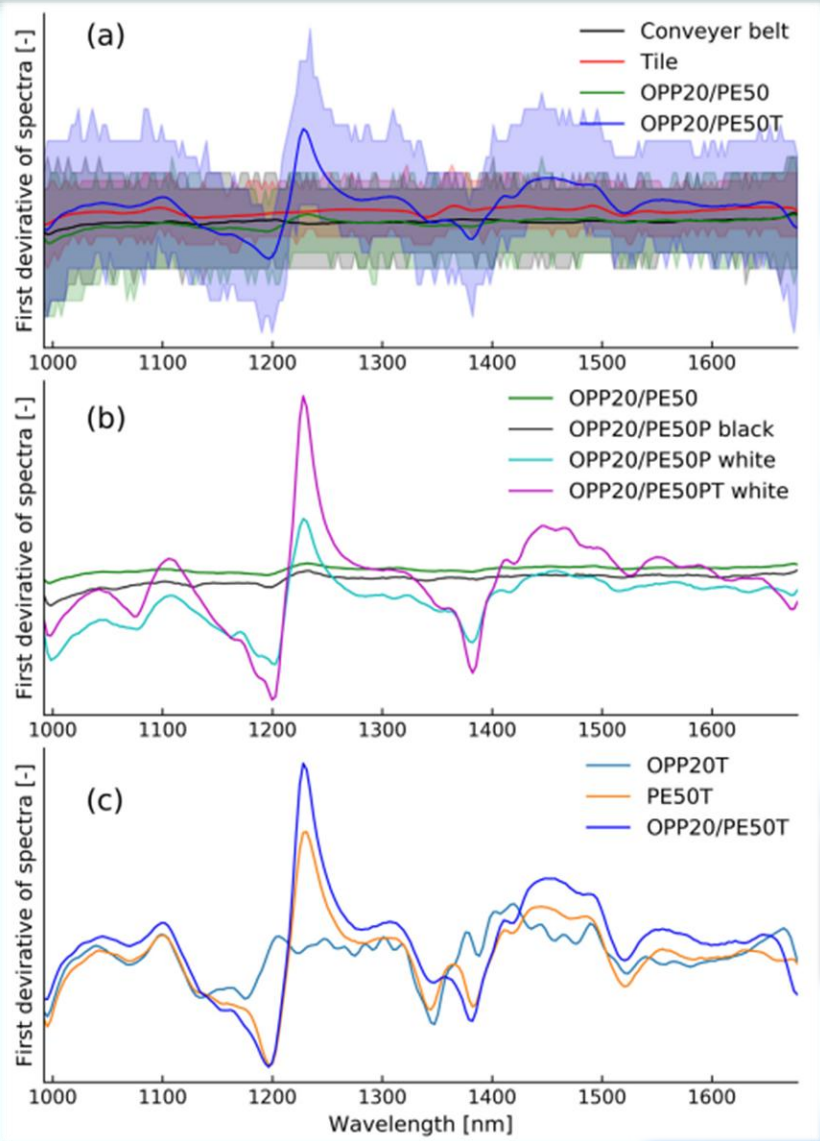
EVOH: 23 – 60 $\frac{g.mm}{m^2.day}$

Reference: The Science and Technology of Flexible Packaging (Book, 2022) ISBN: 978-0-323-85435-1

RECYCLABILITY

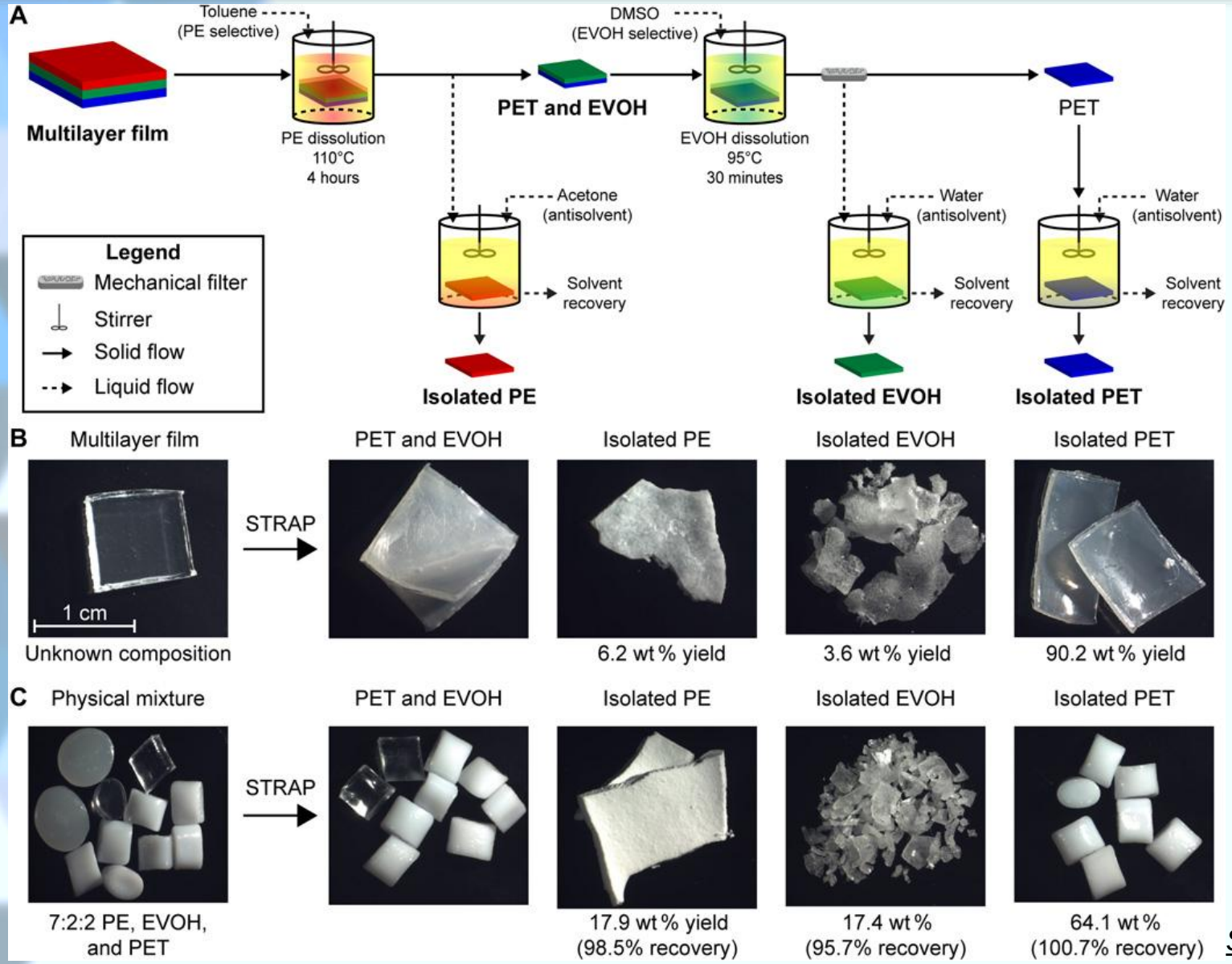
Source:
German plastic sorting process





Source: https://doi.org/10.1016/j.wasman.2021.01.015

RECYCLABILITY



CEFLEX Standard

PE content > 95%

High mechanical recyclable efficiency

Cost savings

Source: DOI: 10.1126/sciadv.aba759

Computational model

Permeability model

$$\frac{P}{x} = \frac{V_A}{(p_{in} - p_{out}).A_s.t} \quad \textbf{(1)}$$

With: $\frac{P}{x}$ is the permeance for 1 layer $[\frac{cm^3}{m^2\ day\ atm}]$

$$\left[\frac{P}{x}\right]_{total} = \frac{1}{(\frac{x_1}{P_1} + \frac{x_2}{P_2} + \cdots + \frac{x_n}{P_n})_{in}} \quad \textbf{(2)}$$

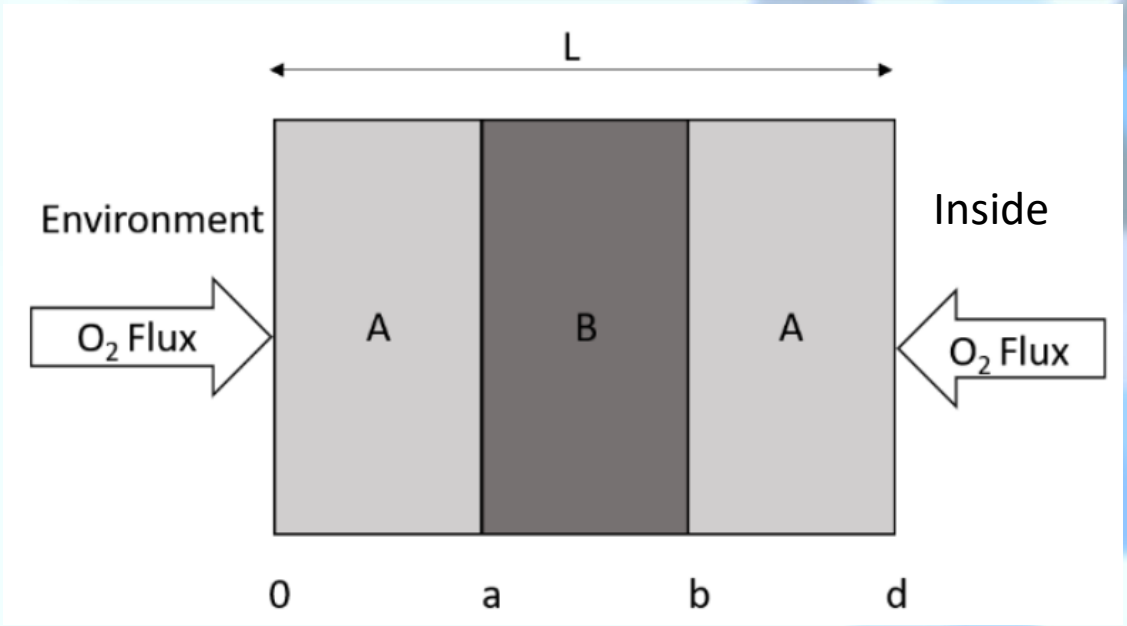
With: $\left[\frac{P}{x}\right]_{total}$ is the permeance for multilayer

Diffusion model

$$\frac{\partial C}{\partial t} = \frac{D.\partial^2 C}{\partial x^2} \quad \textbf{(3)}$$

With: C is the concentration of gas $\left[\frac{mol}{cm^3}\right]$;

x is the thickness of layer $[cm]$



Computational model

Correction with Environment

Temperature:

$$P = P_o e^{-\frac{E}{R}\left(\frac{1}{T}-\frac{1}{To}\right)} \quad \textbf{(4)}$$

Relative Humidity:

$$RH_j = RH_{out} - \left[\frac{\left(\sum_{i=1}^{j-1}\frac{x_i}{P_i}+\frac{x_j}{2P_j}\right)(RH_{out}-RH_{in})}{\sum\frac{x_i}{P_i}}\right] \quad \textbf{(5)}$$

Table 1: Input data

Material	Reference	Water vapor permeability coefficient[a,b]	O_2 permeability coefficient[b,c]	CO_2 permeability coefficient[b,c]	Density (g/cm^3)[b]	Cost [US$/kg][b]
ULDPE	Attane 4001, Dow Chemical	0.0209	46.8397	–[d]	0.905	2.75
PP	Marlex	0.0217	30.0728	–[d]	0.910	0.99
PET	Mylar, DuPont	0.0625	0.8205	2.3026	1.330	1.50
LLDPE	Sclair 11F9, DuPont Canada	0.0088	32.4815	200.0000	0.921	0.90
EVOH	Eval E, Eval Company	0.6100	0.0057[e]	0.0633[e]	1.140	5.83
PA AMORFO	Selar PA 3426, Dupont	0.5500	0.1704[e]	–[d]	1.100	2.93
Tie	–[d]	–[d]	–[d]	1.00	——	

Oxygen permeance: high barrier films

Structure	Measured permeance (mL (STP)/m^2 day atm)	Calculated permeance (mL (STP)/m^2 day atm)	Variation (%)
PA (46 μm)/EVOH-F (8 μm)/PP (28 μm)/PE-m (25 μm)	0.84	0.81	3.83
PP (18 μm)/EVOH F (4 μm)/PP (18 μm)	1.67	1.68	−0.93
PE (21 μm)/EVOH L (4 μm)/PE (16 μm)	0.87	0.85	1.80

Table 2: Oxygen permeance: comparison between experiment and model calculated data

Source: DOI: 10.1177/8756087913484920

Optimization algorithm

Flowchart 1: ML logic

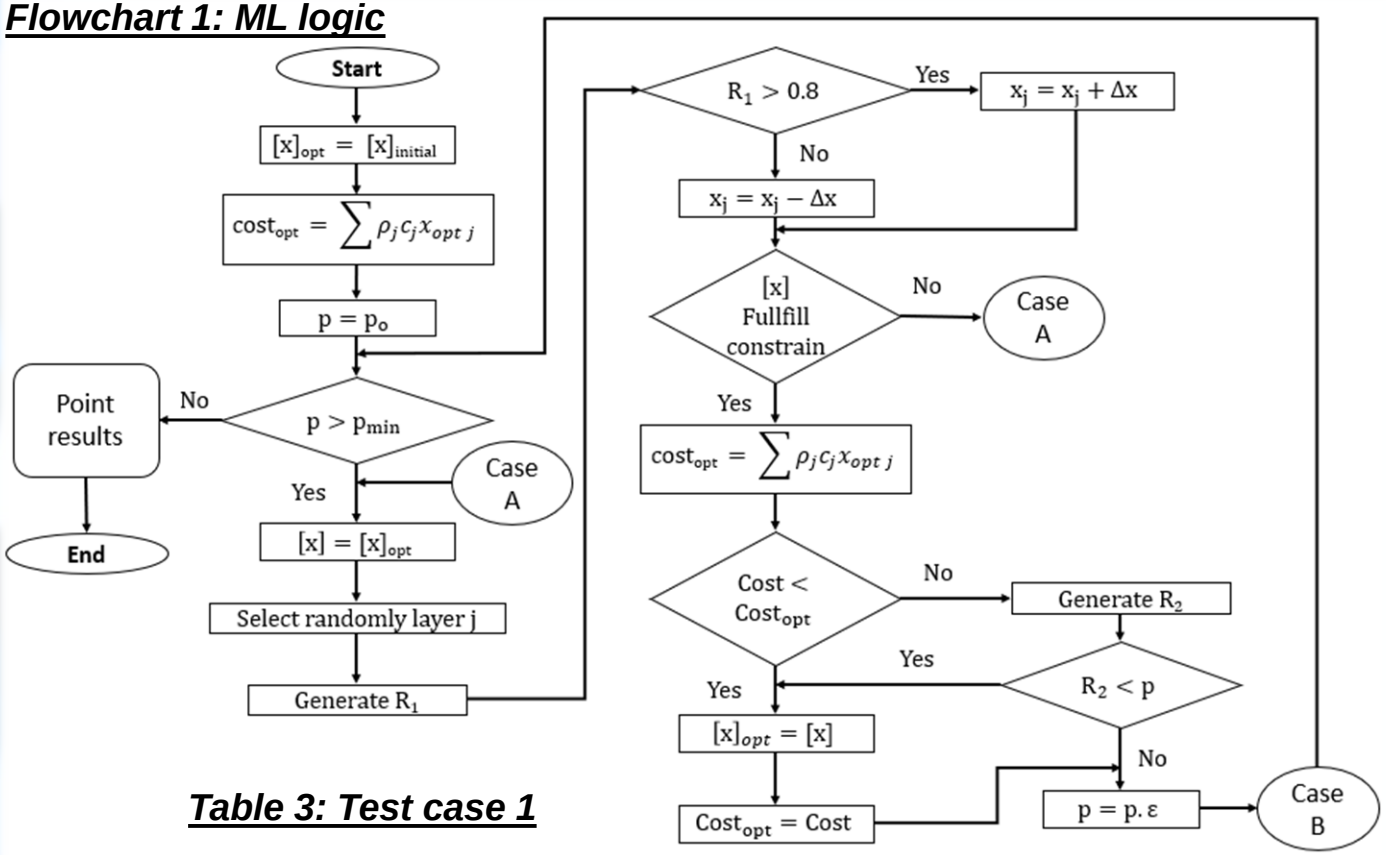


Table 3: Test case 1

	Thickness of each layer (μm)												
	LDPE	LDPE	Tie	EVOH	Tie	LDPE	LDPE+ MLDPE*	Measured Perm. W.V(1) at 38°C 90%RH (3)	Calcula-ted perm. W.V[a] at 38°C 90% RH	Calcula-ted perm. W.V[a] at 23°C, 0% RH	Measu-red perm. O_2^b at 23°C, 0% RH[d]	Calcula-ted perm. O_2^b at 23°C, 0% RH	Cost per unit area [¢/m²]
Experimental	14.7	4.5	3.4	5.6	3.4	3.4	18.1	3.525	3.291	0.8983	1.735	1.767	7.10
Optimized	12.33	8.21	2.00	5.55	2.00	9.20	5.00	–	–	0.8983	–	1.767	6.58

Machine learning Model

Maintain propertise

Reduce usage Material

Cost savings

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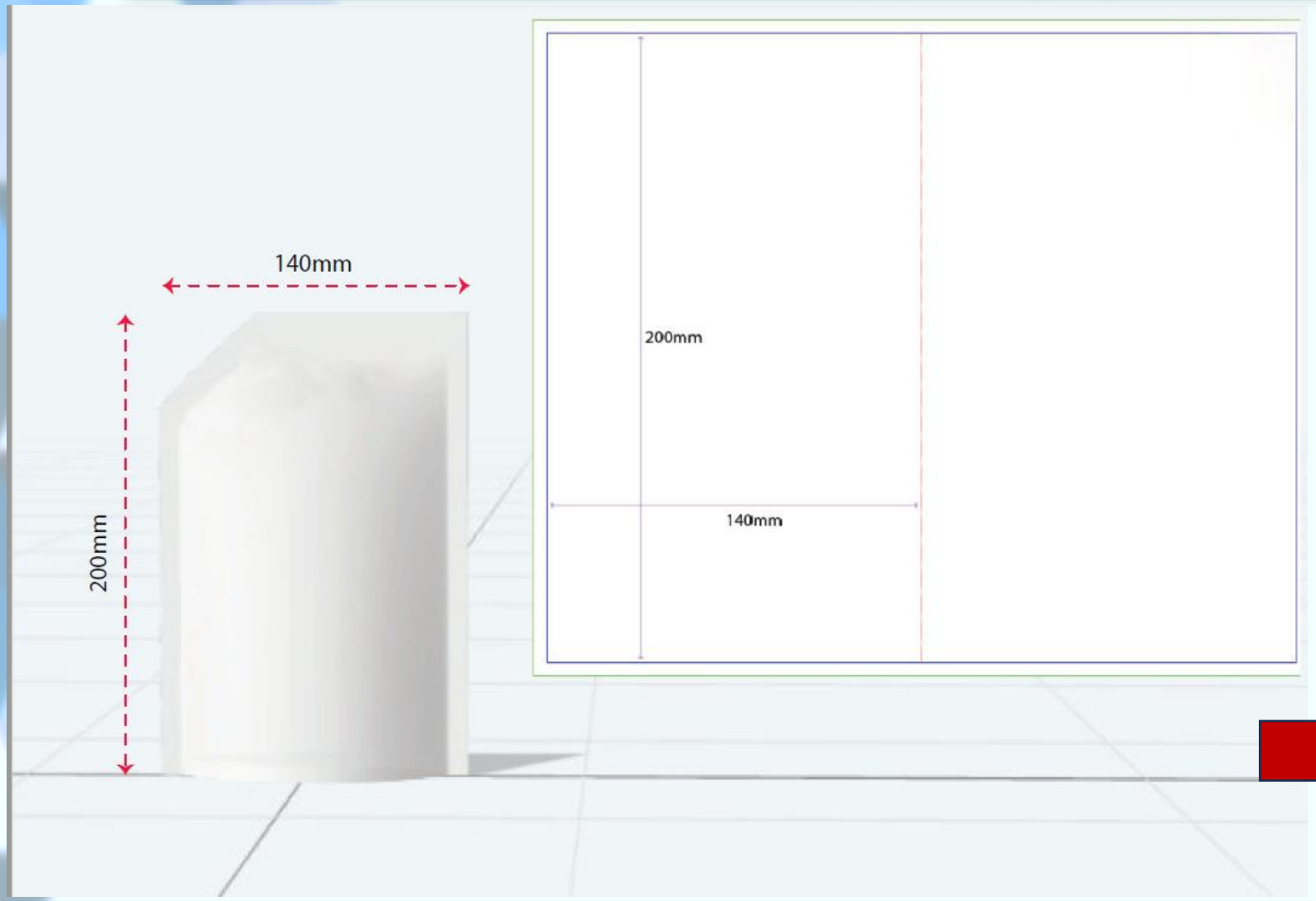
Body packaging dimension



Design standard

FACE WIDTH by FINISHED BAG LENGTH...TOP WIDTH, BOTTOM WIDTH, VALVE SIZE

F x L - T,B,V

A) Most of the time, top and bottom valve widths are the same. This is expressed-

F x L - TBV

Example: 18 1/2 x 22 — 3 3/4 TBV

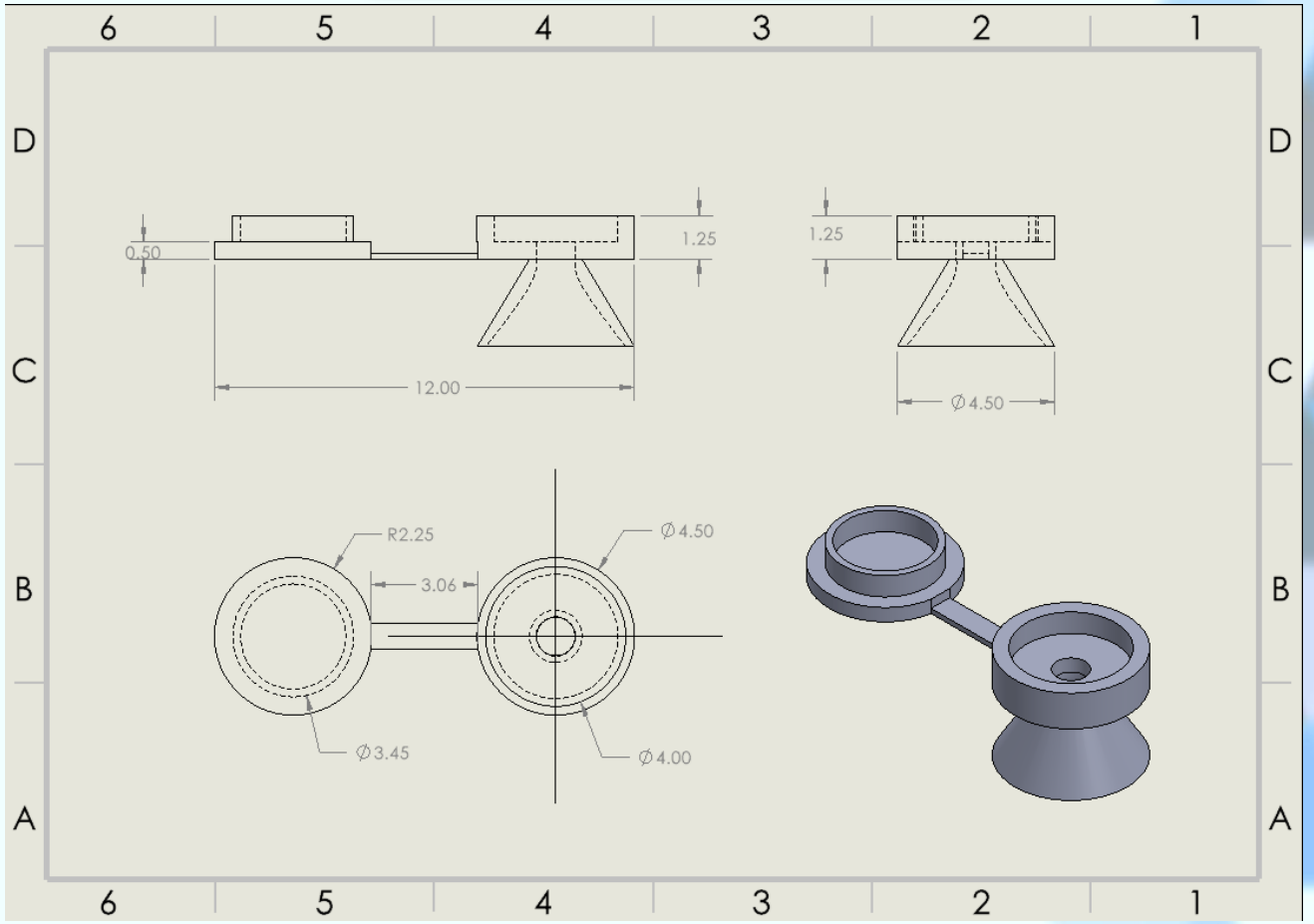
Stone Container Corp. of Chicago Standard

$V_{m\_est} \sim 1.12\ L$

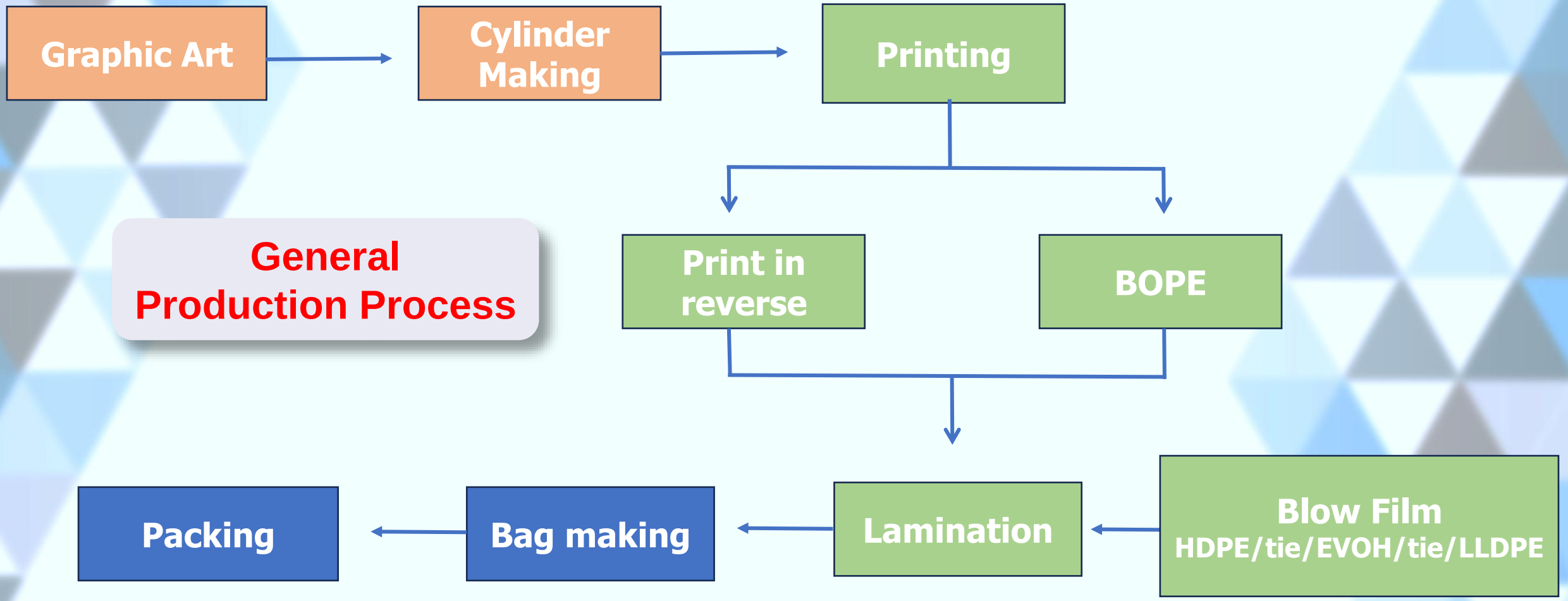
Caps dimension

3D Design

Drawing



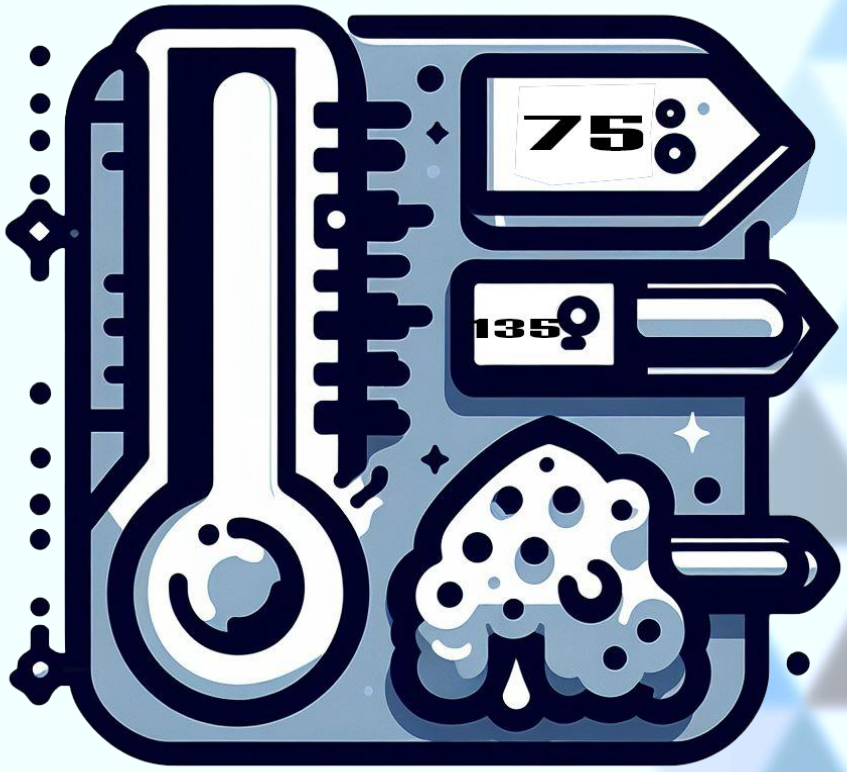
Fabrication process diagram



General Production Process

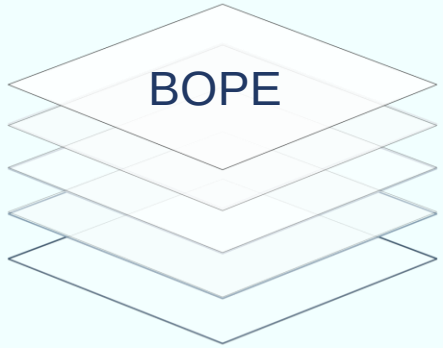
Packaging Paste ability

Typical melting points of different grades of PE	
LDPE	105 - 115°C
LLDPE	110 - 120°C
HDPE	125 - 135°C
EVA	90 - 100°C
mPE	90 - 100°C
Typical SIT of different types of PE	
LDPE	85 - 95°C
LLDPE	80 - 90°C
HDPE	100 - 110°C
EVA	75- 85°C
mPE	75 - 85°C



Regarding stucture

Regarding cost



New spout design

SUMMARY

Achieve sustainable trends

Can achieve compatible performance

Ability to reuse the product

Ensure the recycling process

THANK YOU FOR ATTENTION!