

RECYCLING OF PLASTICS FOR FOOD CONTACT APPLICATIONS

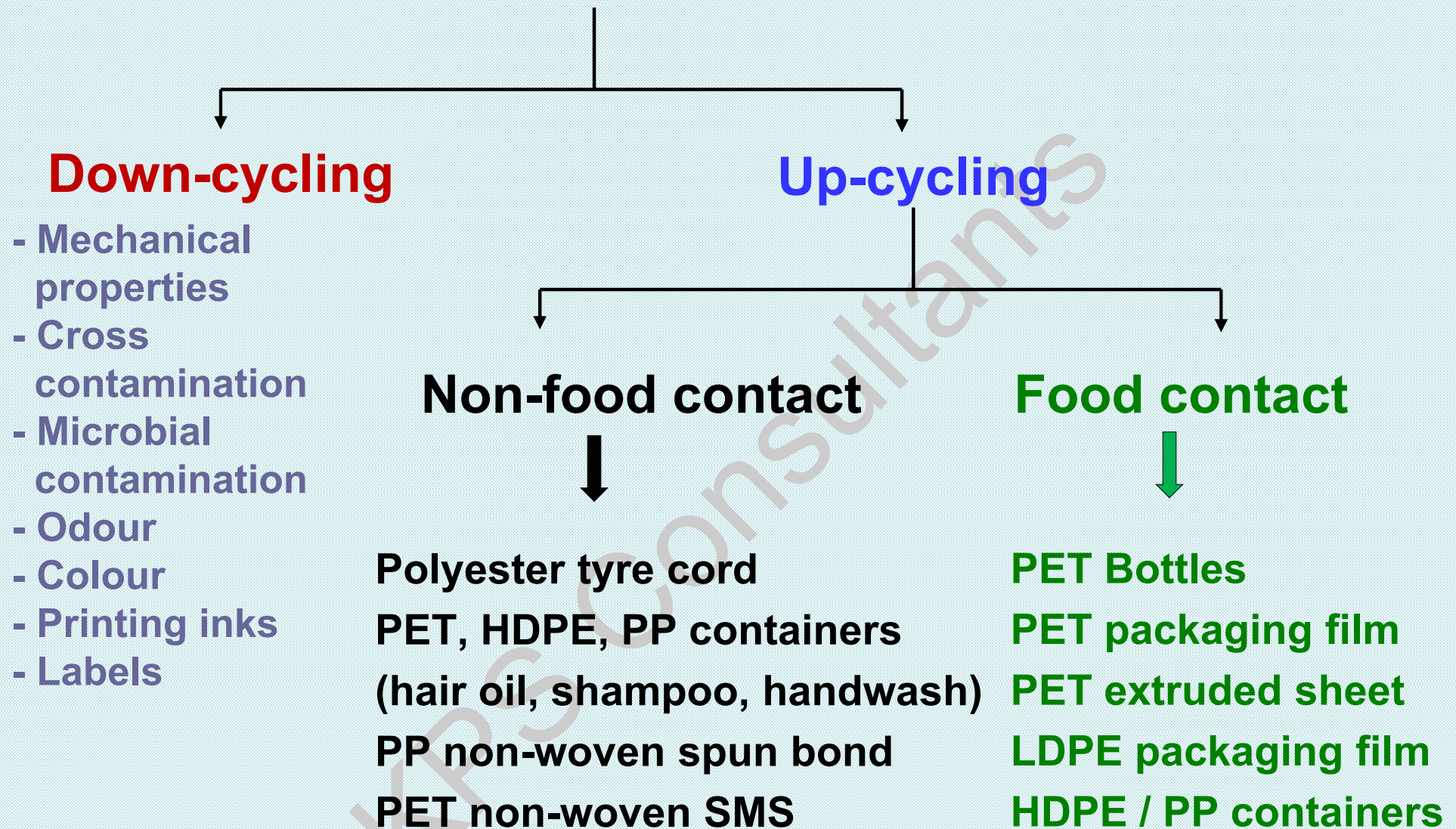
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DECEMBER 14, 2022















**Plastic Packaging Research & Development
Centre - NOIDA**

Recycling of Post Consumer Thermoplastics

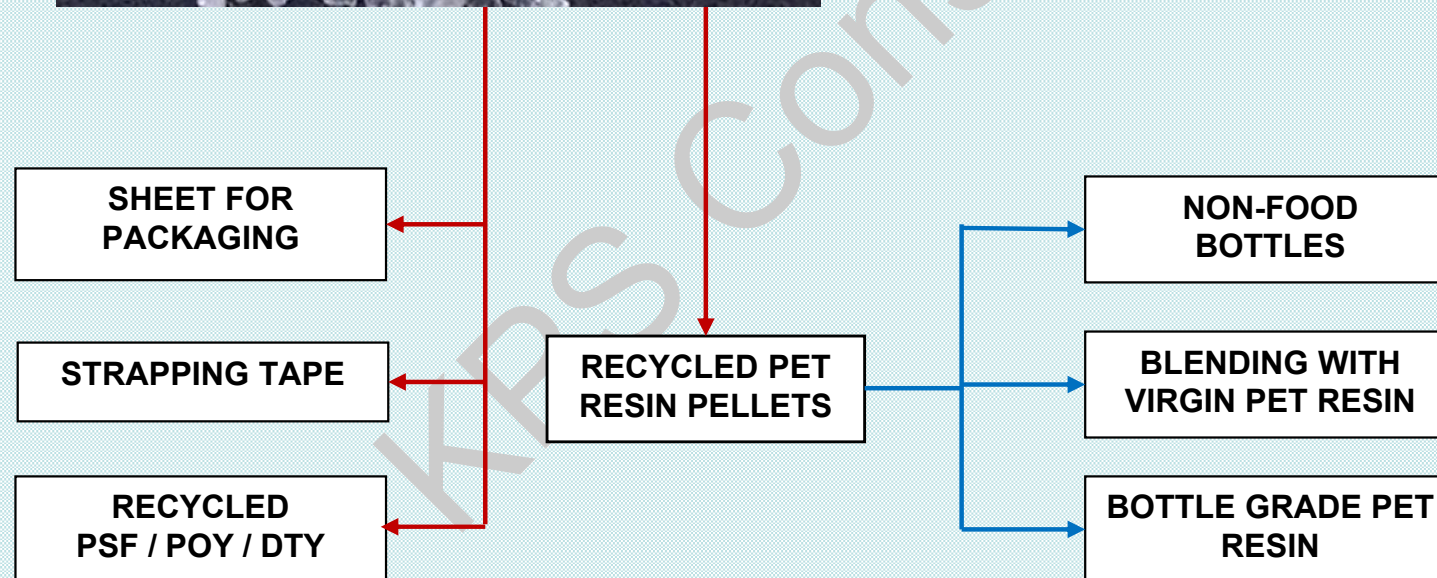


Why the push for Food Contact PCR Thermoplastics?

- Regulatory pressure (MoEF - EPR, FSSAI, CPCB, BIS)
- Commercially viable (price of PCR food contact grade plastics at many instances higher than virgin)
- Different technology options available (process & parameters important criteria for food contact approval)
- Circular economy, Carbon neutral (or at least lowering carbon footprint), environment friendly image - for corporate brand building an essential need now
- Global PCR plastic use mandates - makes it an imperative

Symbol	Polymer Name	Product Examples	
	Polyethylene Terephthalate (PETE or PET)	<ul style="list-style-type: none"> • Soft drink bottles • Water bottles • Sports drink bottles • Salad dressing bottles • Vegetable oil bottles 	<ul style="list-style-type: none"> • Peanut butter jars • Pickle jars • Jelly jars • Prepared food trays • Mouthwash bottles 
	High-density Polyethylene (HDPE)	<ul style="list-style-type: none"> • Milk jugs • Juice bottles • Yogurt tubs • Butter tubs • Cereal box liners 	<ul style="list-style-type: none"> • Shampoo bottles • Motor oil bottles • Bleach/detergent bottles • Household cleaner bottles • Grocery bags 
	Polyvinyl Chloride (PVC or V)	<ul style="list-style-type: none"> • Clear food packaging • Wire/cable insulation • Pipes/fittings • Siding • Flooring 	<ul style="list-style-type: none"> • Fencing • Window frames • Shower curtains • Lawn chairs • Children's toys 
	Low-density Polyethylene (LDPE)	<ul style="list-style-type: none"> • Dry cleaning bags • Bread bags • Frozen food bags • Squeezable bottles • Wash bottles 	<ul style="list-style-type: none"> • Dispensing bottles • 6 pack rings • Various molded laboratory equipment 
	Polypropylene (PP)	<ul style="list-style-type: none"> • Ketchup bottles • Most yogurt tubs • Syrup bottles • Bottle caps • Straws 	<ul style="list-style-type: none"> • Dishware • Medicine bottles • Some auto parts • Pails • Packing tape 
	Polystyrene (PS)	<ul style="list-style-type: none"> • Disposable plates • Disposable cutlery • Cafeteria trays • Meat trays • Egg cartons 	<ul style="list-style-type: none"> • Carry out containers • Aspirin bottles • CD/video cases • Packaging peanuts • Other Styrofoam products 
	Other Plastics (OTHER or O)	<ul style="list-style-type: none"> • 3/5 gallon water jugs • Citrus juice bottles • Plastic lumber • Headlight lenses • Safety glasses 	<ul style="list-style-type: none"> • Gas containers • Bullet proof materials • Acrylic, nylon, polycarbonate • Polylactic acid (a bioplastic) • Combinations of different plastics 

Value added products from recycled pet bottles





**Recycled PET
Granules (Pellets)**



PET Bottles



**HOT WASHED
PET FLAKES**



**RECYCLED PET SHEET
THERMOFORMED END
PRODUCTS**



Upcycling of Plastics – KPS Consultants



**Partially Oriented
Yarn (POY)**



**Polyester Staple
Fiber (PSF)**



Containers for non-food applications

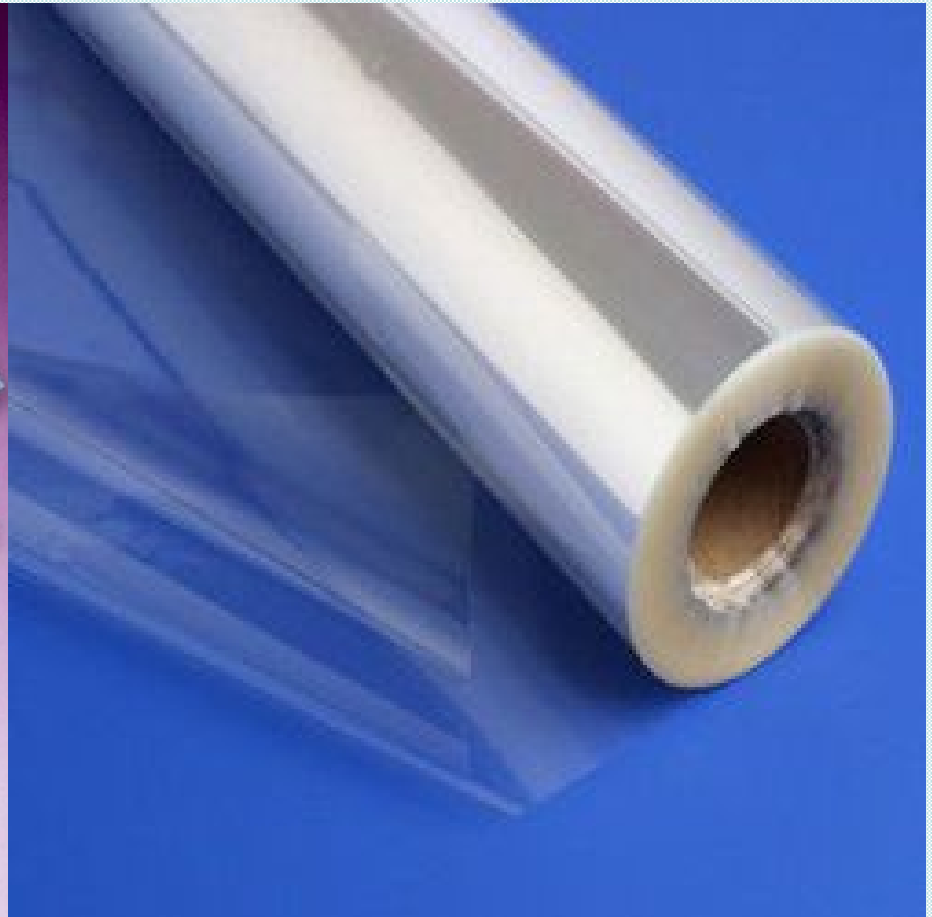


PET Strapping Tape





Non-woven PET Fabric



PET (Polyester) Film

Indicative Intrinsic Viscosity levels for different applications

INDUSTRY / APPLICATION	Desired I.V. (dL / gm)
Virgin PET from resin producers	0.76 – 0.88
Filled bottles by marketers	0.76 – 0.88
Sheets for thermoformed packaging	0.70 – 0.80
Strapping bands	0.84 – 0.92
Monofilaments	0.66 – 0.76
Master batch	0.76 – 0.84
Injection moulded articles	0.80 – 0.84
Industrial Yarns (Tire Cord / Conveyor Belt / Sewing Thread)	0.92 – 1.00
Polyester Staple Fiber	0.60 – 0.65
Polyester Oriented Yarn	0.60 – 0.65
Non-Woven fabric	0.60 – 0.65
Fully Drawn Yarn / Drawn Textured Yarn	0.60 – 0.65

Post Consumer Recycled **PET** for Food Contact US FDA & European EFSA

- Input feedstock > 95% food grade bottles
- To demonstrate strict controls in place to keep out non-food grade PET bottles & non PET bottles from input feedstock
- Mainly mineral water & CSD bottles
- Manual sorting, NIR sorting for polymer & colour
- Removal of PVC labels, polyolefin caps & neck rings
- Hot water washing with NaOH & Surfactants
- Washing with fresh water to remove any traces of detergents
- Centrifugal drying

Post Consumer Recycled **PET** for Food Contact US FDA & European EFSA (Cont.)

- Crystallization and Hot air drying of bottle flakes
- Decontamination step at 180 to 220°C under vacuum < 15 millibar to remove VOCs, aldehydes, moisture etc.
- Extrusion --- polymer melt --- vacuum degassing (to remove VOCs) & melt filtration through fine mesh screen to remove any foreign matter.
- Pelletization – chips / pellets
- Solid State Polycondensation --- heating under vacuum in an inert nitrogen atmosphere to remove VOCs & increase IV

Post Consumer Recycled **HDPE** for Food Contact US FDA & European EFSA

- Input feedstock > 99% food grade bottles
- To demonstrate strict controls in place to keep out non-food grade HDPE containers
- Mainly bottle caps regrind & edible oil jars (milk jars - Europe)
- Manual sorting, NIR sorting for polymer & colour
- Removal of labels
- Hot water washing with NaOH & Surfactants
- Washing with fresh water to remove any traces of detergents
- Centrifugal drying

Post Consumer Recycled **HDPE** for Food Contact US FDA & European EFSA (Cont.)

- Decontamination step at 120°C for > 2 hours to remove VOCs & De-odourization
- Extrusion --- polymer melt --- vacuum degassing (to remove VOCs) & melt filtration through fine mesh screen to remove any foreign matter.
- Pelletization – chips / pellets
- Use PCR HDPE up to 50% in new milk jars (EFSA & FDA)

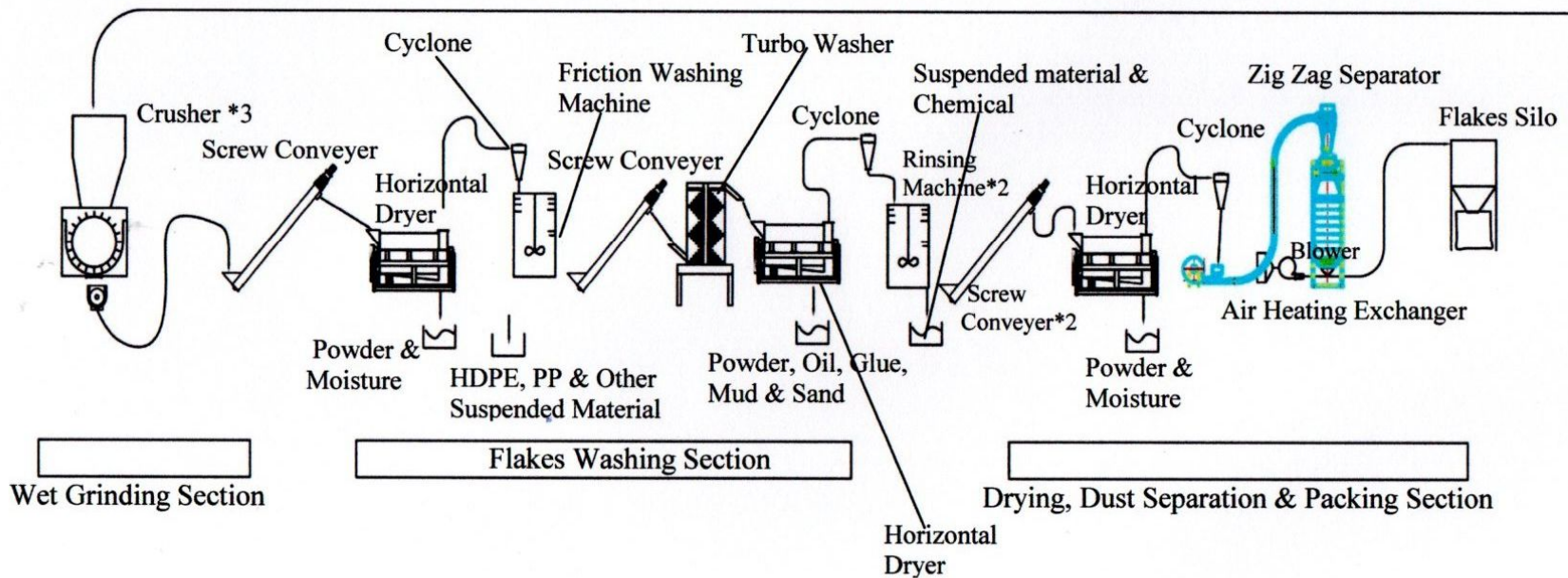
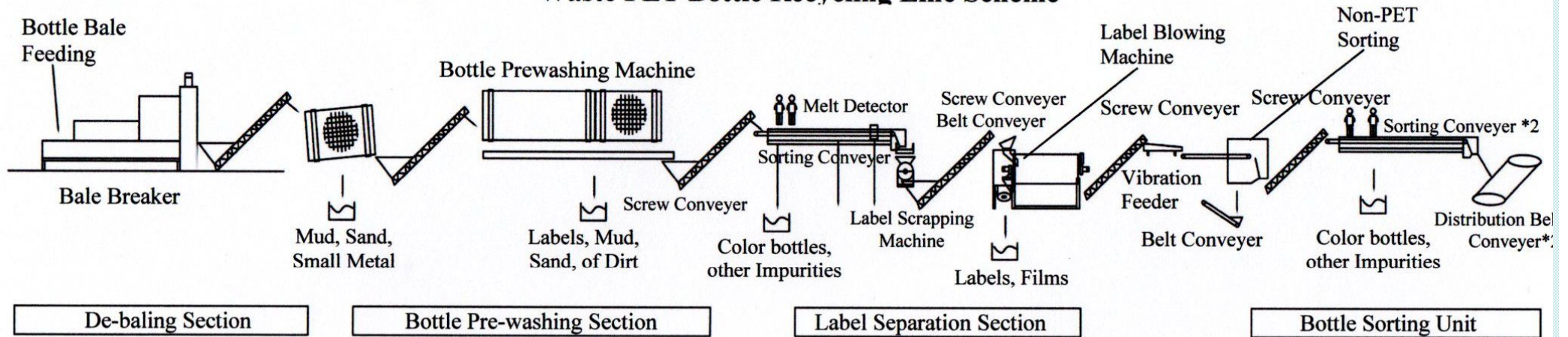
Post Consumer Recycled **LDPE** for Food Contact US FDA & European EFSA

- Input feedstock > 99% food grade post consumer LDPE film
- To demonstrate strict controls in place to keep out non-food grade LDPE / LLDPE film
- Mainly **milk pouches** (possibly bread bags)
- Manual sorting, NIR sorting for polymer & colour
- Hot water washing in alkaline media with Surfactants to remove **adhered contaminants, de-odourization & de-inking**
- Washing with fresh water to remove any traces of detergents, ink residue & organic solid contaminants

Post Consumer Recycled **LDPE** for Food Contact US FDA & European EFSA (Cont.)

- Densified & squeezed LDPE
- Extrusion --- polymer melt --- vacuum degassing (to remove VOCs, Odour & volatile components of ink)
- Use antimicrobial & de-odourization masterbatch if required
- Melt filtration through fine mesh screen to remove foreign matter.
- Decontamination – hot air or steam stripping of recycled pellets for 2 to 8 hours to remove any remaining VOCs & odour (GC – MS before & after decontamination)

Waste PET Bottle Recycling Line Scheme



Source: Borotech

US FDA 'No Objection Letter' for food contact approval

- United States - Food and Drug Administration (US FDA) provides 'No Objection Letter' (NOL) to a manufacturer of recycled plastic based on detailed production process and process parameters submitted by the applicant
- US FDA does not carry out physical inspection or audit of the PCR Plastic manufacturer but provides its opinion on a particular recycling process regarding its efficacy to produce material suitable for food-contact applications
- It is to be noted that NOL issued by US FDA is not legally binding, but just the opinion of USF FDA. US FDA does not recommend or mention any particular recycling equipment and / or supplier in the NOL

US FDA 'No Objection Letter' for food contact approval

- Please refer document *“Use of Recycled Plastics in Food Packaging (Chemistry Considerations): Guidance for Industry”* July 2021 by US FDA.
- PCR PET must comply with *21 CFR 174.5* – General provisions for indirect food additives
- PCR PET must comply with *21 CFR 177.1630* – Indirect food additives (177) & PET (1630)
- FDA will post the LNO on its website
- Self-certification / opinion letter through comparison with a system for which FDA has issued an LNO (no posting on website)
- License an existing LNO. Need to establish your system is same
- FDA permits LNOs to be transferred

Conditions of Use (ref: US FDA)

- A. High temperature heat-sterilized (e.g., over 212 deg.F).
- B. Boiling water sterilized.
- C. Hot filled or pasteurized above 150 deg.F.
- D. Hot filled or pasteurized below 150 deg.F.
- E. Room temperature filled and stored (no thermal treatment in the container).
- F. Refrigerated storage (no thermal treatment in the container).
- G. Frozen storage (no thermal treatment in the container).
- H. Frozen or refrigerated storage: Ready-prepared foods intended to be reheated in container at time of use:
 - Aqueous or oil-in-water emulsion of high- or low-fat.
 - Aqueous, high- or low-free oil or fat.
- I. Irradiation
- J. Cooking at temperatures exceeding 250 deg.F.

Food Types (ref: US FDA)

- I. Nonacid, aqueous products; may contain salt or sugar or both (pH above 5.0).
- II. Acid, aqueous products; may contain salt or sugar or both and including oil-in-water emulsions of low- or high-fat content.
- III. Aqueous, acid or nonacid products containing free oil or fat; may contain salt and including water-in-oil emulsions of low- or high-fat content.
- IV. Dairy products and modifications:
 - A. Water-in-oil emulsions, high- or low-fat.
 - B. Oil-in-water emulsions, high- or low-fat.
- V. Low-moisture fats and oil.
- VI. Beverages:
 - A. Containing up to 8 percent of alcohol.
 - B. Nonalcoholic.
 - C. Containing more than 8 percent alcohol.
- VII. Bakery products other than those included under Types VIII or IX of this table:
 - A. Moist bakery products with surface containing free fat or oil.
 - B. Moist bakery products with surface containing no free fat or oil.
- VIII. **Dry solids with the surface containing no free fat or oil (no end test required).**
- IX. Dry solids with the surface containing free fat or oil.

Food Type Examples (Ref: US FDA)

Examples of Foods Corresponding to Aqueous, Acidic, and Low Alcohol (up to 15%) Food Types

I	II	IV-B	VI-A	VI-B	VI-C (max. 15% alc. by volume)	VII-B
raspberries	vinegar	milk	beer	soda	liqueurs	bread
maple syrup	juice concentrate	sweet cream (18%)	ale		distilled spirits	some cookies
consomme	fruit juice	sweet cream (40%)			most wines	soda crackers
ripe olives	mustard	cream cheese				sandwiches
boiled eggs	catsup	ice cream				muffins
cooked spaghetti	cream dressing	cottage cheese				cake
salads	apple sauce					
canned corn	salad w/ dressing					
jelly	mayonnaise					
	canned peaches					
	sauerkraut					
	pickles					

US FDA Challenge Test for PCR PET for food contact approval

- FDA suggests various surrogate chemicals that can be used in the challenge testing. These recommended surrogates represent the universe of substances accessible to the consumer that could contaminate the plastic.
- The recommended surrogates consist of (1) a **volatile polar** organic substance, (2) a **volatile non-polar** organic substance, (3) a **non-volatile polar** organic substance, and (4) a **non-volatile non-polar** organic substance. FDA requires recyclers achieve certain target levels for each of these contaminants to demonstrate that the recycling process adequately removes the contaminants.
- FDA has established target levels for the contaminants by assuming that the **rPET flakes are soaked in a solution containing the contaminants for a period of 365 days at 25°C**. Further, FDA assumes that **100% of the recycled plastic is contaminated**

Surrogates

<http://www.fda.gov/Food/GuidanceRegulation/GuidanceDocumentsRegulatoryInformation/ucm120762.htm>

Volatile Polar

Chloroform
Chlorobenzene
1,1,1-Trichloroethane
Diethyl ketone

Volatile Non-Polar

Toluene

Heavy Metal*

Copper(II) 2-ethylhexanoate

Non-Volatile Polar

Benzophenone
Methyl salicylate

Non-Volatile Non-Polar

Tetracosane
Lindane
Methyl stearate
Phenylcyclohexane
1-Phenyldecane
2,4,6-Trichloroanisole

*Not needed for PET based on establishing through testing that migration not detected.

Why These Surrogates ?

- Chloroform and toluene are components of cleaning solvents;
- Benzophenone is a suitable substitute for non-volatile polar pesticides such as Diazinon;
- Tetracosane is a good representative for the long-chain hydrocarbons that comprise motor oil.
- Copper (II) 2-ethylhexanoate is a substitute for the toxic salts commonly used in herbicides.

US FDA Challenge Test for PCR PET for food contact approval

Text and data has been removed as it contains confidential information pertaining to our Clients.

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Target Results (Ref: US FDA)

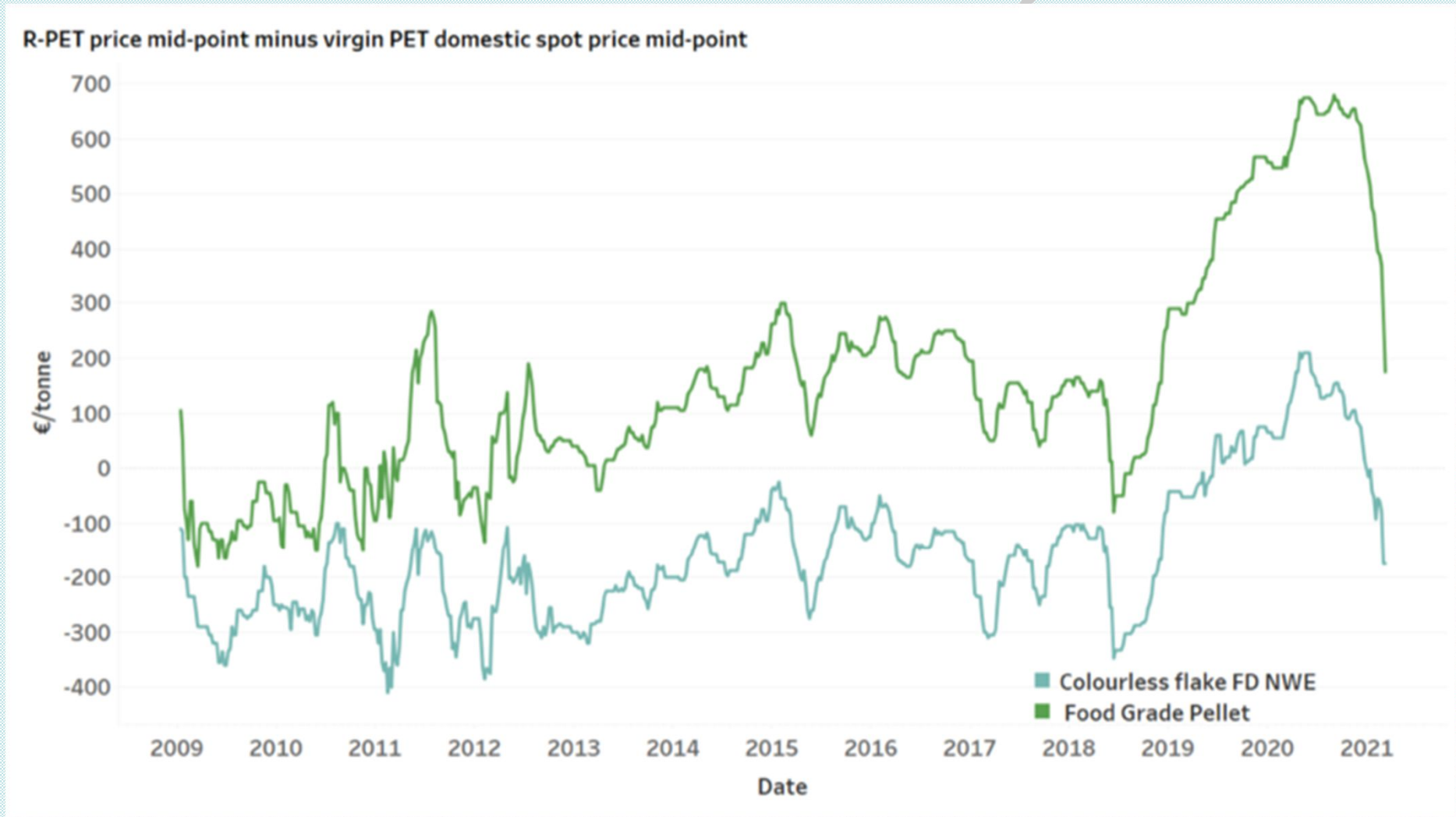
The table below reflects residue levels in several polymers that would result in an EDI of a contaminant of 1.5 micrograms/person/day. These calculations were done using a CF of 0.05 for each recycled polymer, **a container wall thickness of 0.50 mm (~0.02 in)**, and the conservative assumptions that all food types are used with each polymer and that the finished article will consist of 100% recycled polymer.

Thus, to achieve EDIs below 1.5 micrograms/person/day for recycled containers of 0.50-mm thickness, individual chemical contaminants should not be present at levels greater than those given. The calculated levels depend on the thickness of the packaging — the thicker the packaging, the lower the maximum residue levels must be to meet the 1.5 microgram/person/day EDI limit.

Recycled Polymer	Density, g/cm ³	Maximum Residue
PET	1.4	220 µg/kg
Polystyrene	1.05	300 µg/kg
PVC	1.58	200 µg/kg
Polyolefins	0.965	320 µg/kg

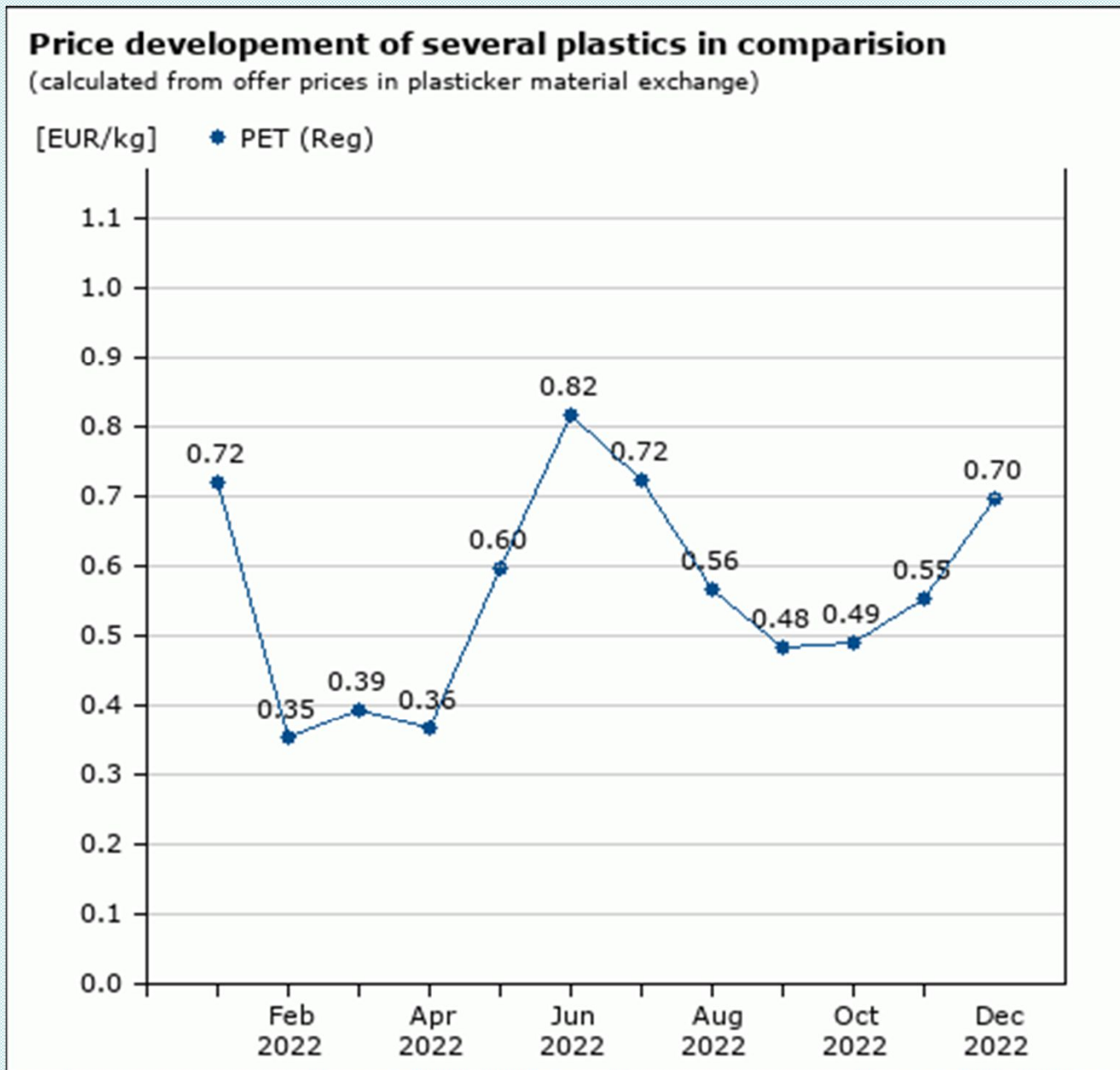
Recycled resin prices rise in Europe even as virgin resin prices drop

02-Aug-2022 — In June, clear food-grade recycled PET pellet prices were **€650 per tonne higher than virgin PET** prices, compared to €270 per tonne in January. (source *Plastics News*)



Source: *Sustainable Plastics*


**PET Flakes
Clear, hot
washed
(NWE)**



Last update of price tables: 2022-12-03, 10.00 a.m.

Recycled PET Chain Prices 1st Week Dec 22

Source: PET Scrapwala

Item	Today	Compare
PSF 1.4 Dn Export	895.68	896.54
PSF 1.4 Dn	93.23	93.32
R-PSF HT 1.4 Dn	75.24	75.32
PET Bottle Bale Regular	43.47	43.54
PET Flakes B2B Grade 1	75.54	75.65
PET Flakes B2B Grade 2	73.95	74.06
PET Flakes Grade 1	69.73	69.82
PET Flakes Grade 2	62.66	62.75
 PET Flakes Grade 3	60.01	60.10

THANK YOU

**THE FUTURE BELONGS TO THOSE WHO SEE
POSSIBILITIES BEFORE THEY BECOME OBVIOUS**

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