PREVENT WASTE ALLIANCE e-waste working group

PREVENT
Abfall Allianz

Piloting treatment solutions and innovative finance models for problematic fractions of e-waste
Technical training concepts: Waste plastics management

COMING UP TODAY

PREVENT

- Brief overview on PREVENT
- Who do we have with us and what are your challenges?
- “Plastics Identification, Sorting and Recycling” with Mario Champagne

- Questions can be posted into the “chat” section.


PREVENT
Waste Alliance
Together for a circular economy

WHO WE ARE

PREVENT

Launched in **May 2019** by the **German Federal Ministry for Economic Cooperation and Development** (BMZ).

Platform for **exchange and international cooperation** in the field of **circular economy.**

More than **200 organisations** from the

- private sector
- academia
- civil society
- public institutions.

MISSION AND VISION

PREVENT

We want to contribute to

- **minimising waste,**
- **eliminating pollutants and**
- **reutilising resources in the economy.**

We strive to **reduce waste pollution** in low- and middle-income countries through **developing functioning waste management and circular economy approaches**. We work together for **waste prevention, collection, and recycling** as well as the increased **uptake of secondary resources**. As a result, we commit to our individual responsibility for a circular economy.

OUR WORKING GROUPS

PREVENT

WG Plastics
Conservation of resources, prevention of plastic waste and development of recycling systems for plastic packaging

WG E-Waste
Establishment of take-back and recycling systems for waste electric and electronic equipment

WG Framework Conditions
Improvement of framework conditions for waste management and circular economy at municipal level

Awareness raising and behaviour change: Best Practices and recommendations

Financing mechanisms: Extended Producer Responsibility (EPR), ‘Credit’ Systems

ACTIVITIES IN THE E-WASTE WORKING GROUP

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Activities on Refurbishment to come

PREVENT- StEP WG: experiences on and improving implementation of the PIC notification process for export of e-waste fractions

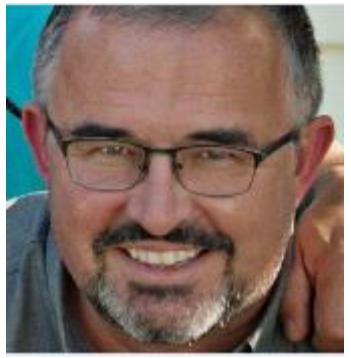
Closing e-waste cycles - PREVENT Waste Alliance (prevent-waste.net)

PRESENTATION BY

PREVENT

Mario Champagne, chemical engineer

- Technical and Audit Manager for European Recycling Platform and H2 Compliance, both part of Landbell Group
- 17 years of experience in WEEE and Batteries recycling services compliance + 16 years in chemical production industry.
- Audited 550 sites in 33 countries.



LANDBELL GROUP

DS	Facility waste management and transport packaging (DACH)
European Recycling Platform	Multinational WEEE, batteries and packaging compliance
H2 COMPLIANCE	Global consultancy for environmental and chemical compliance
LANDBELL	Take-back scheme for packaging in Germany
prodigentia	Digital compliance and take-back solutions

European Recycling Platform
A Landbell Group Company

H2 COMPLIANCE
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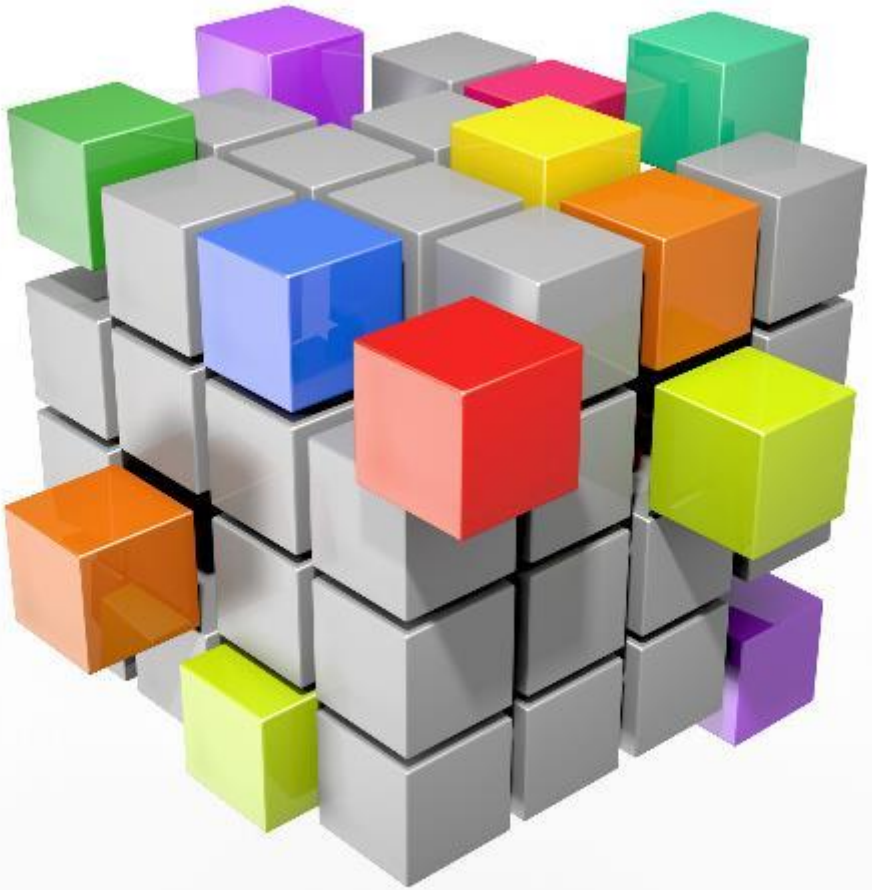
SUMMARY

1. Types of plastics
2. Chemistry and Identification Tips
3. Environmental, Health and Safety Aspects
4. Emergency Situations Management
5. Collection, Handling and Storage
6. Sorting processes
7. Management of Sorted Fractions:
    - 7.1 - Recycling
    - 7.2 - Elimination



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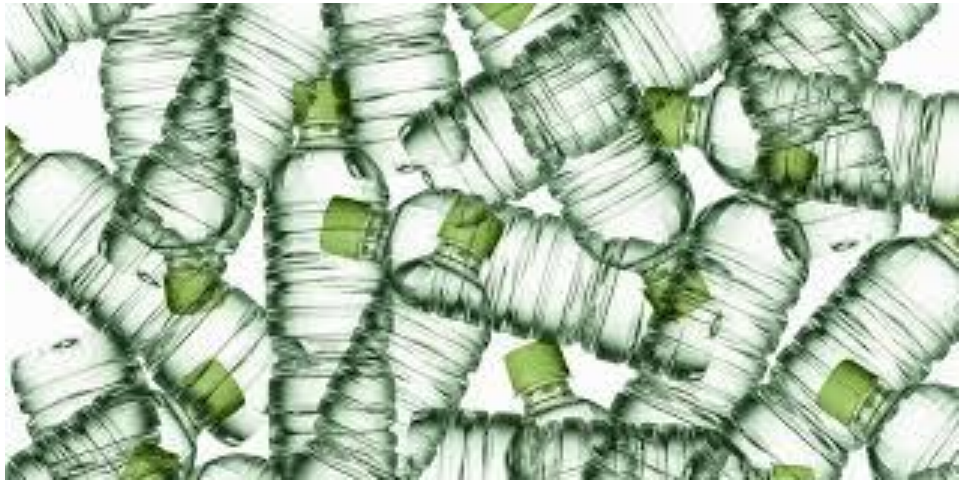
1. TYPES OF PLASTICS

- Nowadays, plastics are found and used everywhere, from packaging, to pencils, from toys to cars, from phones to refrigerators.
- Plastic Qualities: Cheap, easy to mold, solid, recyclable most of the time, which means lower CO2 emissions by avoiding use of virgin material.
- Unfortunately, it is also very found in nature and the ocean due to mankind mismanagement, lack of adequate collection system and bad habits.



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WHY IDENTIFYING AND SORTING E-WASTE PLASTICS IS GOOD FOR THE PLANET?

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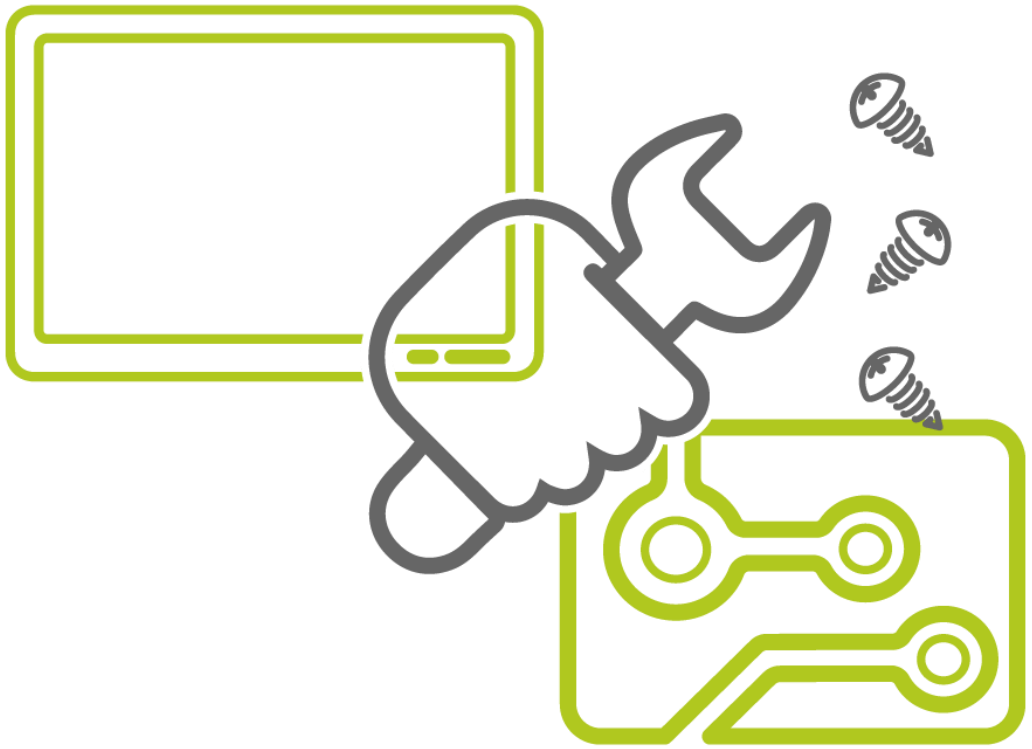
- Pre-requisite to enable safe and environmentally sound management of this material that is not natural.
  - Remove hazardous additives
  - Protect Life, Environment and Assets
  - Replace virgin materials with recyclate
  - Less CO_2 emissions and less plastic waste landfilled or lost in the nature.
- To get to profitability in recycling
  - Some plastics have value, some don't.

Sorting is easy to implement by building one's own experience which is a process relevant for the recycler in a low or a middle-income country.

But what are the types of plastics? How are they classified? What is good to know about them? Which ones have value?



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THE IDEAL PLASTICS CYCLE - WEEE

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15 types of plastics in WEEE, from cradle to grave, to be perpetually reborn again.

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WEEE PLASTICS FACTS

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Some facts* about plastics from Europe:

2.6 million tonnes per year generated:

- 1.3 million tonnes of WEEE plastics collected
- 1 million tonnes sent to WEEE plastics recyclers or smelters for the one on printed circuit boards.
- 300 000 tonnes sent for:
  - Incineration (destruction, recovery of energy or substitute fuel in the cement furnace.
  - Lost in metal fractions due to the lack of efficiency of the separation process
  - Landfill (negligible)

Half of WEEE plastics are lost, not going through official channels:

- recycle bin
- processed in substandard recycling facilities
- fly tipping
- exported.

- WEEE plastics represent, on average, 25% of all WEEE generated annually by weight and consist of a complex mixture of different polymers containing a wide range of additives.

* Data source : Study on the Impacts of Brominated Flame Retardants on RECYCLING WEEE Plastics in Europe by Arthur Haarman, Federico Magalini, Joséphine Courtois for SOFIES, November 2020

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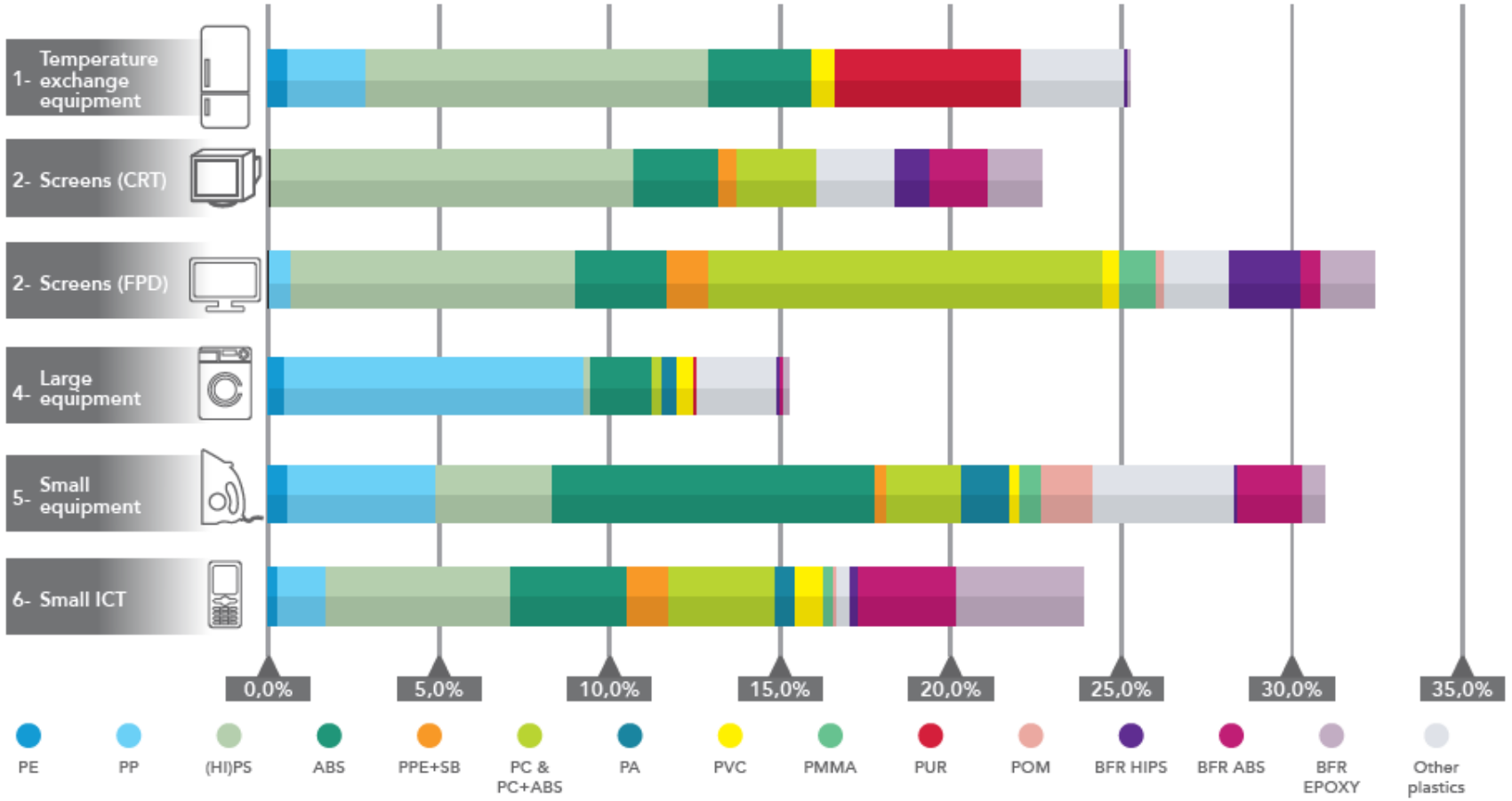
PLASTIC FRACTIONS - WEEE

Figure 3: WEEE plastics composition, per category. FPD refers to flat panel displays monitors and TVs but also, in the scope of this study, laptops and tablets.



- ABS, PP, (HI)PS and PC-ABS are the most found polymers in WEEE, representing 75% of all WEEE plastics.
- 25% consists of various polymers, including PUR, PA and PVC, etc.
- More than 800 data points have been compiled in total, many sources including published study, batch tests provided by WEEE recyclers, WEEE plastic recyclers and compliance schemes.

Data Source : Study on the Impacts of Brominated Flame Retardants on RECYCLING WEEE Plastics in Europe by Arthur Haarman, Federico Magalini, Joséphine Courtois for SOFIES, November 2020

PLASTIC FRACTIONS - WEEE

- Plastics are the main components of WEEE, but the problem faced by recyclers is the large number of types of plastics with very different properties that depend on the content of chemical resins and the presence of additives that are incorporated to improve specific properties:
- Flame retardants (more than 45 types)
- Fillers
- Pigments
- Stabilizers

Examples:

brominated fire retardants

lead (Pb) for cables stability, to make sure that that plastic doesn't fall apart or turn brittle."

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2. CHEMISTRY AND IDENTIFICATION TIPS

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Plastics are generally classified into three types based on their characteristics:

Thermoplastic

A thermoplastic is a plastic polymer material that becomes flexible or moldable at a certain high temperature and solidifies during cooling process.

Easily recyclable.

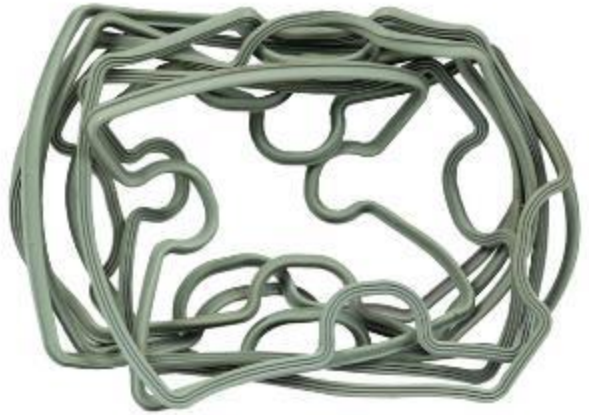
Thermosets

The transformation of a thermosets material involves polymerization, which is irreversible and results in a solid finished product, usually rigid.

This material is not transformable, which prevents its recycling.

Elastomers

An elastomer is a polymer that exhibits "elastic" properties, obtained after crosslinking. Supports very large deformations before breakage. The term rubber is a common synonym for elastomer.



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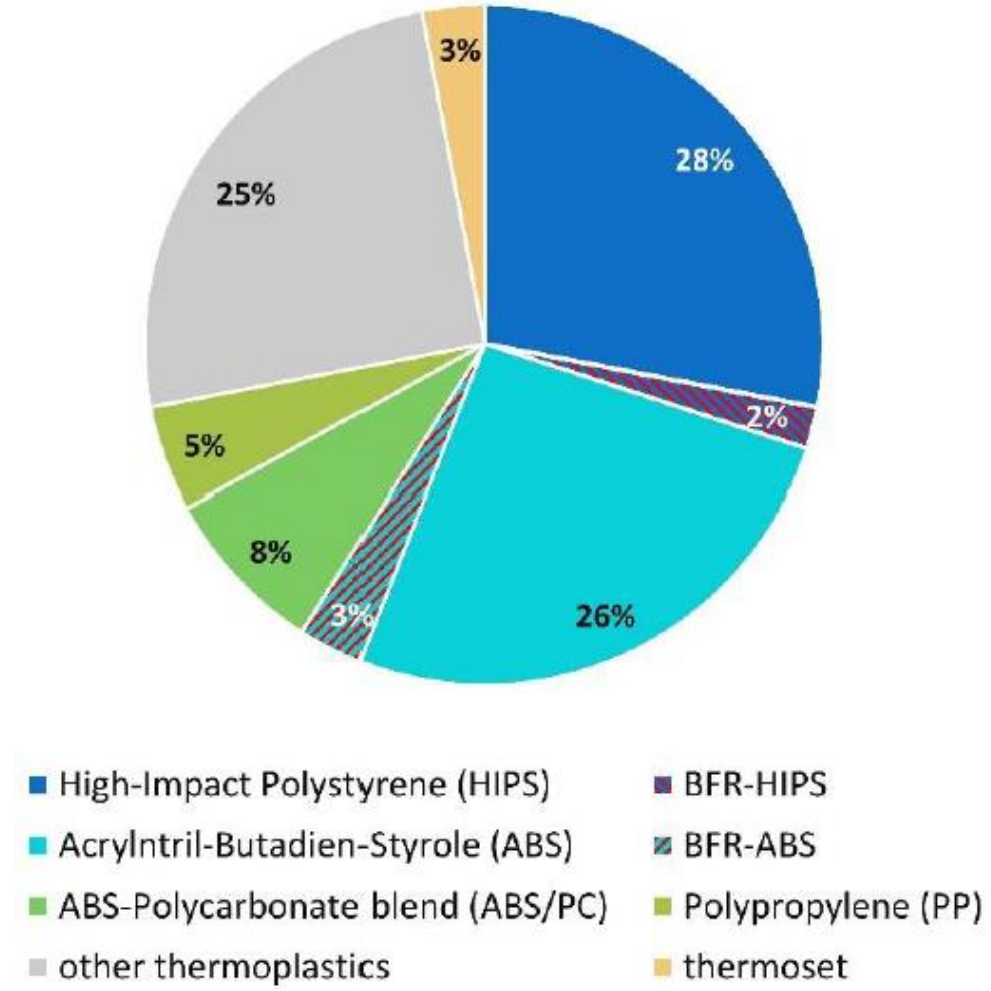
WEEE PLASTICS

- Generally, thermoplastics are found in many WEEE, a fraction that can be easily recycled because it can be melted and molded again.
- Generally, 15 types of plastics observed in the composition of the WEEE.
- Manufacturers of goods wish to get clean sorted plastic loads, when they accept secondhand materials, as this ensures better quality of the final products in their manufacturing process.
- With well sorted plastics, loads of quality, manufacturing processes will produce quality products with reliable characteristics in terms of durability, hardness, flexibility and visual aspects.

Main types of plastics found in WEEE*



* Plastic composition determined by: C. Slijkhuis, WEEE Plastic recycling requiring a sensible and practical approach in POPs, in: Going Green Care Innovation 2018

A QUICK LOOK AT THE PACKAGING CASE: PLASTIC INDUSTRY SOCIETY CODE (USA, 1988)

PREVENT

1. POLYETHYLENE TEREFTALATO (PET)It is the most common plastic, found in refrigerant bottles and packaging for the food industry. This plastic recycles very well.
2. HIGH DENSITY POLYETHYLENE OR HIGH-DENSITY POLYETHYLENE (4)Often used for bottles of household products; represents 50% of the plastic bottle market.
3. POLYCHLORINATION OF VINYL (PVC)Used in most supermarkets to pack cheese and meat, despite its widespread use, this plastic is poorly recycled because it releases dioxins and carcinogens.
4. LOW DENSITY POLYETHYLENE OR LOW-DENSITY POLYETHYLENE (LDPE) Used for some plastic bags and packaging.
5. POLYPROPYLENE (PP) Widely used worldwide, it is used for certain children's cups, food containers such as yogurt pots, microwave dishes or even medical packaging, car parts.
6. POLYSTYRENE (PS)Single-use packaging for cold meats and meats, ice cream and vegetables, appliances, cups, etc.
7. OTHER Any plastic other than those named from 1 to 6, e.g., polycarbonate-based plastics or containing various types of plastics.

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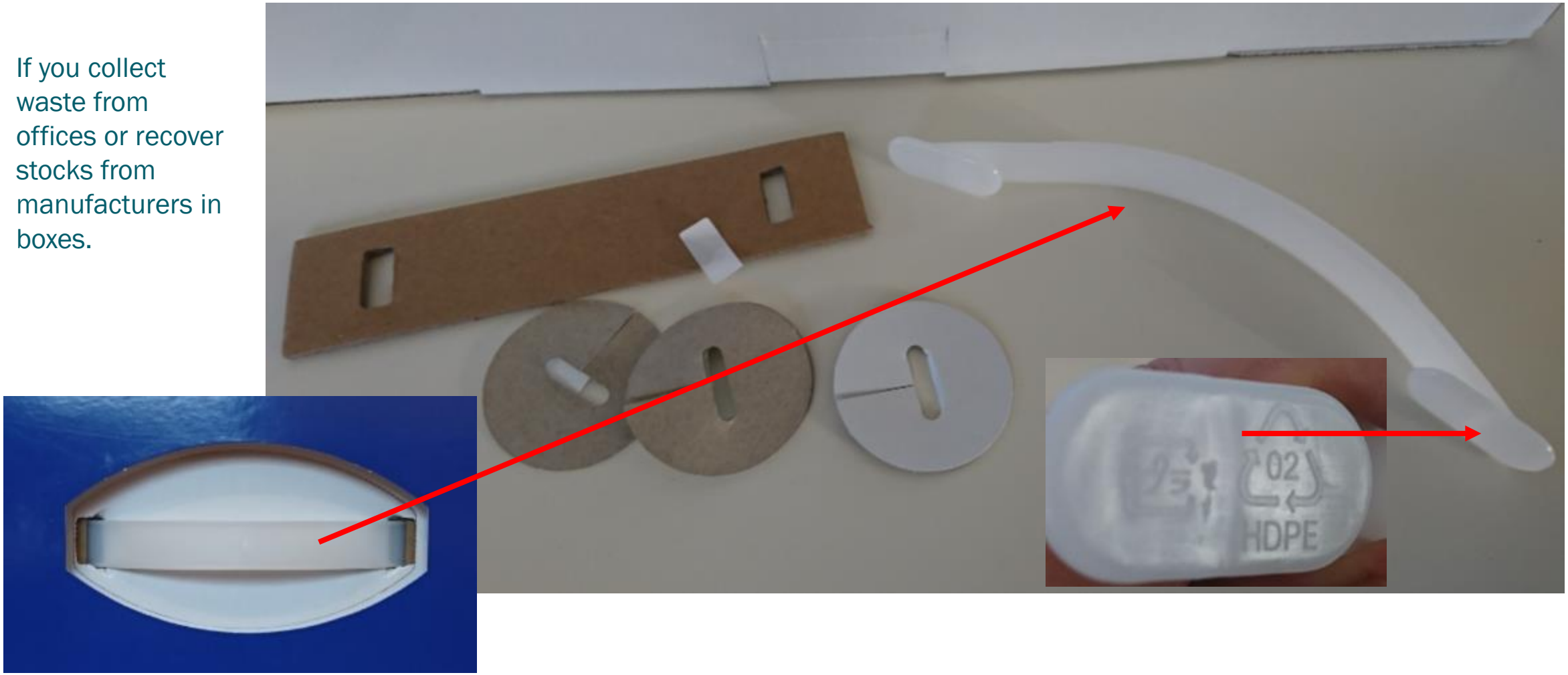
EXAMPLE : WEEE PACKAGING PLASTICS

If you collect waste from offices or recover stocks from manufacturers in boxes.



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MARKING OF EEE PLASTICS

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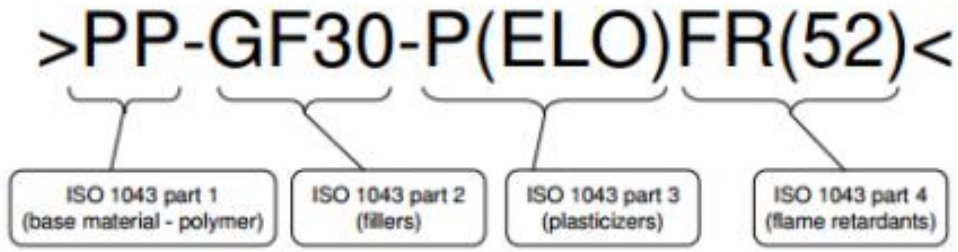
- ISO/DIS 11469 Plastics - Generic Identification and Marking of Plastic Products
- ISO-1043-1 through ISO-1043-4 - Plastics - Symbols and specify the requirements for generic marking of polymers.

- **HOWEVER: Markings are often not reliable as cheaper products will be made using the same mold and not so meticulous manufacturers will not pay attention to markings.**
- **Additional checks may be needed that we will discuss later.**

- If the size of the piece, geometry, and cosmetic and effective function permit, all plastic parts and products must be physically marked with the appropriate symbols or codes (identified in the tables within these standards) to designate the following characteristics:
- Basic polymer in part
- Flame retardant material used
- Filling or reinforcement used to manufacture the part
- Plasticizer used
- Recycled content

- **ID material : ex: >ABS <**
- **Polymer mixture : ex >PC+ABS <**
- **Laminates : e.g. >PVC,PUR,ABS <**
- **Flame Retardant: e.g., >PC-FR(40) <**
- **Filling and reinforced composition : e.g. >PS-HI-GF10< 10% fiberglass**
- **Plasticizer: ex: >PVC-P(DBP) <**
- **Recycled content: e.g. >ABS(REC85)< 85% of recycled content**

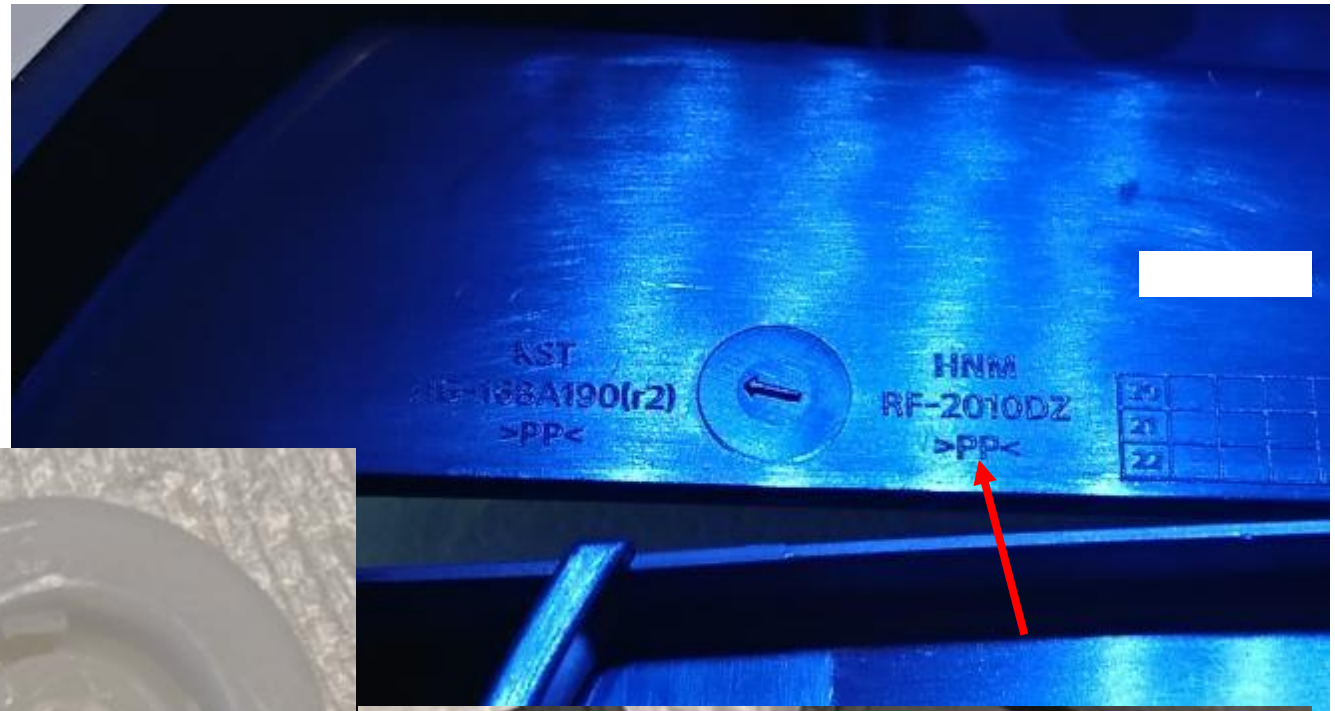


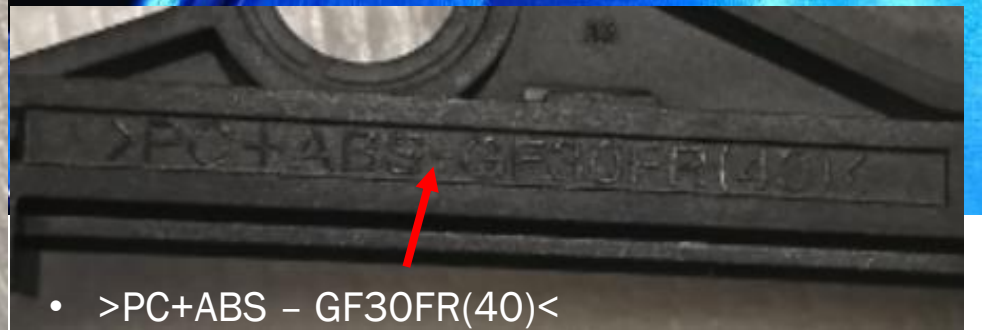
>MARKING< EEE/WEEE PLASTICS

Examples of the most common types of plastics found in WEEE are:

PS, ABS, PP, PE, PC, POM, elastomers and thermosets

POM





- >PC+ABS – GF30FR(40)< polymer mixture with FR (flame retardant halogen-free - organic phosphorus compounds)

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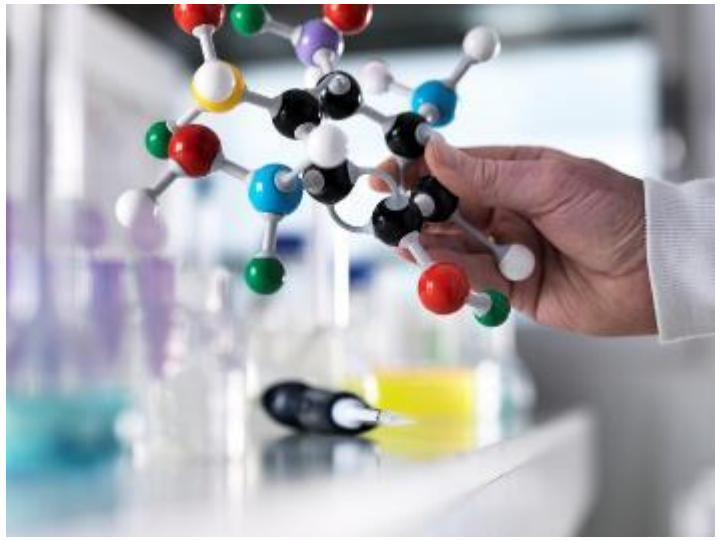
ADDITIVES

- Additives and fillers are organic or inorganic compounds that are introduced into a plastic in order to change the properties of plastic
- Although most plastics in their original form are impact resistant and durable, they are often brittle, hard, combustible or too heavy for intended use.



That is mainly why these additives below are added to improve the properties of plastic polymers.

- Flame retardants,
- Fillers
- Pigments
- Stabilizers

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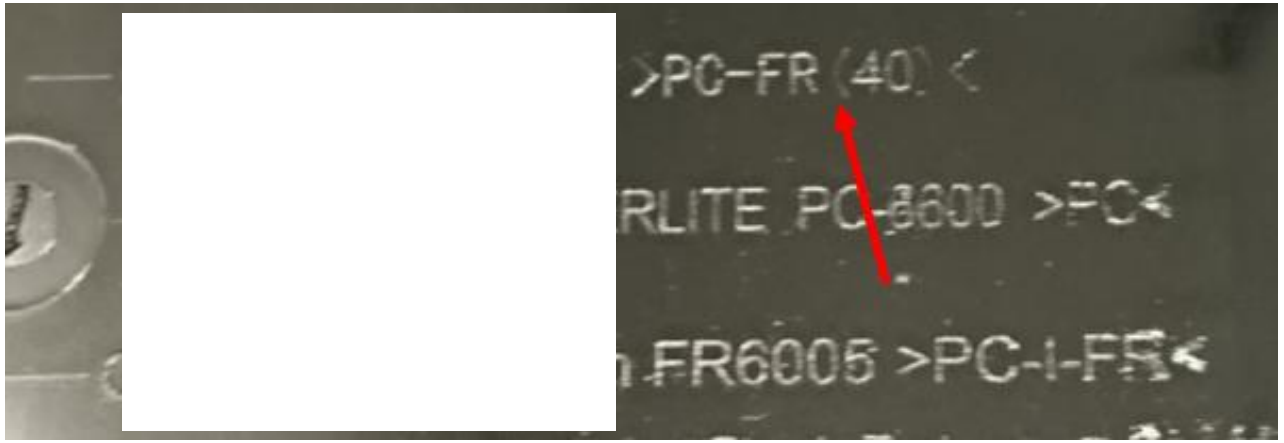
ADDITIVES: FIRE RETARDANTS

- Fire retardants reduce the flammability of plastics exposed to high heat source.
- Bromine fire retardants are generally included as an ingredient for power supply enclosures, optical readers and cathode ray tube monitor housing.
- These are classified as toxic and need to be disposed of in hazardous waste incinerators in Europe - an option often not available in low- and middle-income countries. It is important to sort these out of the recycling stream.
- Since many years, the threshold was 2000 ppm, now 1000 ppm.



- GF30: 30% of glass fibers.
- FR (40) : Flame retardant - organic phosphorus compounds without halogen

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POPS– STOCKHOLM CONVENTION

PREVENT

- Polybrominated diphenyl ethers (PBDEs) have been used extensively as flame retardants in the plastic components of electronic and electrical equipment (EEE).
- PBDEs are listed in the Stockholm Convention on Persistent Organic Pollutants (POPs).
- POPs are organic chemical substances that persist in the environment, bioaccumulate through the food chain, and pose a risk of causing adverse effects to human health.
- TetraBDE, pentaBDE, hexaBDE and heptaBDE were listed as POPs in 2009 and decaBDE was added in 2017.
- The EU POPs Regulation has implemented the Stockholm convention and sets a maximum concentration limit (MCL) of 1,000 mg/kg for the total concentration of tetraBDE, pentaBDE, hexaBDE, heptaBDE and decaBDE in waste material. (threshold aligned with Regulation (EU) 2019/1021)
- When items containing POPs above the MCL become waste, they must be treated in such a way that the POPs are destroyed or irreversibly transformed.
- Although the use of PBDEs in EEE was banned from 2007/8, and many manufacturers had voluntarily phased them out before this, POPs are still be present in WEEE arising today.

ADDITIVES: PLASTICIZERS

- A plasticizer is a substance that is added to a material to make it softer and more flexible, to increase its plasticity, to decrease its viscosity, or to decrease friction during its handling in manufacturing.
- Plasticizers are commonly added to polymers such as plastics and rubber, either to facilitate the handling of the raw material during manufacturing, or to meet the demands of the application of the final product.
- For example, plasticizers are commonly added to polyvinyl chloride (PVC), which is otherwise hard and brittle, to make it soft and flexible; which makes it suitable for products such as vinyl flooring, clothing, bags, hoses and electric wire coatings.

- Almost 90% of polymer plasticizers, most commonly phthalate esters, are used in PVC, giving this material greater flexibility and durability.
- Most are used in films and cables.

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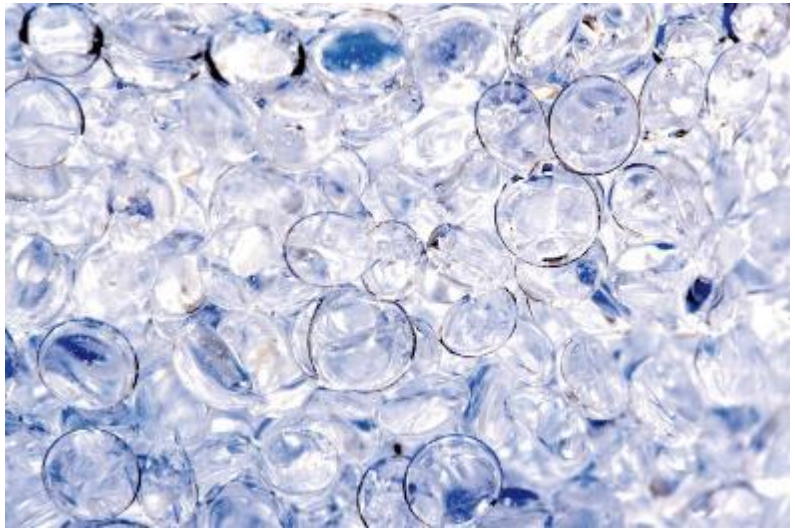
ADDITIVES: FILLERS

- Fillers are often added to polymers to lower their price.
- Generally, such fillers are finely ground inorganic materials, such as:
- Calcium carbonate, talc, silica, wollastonite, clay, calcium sulfate fibers (also known as franklin fibers), mica, glass beads and alumina trihydrate.

- As a result of the presence of filling, the mechanical properties of the material are changed



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ADDITIVES: PIGMENTS

- Plastics (resin) are almost colorless (milky white). Dyes such as pigments are added to produce plastic products in various colors.
- There are approximately two staining methods: external staining (surface) and internal (mixed) staining.

- Cadmium pigments

- Pigments are insoluble organic or inorganic particles added to the polymer base to give a specific color or functional benefits to plastic.
- Pigment families are mainly categorized into:
- Organic pigments
- Inorganic pigments
- Carbon black
- White pigments
- Special effect pigments
- Aluminum pigments

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ADDITIVES: STABILIZERS

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- Stabilizers are "intentional additives" used to prevent environmental effects (heat, UV light, etc.) on the polymer.
- They are added to plastics to allow protection against heat (thermal), UV and mechanical degradation of the polymer during processing and use.
- Due to polymer chain splitting, uncontrolled recombination and cross-linking, many key properties such as strength, malleability, appearance and color are affected over time without it.

- They allow plastic items to be produced faster and with fewer defects, extend their service life and facilitate their recycling.

<u>Also known as:</u>

Antioxidants

Antiozonants

Light stabilizers

Heat stabilizers

Antacids

Biocides

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WHAT IS IMPORTANT TO RETAIN HERE ?

PREVENT

- Plastics are transformed materials that may come in multiple form of recipes due to additives that will give them special features.
- We are facing a complex mixture of many materials.
- Red color may be associated to cadmium pigments. Cadmium is a heavy metal.
- Plastic generally in contact with source of heat may have been protected by addition of brominated fire retardants that may potentially identified by a marking >FR<, or not.
- BFR plastics needs to be destroyed according the Stockholm convention when they meet the established threshold.
- Large plastics parts are marked but can’t always be trusted.

- We need to have more knowledge on plastic types to recognize them.
- Let’s look per type.

TYPE : ACRILONITRILE BUTADIENE STYRENE- ABS

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...and ABS/PC mix.

Most famously used in LEGO bricks, ABS is notable for being very lightweight, while being extremely durable and shock resistant.

It can be found in:

- Vacuum cleaner housing
- Large parts that need to support shocks.
- Monitors housing that may contain BFR (CRT)

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TYPE: HIGH IMPACT POLYSTYRENE - HIPS

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- Found in appliance components, toy parts, TV and audiovisual equipment, computer boxes, refrigerator wall sheets.
- If the piece doesn't have to cope with heat, BFR free.

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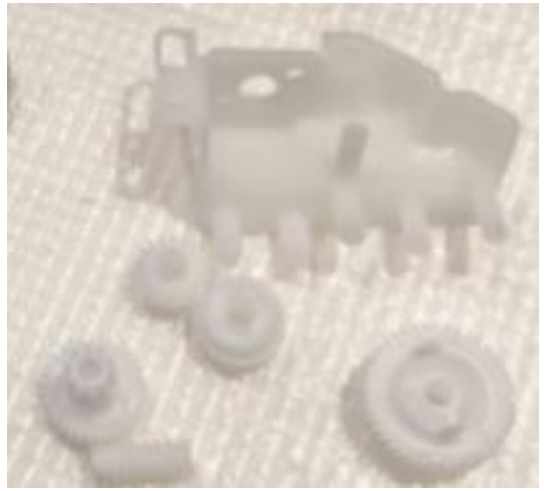
TYPE: POLYOXYMETHYLENE - POM

- Also known as acetal, polyacetal and polyformaldehyde, it is an engineering thermoplastic used in precision parts.
- Usually white, easy to recognize.
- Soft plastic
- Not always indicated due to the shape.
- We often see in mechanical system, as computer disk readers.
- BFR free in general



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TYPE: POLYPROPYLENE - PP

- Polypropylene is a very flexible and soft material with a relatively low melting point.
- It doesn't cut clean.
- Polypropylene also has low density compared to other common plastics.
- Often use as hinge for lids, flipping covers which don’t contain BFR

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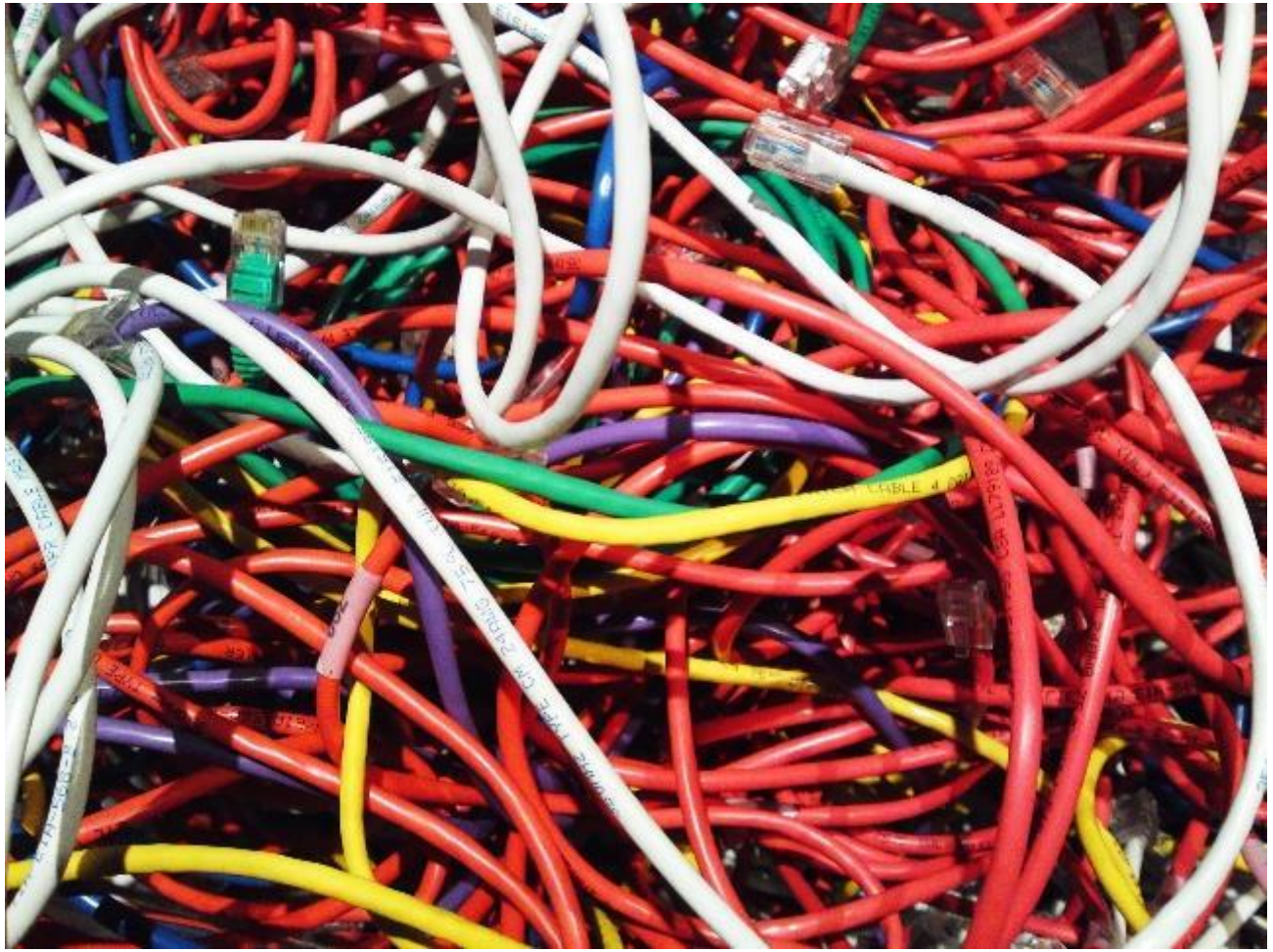
TYPE: POLYETHYLENE – LDPE & HDPE

- Polyethylene is used in applications ranging for films, tubes, plastic parts, laminates, etc.
- Insulation of wires and cables.
- No BFR



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TYPE: POLY VINYL CHLORIDE - PVC

Cables

- It can be made softer and more flexible by adding plasticizers, the most used being phthalates.
- It may contain lead stabilizers, but calcium and zinc stabilizers are also used.
- No BFR
- Burning cables to get metals is a total " No go"! Doing this may release toxic gas to the environment.
- Instead of burning cables, shredding is recommended, allowing separation of plastics and metals.
- Ex: https://www.youtube.com/watch?v=Bex1l-NCFyQ
- To be recycled, the sheathing and the insulation of electrical cables, after being separated from the conductor, may be subjected to a mechanical process called micronisation. The micronised PVC is sold on the market to be used in suitable applications to produce new products.
- Sold as powder, with higher reactivity when it is in this state.
- PVC from cable is recyclable, can be used in flooring mat, and other PVC product.

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TYPE: POLYCARBONATE - PC

- Transparent, strong and rigid thermoplastic with excellent impact resistance.
- No BFR

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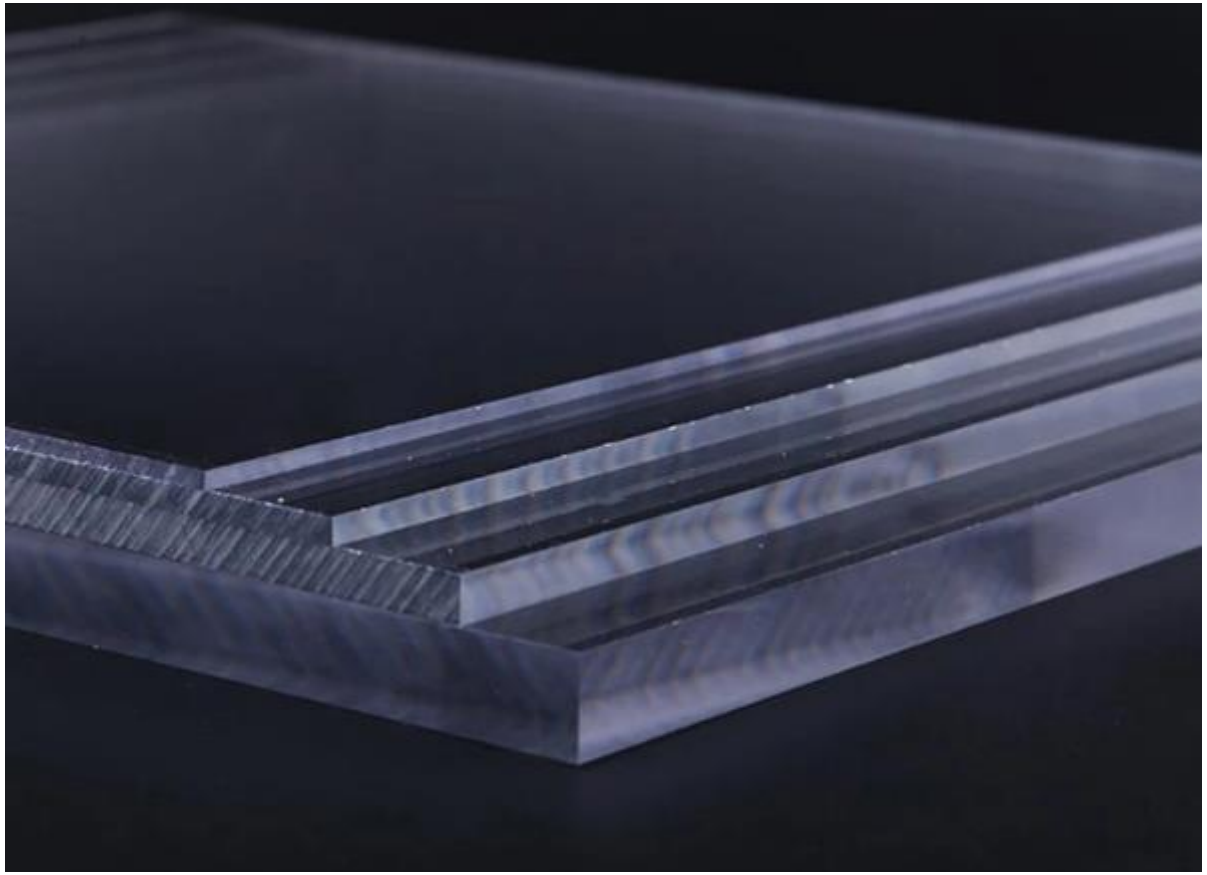
TYPE: POLY (METHYL METHACRYLATE) - PMMA

- Also known as acrylic, acrylic glass, Perspex or Plexiglass.
- PMMA is often used as a lighter, shatter-resistant alternative to glass.
- Most found as large boards on flat panel displays.
- It sells at a very good price per tonne
- BFR free



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TYPE : POLYAMIDE - PA

- PA is a synthetic thermoplastic polymer commonly used in injection molding applications.
- Same family : Nylon, Kevlar
- It also often features in the production of items that require both strength and flexibility, including electrical connectors, gears, cables and wire protection.
- Nylon polyamide has a density of about 1.31 g/cm3

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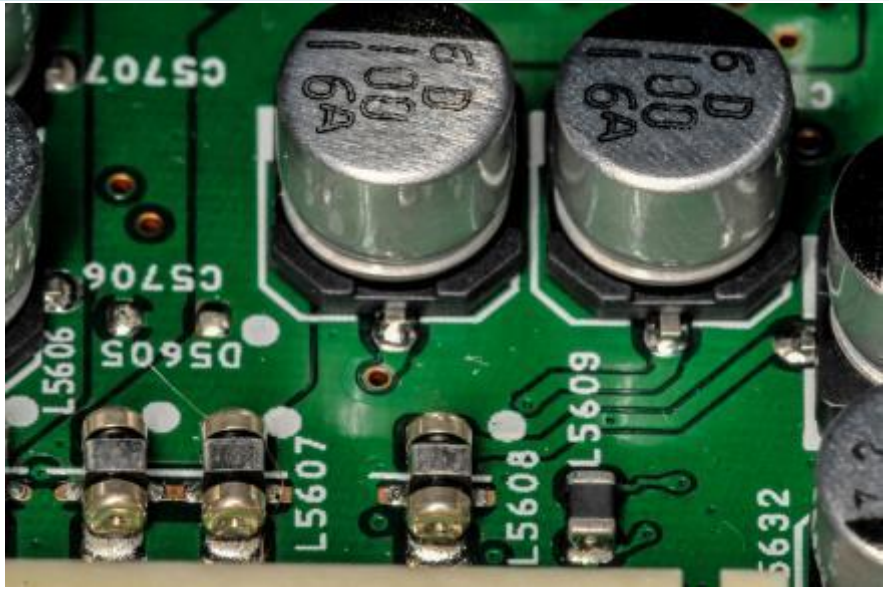
TYPE: EPOXY RESIN

- Printed circuit boards are generally an assembly of electronic components attached to an epoxy resin board.
- Flame retardants are present in these boards, and they are generally sacrificed in the smelting process as an energy source. It can't be recycled but recovered as energy.
- Smelters must have adequate pollution control abatement system to recover some potential dioxins and furans emissions.
- Burning Printed Circuit boards to get precious metals is a total " No go"! Doing this release heavy metals to the environment, but also POPS that will bioaccumulate in the life chain, leading to disaster for the health of many population of living organisms, including men.
- Aqua Regia (Acid baths) for treatment of printed circuit boards is highly polluting and may lead to poisoning of individuals. Another "No go"!



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CONCLUSION ABOUT PLASTICS

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- We saw that some plastics have potentially toxic metals in them such as cadmium, lead and POPS.
- Diverting these substances from nature will keep them away drinking water sources and limit impact to the environment.
- Most plastics can be recycled, which means potentially valuable material can be reclaimed
- Recycling plastics minimizes the need to use virgin resources and protect the habitat.
- Reduce carbon footprint of manufacturing process.
- But there is also some money to make from it, which means creation of richness.

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POTENTIAL PROFITABILITY

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Table 2: Standard plastics price according to plasticker; listed in €/t.

	October[6] 21	Sept. 21	August 21	July 21	June 21	Sept. 20
HDPE regrind[1]	610	620	630	600	640	490
HDPE regranulates[5]	930	830	920	930	1040	700
LDPE bale goods[2]	240*	290*	270*	240	270*	170
LDPE regrind[1]	340*	380	420	450	470	430
LDPE regranulates[5]	780	690	700	720	980	590
PP bale goods[3]	430*	0*	0*	200*	260*	450*
PP regrind[1]	720	620	570	560	620	490
PP regranulates[5]	1230	930	880	910	1130	720
PS regrind[4]	760*	700*	650*	600	700*	540
PS regranulates[5]	970	890	850*	960	1470	790
PVC_P regrind[1]	310*	270*	400*	350*	290*	460*
PVC_U regrind[1]	0*	50*	540*	520*	570*	290*
PET bale goods	380*	180*	160*	200	70*	90*
PET regrind mixed colours	450	420	440	480	430	300
Average Price	**(582)**	**491**	**531**	**551**	**639**	**465**

- Data source : https://plasticker.de/preise/marktbericht2_en.php?id=221

- Old fridges: 80% HIPS/ 20% PP

Table 3: Technical plastics price according to plasticker; listed in €/t.

	October[6] 21	Sept. 21	August 21	July 21	June 21	Sept. 20
ABS regrind	700	660	630	630	640	550
ABS regranulates[5]	2030	1900	2390	2280	2410	1030
PC regrind	950	930	1000	860	1030	850
PC regranulates[5]	2440	2410	2130	1980	1910	1700
PBT regrind	620	710	560	540	610	440
PBT regranulates	2080	2200	2440	2080	2140	1770
PA 6 regrind	1020	1060	970	900	950	810
PA 6 regranulates[5]	2400	2420	2310	2420	2320	1810
PA 6.6 regrind	1040	1070	1040	930	1010	870
PA 6.6 regranulates[5]	2880	2570	2550	2830	2910	2110
POM regrind	710	700	650	690	600*	560
POM regranulates[5]	2790	2780	2160	2250	2480	1310
Average Price	**(1638)**	**1618**	**1569**	**1533**	**1584**	**1151**

[5]: equivalent to the grade "regranulates, black"; [6]:preview (may be amended by additional quotes).

Getty image

3. ENVIRONMENTAL, HEALTH AND SAFETY ASPECTS

- As for all industrial activities, safety gears are recommended to prevent any accident.
- Health and environment: the burning of plastics is not recommended due to potential toxic emissions, especially with the presence of fire retardants, chlorine release (PVC), potential dioxins emissions and presence of other persistent organic pollutants.
- Handling of plastic pieces with gloves is recommended especially in cases where the loads have been stored in areas where wild animals may have come around an contaminate loads with feces and urines, vector of some diseases. Ex: Leptospirosis that may lead to renal disfunction.

Getty image

4. EMERGENCY SITUATION MANAGEMENT

- The main risk with plastics is scattered contamination of the site area, due to fire that will release “POPS” and toxic combustion by-products.
- The facility should think of storage areas to avoid having sources of fire and sparks in the same area.

  example: Do not stock plastic waste loads near lithium batteries.
- Implement a storage plan to enforce discipline across teams
- Water fountain, water tanks with pumps, fire extinguishers.
- Evaluate the containment of fire fighting water contaminated which is contaminated by the product of combustion.
  - To avoid releases in rivers or drinking water sources.
- Compatibility of Stored Materials to be evaluated
- Inform local emergency fire brigades about the storage plan. Be proactive! They can provide advices! This can help reduce intervention time.
- Organize a local intervention team (provide training) that will intervene while firefighters are on their way.

Getty image

5. COLLECTION, HANDLING AND STORAGE

- Determine a storage plan to avoid mixing other waste with plastics and to ensure to not mix unsorted plastics with the sorted ones.
- Avoid direct storage over the soil, leading to dirt build-up and plastic contamination
- Some studies claim that long-term storage over soil of plastics containing flame retardants can lead to leaching of contaminants in nature.
- Long term storage under sunlight will degrade the polymeric chains.
- Storage inside or covered is recommended to keep it clean.

Getty image

6. SORTING - WHAT PLASTICS SHOULD I SORT FOR RECYCLING?

PREVENT

- Get to know compounders or manufacturers in the area and small medium enterprises developing projects .
  - The compounders will transform the plastic in a format ready for molding machines.
  - Manufacturers get supplies from compounders.
- What are their needs? Align with their priorities.
- Is there collection network feeding compounders for producers?
- Study the market for pricing.
- What are alternative use for plastics?
- Profitability? Look at pricing evolution.
- Permits needed?

6. SORTING - WHAT PLASTICS SHOULD I SORT FOR RECYCLING?

The classification process selected will depend on several factors.

- Inventory availability and storage capacity
- Labor / energy cost
- Investment capacity
- Local specifications of compounders for second-hand raw materials
- Level of contamination

Sorted as :

- similar bulk parts (baled)

- flakes (shredded)

In Europe, the trend is to have the WEEE plastics transform in flakes and sent to third parties with processes to separate plastics.

- Per Type BFR/non BFR,
- Per chemistry.

Getty image

6. CLASSIFICATION - MANUAL PROCESS

Manual process

Manual dismantling /visual classification based on knowledge of the appearance and marking of the material is the fastest way, but there is a learning curve.

Some other specific tests can be applied by dismantlers, as suggested by the "EMPA classification methodology", but some steps could be difficult to implement as a continuous process.

To be used when there is a doubt about the nature of the material.

- Disc readers

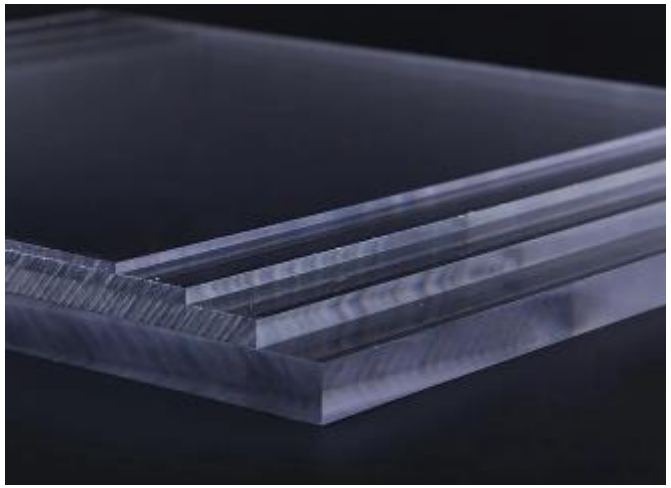
- Try working on lots of similar > - generating loads of similar plastic polymer parts

Getty image

6. SORTING - QUICK WINS

Examples of quick wins on sorting processes:

- PMMA flat panel monitors
- CRT plastic housing: attention: BFR plastics (45 different types possible). Mainly ABS/HIPS, PC/ABS ->disposal recommended for BFR types.
- But analysis or tests can help classify what's good or not. We will develop this!
- Cables : PVC, PE
- Computer: Polycarbonate fractions, POM gears (white plastic)



Getty image

6. SORTING - TECHNOLOGY

Manual process

- Manual dismantling and special analyzer to detect to the nature or presence of contaminants.
- Laser technology that identifies chemical components regardless of the color of plastics: light, dark or even black.
- Raman spectroscopy and Raman micro spectroscopy are nondestructive methods of observation and characterization of the molecular composition and external structure of a material, which explores the physical phenomenon according to which a medium slightly modifies the frequency of light circulating in it.
- NIR - Near infrared spectroscopy, often referred to by its acronym NIRS, is a technique for measuring and analyzing reflection spectra in the wavelength range of 0.78 to 2.5 µm
- Price tags: see websites but count many thousands of Euros, if you have the budget. (3k- 5 k€) but some are much more expensive. And you need to verify with makers if good for all plastics.
- Nice to have but there are other ways.

- https://www.nir-industry.com/polymax-plastics-analyzer/?lang=en

- https://www.thermofisher.com/order/catalog/product/MICROPHAZIRPC#/MICROPHAZIRPC

- Images nir-industry.com, thermofischer.com

6. SORTING VS BFR– STOCKHOLM CONVENTION

The EU POPs Regulation has implemented the Stockholm convention and sets a maximum concentration limit (MCL) of 1,000 mg/kg for the total concentration of tetraBDE, pentaBDE, hexaBDE, heptaBDE and decaBDE in waste material. (threshold aligned with Regulation (EU) 2019/1021)

When items containing POPs above the MCL become waste, they must be treated in such a way that the POPs are destroyed or irreversibly transformed.

- Can I detect them?
- Some instruments will detect presence of bromine, and it is a way to discard them rapidly.
- Also we saw that plastics with BFR :
  - was often used in old CRT monitors housing.
  - but can be found around power supplies
  - optical readers
  - where there are sources of heat.
  - Were sometimes marked with >FR<
- But we already mentioned that marking may not be always accurate due to non meticulous mold management .

6. SORTING VS BFR – LABORATORY ANALYSIS

- Analysis of gas chromatography mass spectrometry (GCMS) to identify bromine compounds present in plastic, with special emphasis on POPs-PBDEs.
- This technic can be used on a sample of processed plastic considered clean to check residual contamination and establish whether the load is below or above the MCL.

- EN 15002 Sample preparation

EPA 5050 -1994 METHOD OF PREPARING PUMPS FOR SOLID WASTE This method describes the sample preparation steps required to determine the total chlorine in solid waste by oxidation and titration of pumps or ion chromatography.

Or for bromine, sample digestion and subsequent analysis should be performed according to EN14582. This standard specifies a combustion method for the determination of halogen and sulfur content in materials by combustion in a closed system containing oxygen (calorimetric pump), and subsequent analysis of the combustion product using different analytical techniques.

EPA 9056A-2007 DETERMINATION OF INORGANIC ANIONS BY ION CHROMATOGRAPHYIEC 62321-6:2015 June 2015 - Determination of certain substances in electrical engineering products - Part 6: Polybrominated biphenyls and polybrominated diphenyl ethers in polymers by phase chromatography mass spectrometry

(GC-MS) - ANALYSIS OF THE PRESENCE OF RETARDANTS OF FIRE BFR IN PLASTIC MATERIALS

6. SORTING - ALTERNATIVES

Other "low tech" sorting methods based on:

- Flexibility/breakage: manual process, visual observation of effects
- Sound emitted when hitten : manual process
- Density : The sink/flotation process is widely used industrially, with different tanks series with various densities. But it can be used for small homemade batch systems.
- Reaction with solvent:
  - **Acetone on ABS -PS : sticky result : manual process**
  - **Acetone on PC & PC-ABS : white marks, visual process**
  - **Limonene at PS & HIPS : Sticky, manual process**
- Smell when burning: Well, forget it! (It should be avoided due to toxic gases released)

*Ideas from EMPA, Research Institute from Switzerland, https://www.sustainable-recycling.org/wp-content/uploads/2019/12/Plastic-Handbook-Final.pdf

6. SORTING - BY DENSITY

PREVENT

Density (e.g. sink/float process)

Use physical properties to segregate types of plastics.

Create a salty solution with the help of the attached table.

Make sure the surface is clean, as dirt will affect the behavior of the parts.

In addition, attached pieces of foam, rubber, metals can create abnormal behavior (floating or sinking)

Some tools here:

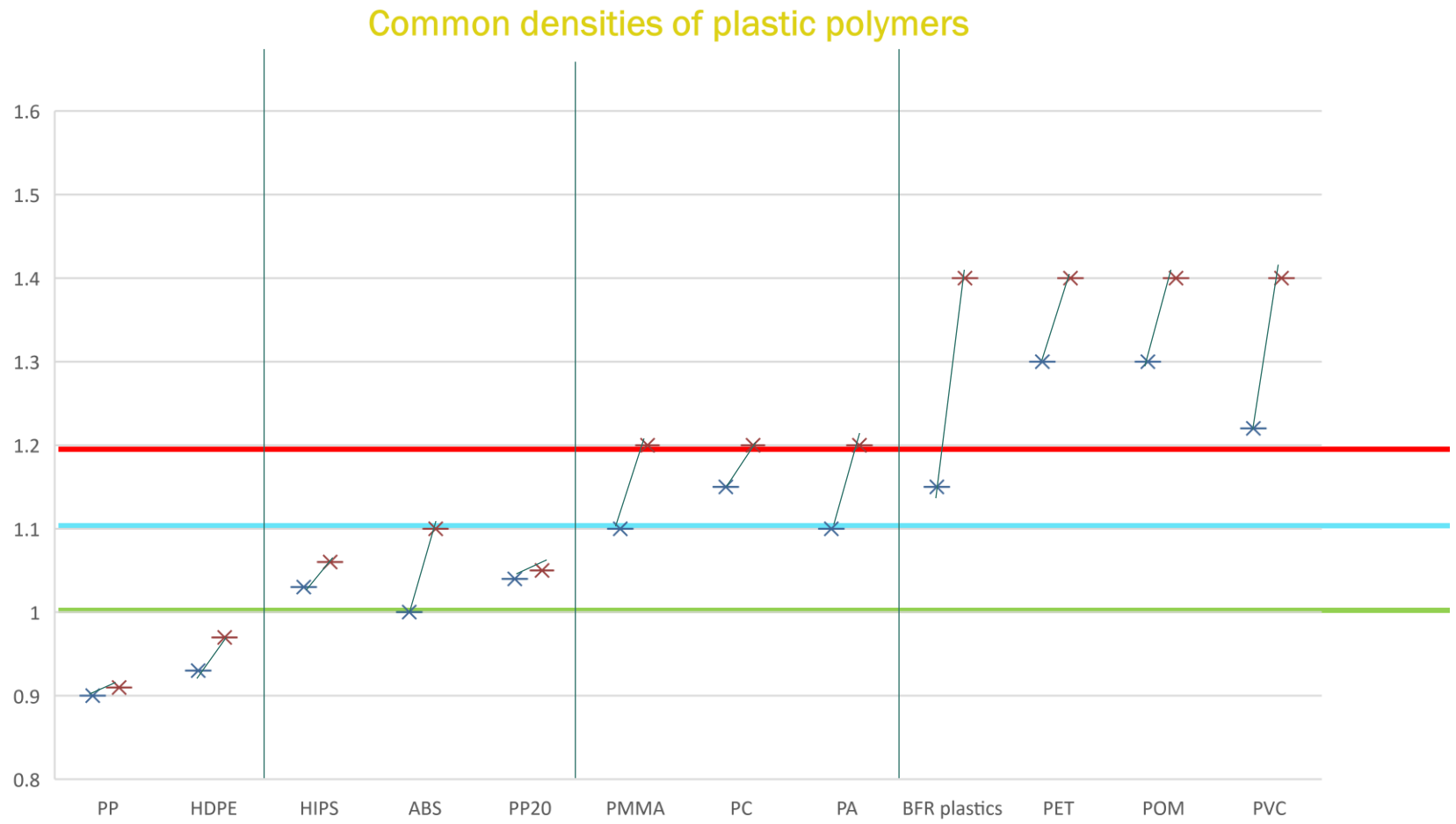
- https://plasticranger.com/density-of-plastics/

% NaCL en poids de solution	Densité	NaCL g/l de solution	H2 O g/l de solution	NaCL g/1000 g d'eau	TEMPERATURE DE CONGELATION
1	1.0053	10	995	10.10	
2	1.0124	20	992	20.41	- 1.2
3	1.0196	31	989	30.93	- 1.9
4	1.0268	41	986	41.67	- 2.5
5	1.0340	52	982	52.63	- 3.18
6	1.0413	62	979	63.83	- 3.5
7	1.0486	73	975	75.27	- 4.7
8	1.0559	84	971	86.96	- 5.1
9	1.0633	96	968	98.90	- 6
10	1.0707	107	964	111.11	- 6.6
11	1.0782	119	960	123.60	- 7.8
12	1.0857	130	955	136.36	- 8.3
13	1.0932	142	951	149.43	- 9.95
14	1.1008	154	947	162.79	- 10.2
15	1.1085	166	942	176.47	- 11.4
16	1.1162	179	938	190.48	- 12
17	1.1240	191	933	204.82	- 13
18	1.1319	204	928	219.51	- 14
19	1.1398	217	923	234.57	- 15.5
20	1.1478	230	918	250.00	- 16.2
21	1.1559	243	913	265.82	- 17.5
22	1.1640	256	908	282.05	- 19
23	1.1722	270	903	298.70	- 20.7
23.31	1.1780	275		303.92	- 21.12
24	1.1804	283	897	315.79	- 15.8
25	1.1888	297	892	333.33	- 8
26	1.1972	311	886	351.35	- 1.5
26.43	1.2008	317	883	359.25	0,1

- Data Source
- http://www.viabilite-hivernale.developpement-durable.gouv.fr/IMG/pdf/table_cle244955.pdf

6. SORTING - DENSITY OF PLASTIC TYPES

- Below 1 200 kg/ m”
- Below 1 100kg/ m3
- Below 1 000 kg/ m3



- 360 g/ l of salt
- 160 g/L of salt
- Pure water

*Densities sugested by EMPA Research Institute from Switzerland, https://www.sustainable-recycling.org/wp-content/uploads/2019/12/Plastic-Handbook-Final.pdf

6. SORTING - DENSITY VS POLYMER TYPES

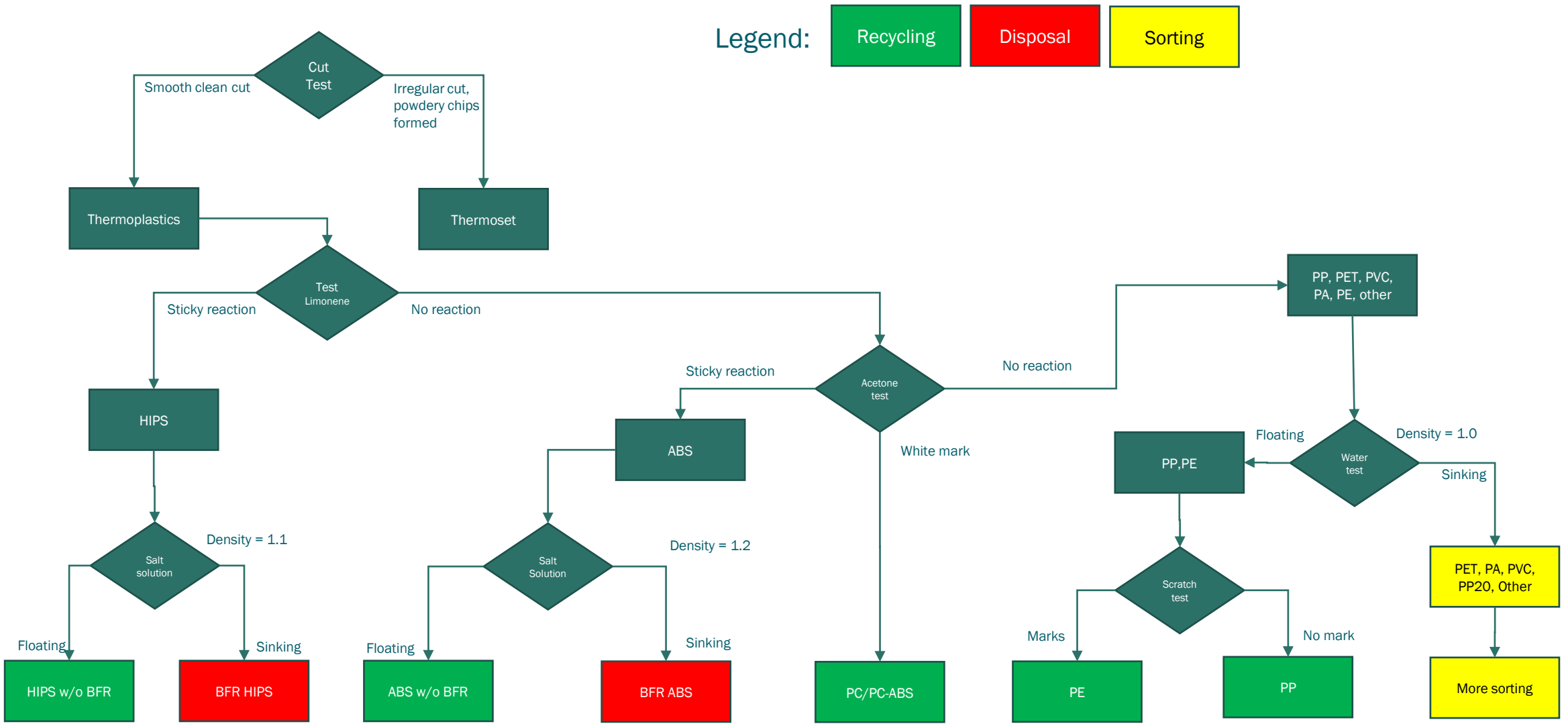
Density fractions and plastic groups.

Density Fraction (DF)	Density	Polymers
DF 1	<1.0 g/cm^3	PE, PP
DF 2	1.0–1.1 g/cm^3	ABS (non-halogenated) PS (non-halogenated)
DF 3	1.1–1.25 g/cm^3	ABS (halogenated), PS (halogenated) PC, Soft PVC, PMMA
DF 4	>1.25 g/cm^3	POM, Hard PVC, PA

- Note: Various densities can be shown for each type of plastic polymer - > all depends on the presence of additives or not.
- Halogenated = Brominated fire retardants

- Data source Recycling Potential for Unvalued Plastic Fractions of Electrical and Electronic Energy by Laura Strobl , Thomas Diefenhardt , Martin Schlummer, Tanja Leege and Swetlana Wagner May 19, 2021.

6. SORTING - METHOD FOR UNIDENTIFIED PLASTICS – EMPA*



*Research Institute from Switzerland, https://www.sustainable-recycling.org/wp-content/uploads/2019/12/Plastic-Handbook-Final.pdf

VIDEO PRESENTATION

PREVENT

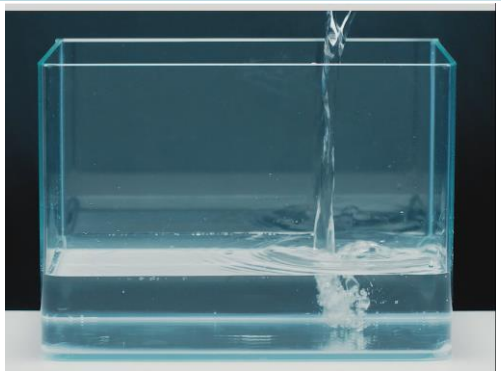
After too much words let's look at "How Density will work for you!"

1. Density
2. Acetone
3. Limonene

Getty image

DENSITY SORTING

PREVENT

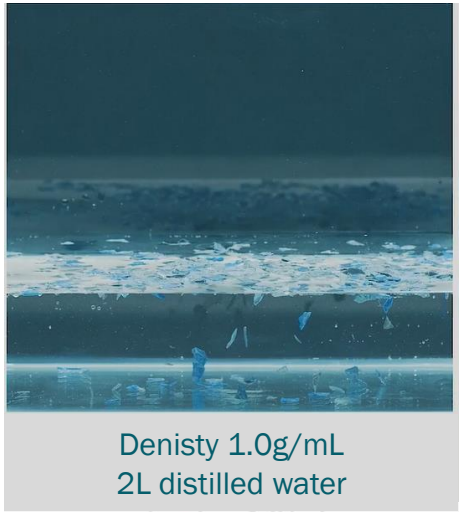


2 litres of distilled water

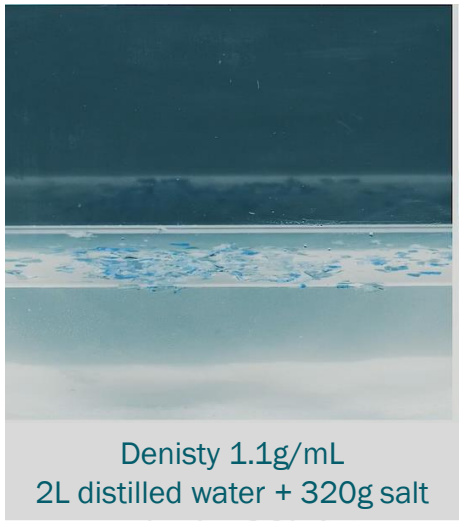
+

0g/320g/720g of salt

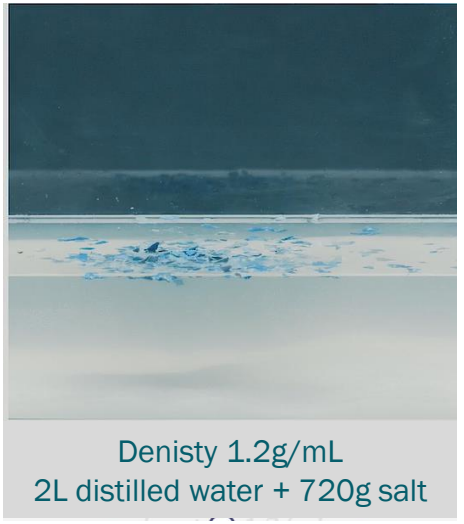
Screenshots from video: source PREVENT/Landbell Group



Denisty 1.0g/mL
2L distilled water



Denisty 1.1g/mL
2L distilled water + 320g salt



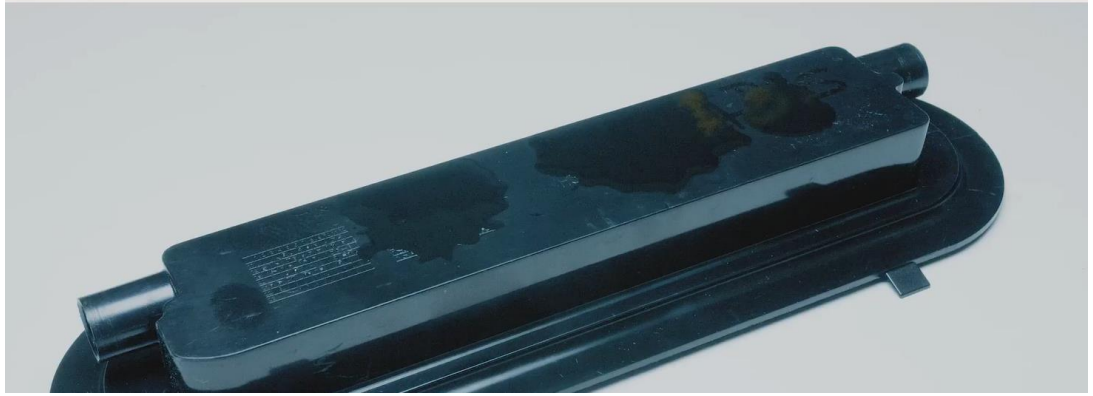
Denisty 1.2g/mL
2L distilled water + 720g salt

Conclusion: If add ABS flakes to three different density solutions, the flakes will float in 1.1g/mL and 1.2g/mL and sink in distilled water. If the ABS contains BFRs will also sink in 1.1 and 1.2g/mL

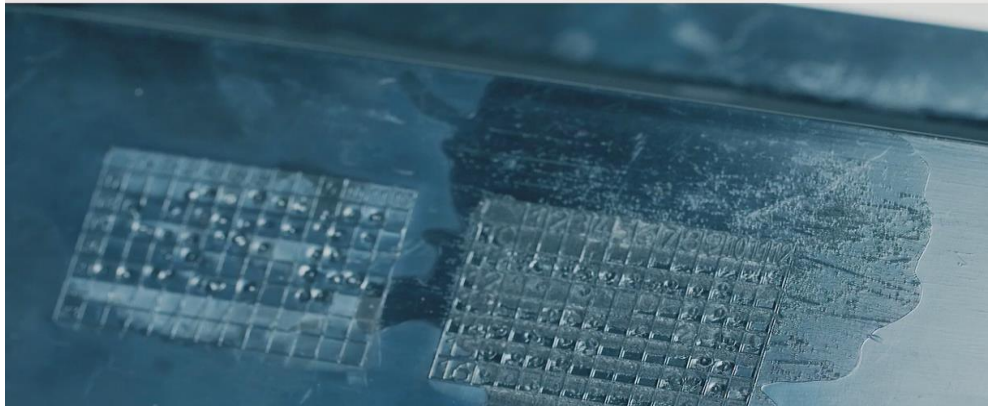
ACETONE TESTS ON ABS

PREVENT

PEÇA DE PLÁSTICO ABS *ABS PLASTIC OBJECT*



PEÇA DE PLÁSTICO ABS *ABS PLASTIC OBJECT*



FLAKES DE ABS *ABS FLAKES*

FLAKES DE ABS *ABS FLAKES*

CONCLUSÕES: A reação do plástico ABS à acetona é mais visível no formato de flakes, que ficaram pegajosos e agrupados como se estivessem colados e com aspeto brilhante

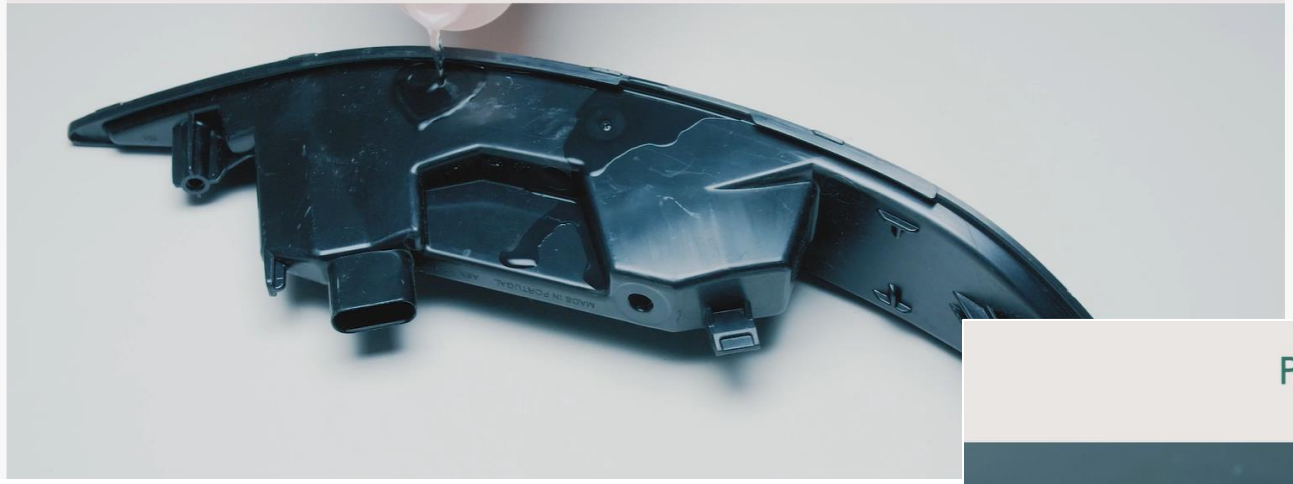
CONCLUSIONS: The reaction of ABS plastic to acetone is more visible in the form of flakes, which became sticky and grouped together as if they were glued together and look

Screenshots from video: source PREVENT/Landbell Group

ACETONE ON PC/ABS PLASTIC

PREVENT

PLÁSTICO PC/ABS *PC/ABS PLASTIC*



PLÁSTICO PC/ABS *PC/ABS PLASTIC*

CONCLUSÕES: Em contacto com a acetona, a peça de plástico PC/ABS ficou com uma marca branca

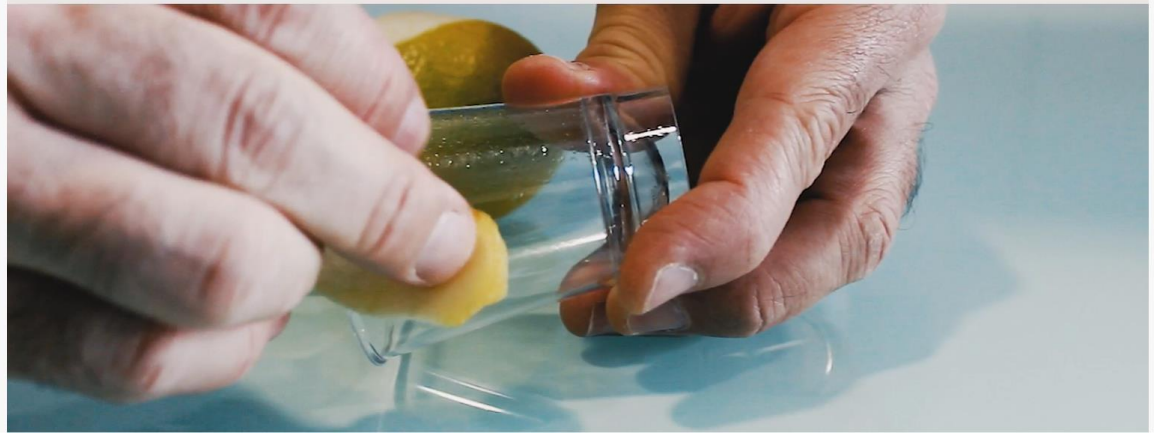
CONCLUSIONS: In contact with acetone, the PC/ABS plastic skin left a white mark

Screenshots from video: source PREVENT/Landbell Group

LIMONENE TESTS ON PS

PREVENT

COPO DE PLÁSTICO DE POLIESTIRENO *PS GLASS*



COPO DE PLÁSTICO DE POLIESTIRENO *PS GLASS*

CONCLUSÕES: Em contacto com limonene, o plástico PS ficou pegajoso e dissolveu-se

CONCLUSIONS: In contact with limonene, the PS plastic became sticky and dissolved itself

Screenshots from video: source PREVENT/Landbell Group

6. SORTING - DENSITIES

- A high-density fraction is created, containing a complex mixture of heavy plastics and various additives that are not suitable for recycling and are therefore discarded.
- This fraction contains more than 95% of the original BFR content, since density classification is a highly effective way to separate bromine poor-rich fractions.

- The addition of flame retardants (mainly organic bromine compounds, which can be released through heat treatment - also when extruded - to highly toxic reaction products) prohibits the recycling of classic plastic through a melting process (re-granulation) because it would increase decomposition reactions.
- Needs for safe elimination-> as we will discuss in last section.

Please : Make sure that BFR plastics cannot be used for manufacturing plastic food containers and toys

Getty images

6. SORTING - INDUSTRIAL

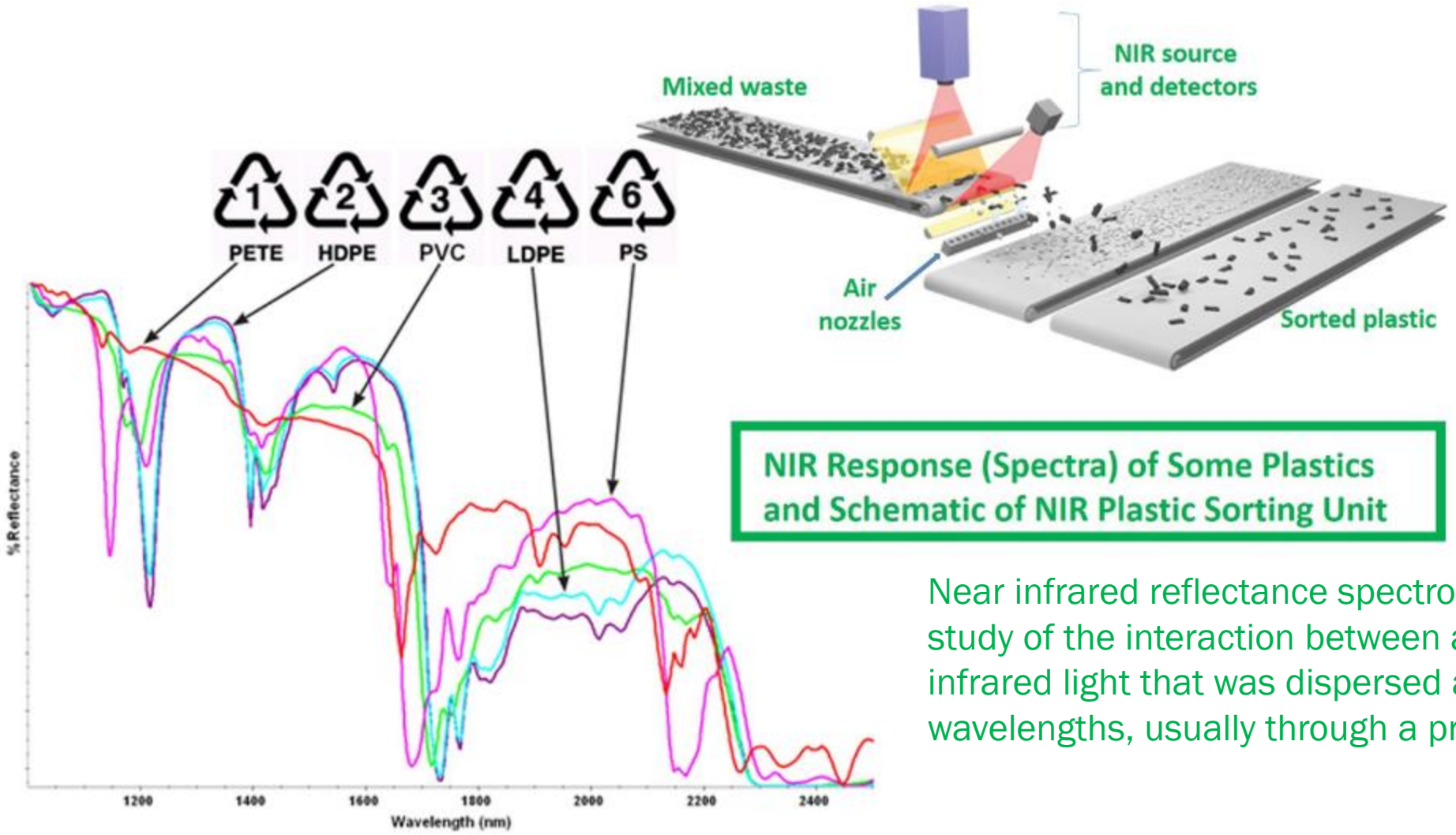
Mechanical processes:

- Washing process
- Size reduction process to generate flakes of 10 to 20 mm.
- Magnet to remove screws and nails.
- Through a combination of classification technologies based on:
  - density
  - electrostatic separation
  - or near infrared (NIR) reflectance classification

These polymers can be separated from each other in a high degree of purity and transformed into pellets that can replace virgin materials into new products.

Getty image

6. SORTING



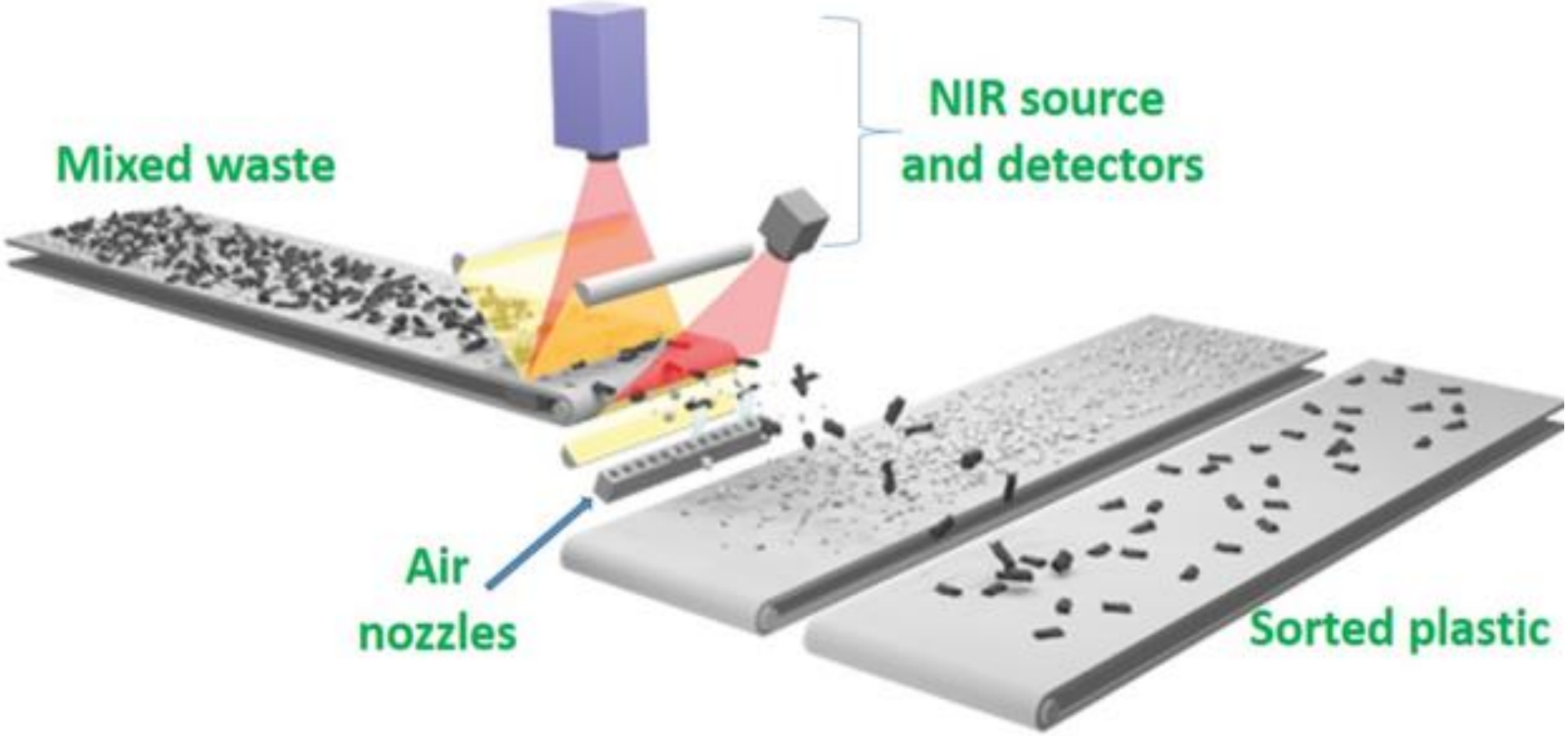
NIR Response (Spectra) of Some Plastics and Schematic of NIR Plastic Sorting Unit

Near infrared reflectance spectroscopy: study of the interaction between a sample and infrared light that was dispersed at individual wavelengths, usually through a prism.

- Image polymerinnovation.com

6. SORTING – CLOSER VIEW

- When the type of polymer and position in the conveyor band is identified by the detector, a signal is sent to a corresponding compressed air valve, releasing an air jet that pushes the fraction to be classified.



- Image polymerinnovation.com

6. SORTING - INDUSTRIAL

- Example of a best available technique:
- The CreaSolv® solvent-based process removes contaminants and additives that reduce the quality of recycled plastic produced by conventional recycling processes.
- Multiple-step solvent-based process
- https://www.ivv.fraunhofer.de/en/recycling-environment/recycling-plastics-creasolv.html

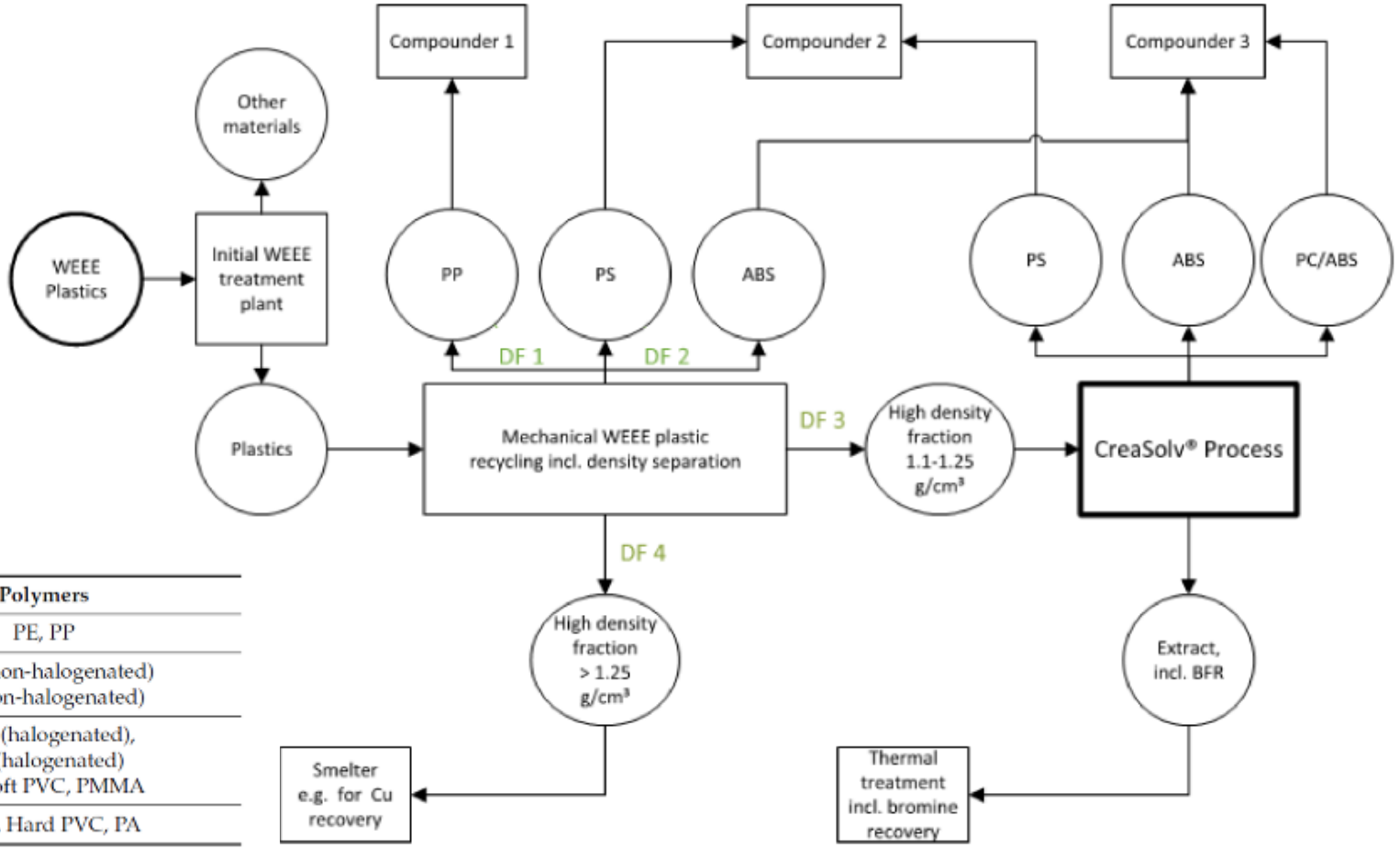


Figure 4. Recycling concept for WEEE plastics combining density separation with CreaSolv® Process.

Table 2. Density fractions and plastic groups.

Density Fraction (DF)	Density	Polymers
DF 1	<1.0 g/cm³	PE, PP
DF 2	1.0–1.1 g/cm³	ABS (non-halogenated) PS (non-halogenated)
DF 3	1.1–1.25 g/cm³	ABS (halogenated), PS (halogenated) PC, Soft PVC, PMMA
DF 4	>1.25 g/cm³	POM, Hard PVC, PA

- Source Recycling Potential for Unvalued Plastic Fractions of Electrical and Electronic Energy by Laura Strobl , Thomas Diefenhardt , Martin Schlummer, Tanja Leege and Swetlana Wagner May 19, 2021.

7. MANAGEMENT OF CLASSIFIED FRACTIONS

- Keep clean, away from dust, plastic supplies,
- Away from heat sources, sparks and lithium batteries
- Away from contamination, such as oil, solvents, chemicals.
- Use clean containers.

Volume reduction has an incentive to reduce costs for transport:

- Baler
- Crusher for flake production.

“Big bags” are commonly used. Easy to fill and handle. Easy after use management.

Keep large bags away from collision paths to prevent bags from being punctured

Getty images

7.1 - RECYCLING

PREVENT

Challenges for recycling WEEE plastics back into high value products:

- Plastic-plastic separations and purification
- Removal of non-plastic contaminants (e.g., rubber rings)
- Demanding mechanical property requirements
- Demanding requirements for processability (i.e., recycled plastic should be processed similarly to comparable virgin plastics)
- Presence of “legacy” heavy metals and flame retardants
- Cadmium from historic coloring compounds
- Metals traces resulting of the WEEE shredding process, if applicable.

Getty image

7.1 RECYCLING

Challenge-> Get high quality plastics fractions for compounders that will generate pellets.

- The starting point for recycling plastics is targeted collection and then sorting of the waste streams so that plastics of the same type can be processed separately.
- The recycling of mixed plastics into clean, recyclable plastic flakes is a challenge due to the high complexity of the plastic mixture.
- The composition of plastics in WEEE can comprise more than 15 different polymer types as well as containing additives including harmful substances like brominated flame retardants (BFR) and cadmium.
- We discussed of :
  - Manual process
  - Mechanical process
  - Density process
  - Specialized WEEE plastic recycling facilities that apply several sorting stages that typically include a stepwise density separation
- We saw that is is possible to get :
  - A high-density fraction is created containing a complex mixture of heavy plastics and various additives that are not suitable for recycling and are therefore discarded.
  - This fraction contains more than 95% of the original BFR content, since density classification is a highly effective way to separate BFR and non BFR fractions.

What potential process could we put in place here in a situation of small budget?

7.1 RECYCLING ON A BUDGET - LOCALLY

- Establish plastic needs of compounders
- Identify source of collection of plastics
- Inventory of what can be found in your loads.
- Preliminary sorting based on quick wins mentioned before. Store adequately
- Think to wash if plastic is very dirty to ensure good quality end-product. May help remove dust from shredding processes. (spent water management!)
- Determine suitable method of sorting -> EMPA Process Multiple steps diagram slide 56
- Size reduction for sink float ? 10 to 20 mm.
- Sink/Float process shall lead to sorted fractions. Try batches with metals skips, modified with bottom valve, or if you want to start small with drums.
- Get salt! Use density table slide 53
- Sample resulting streams, confirm non BFR content or get agreement with compounder for analysis.
- Look for solution for unsorted/ unknown material.
- Store final material / Ship final material to compounders

Getty image

7.1 RECYCLING

Now, enter the compounders.

The subject of the next pages .

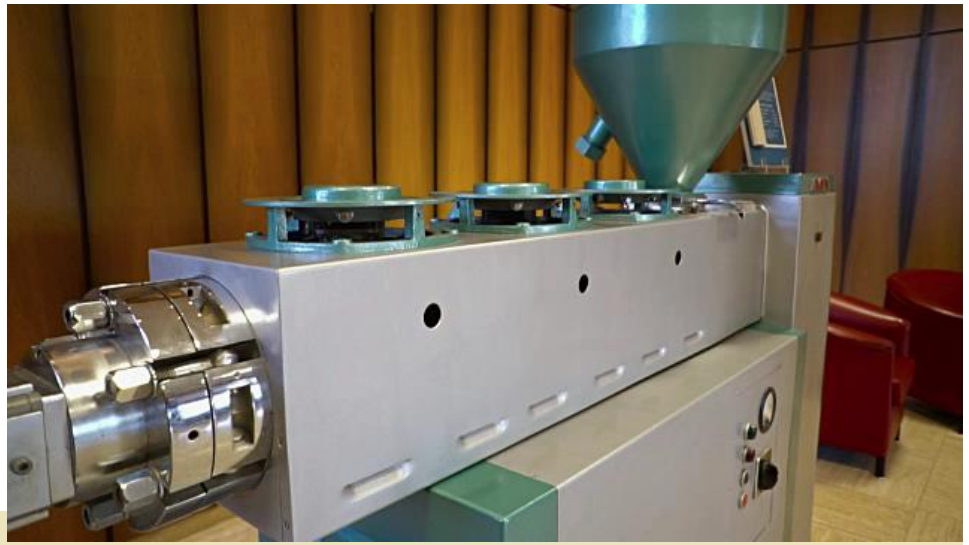
Compounder's process.

Schematic developed on the basis of a drawing from **Plastic Waste Flows** -European & Chinese plastic waste data, markets, manufacture, use and disposal of plastic waste by Dr Paula H. Blanco & Professor Paul T. Williams - Action: H2020-H20202-MSCA-RISE-2014.

Getty images

7.1 RECYCLING

- Extruder



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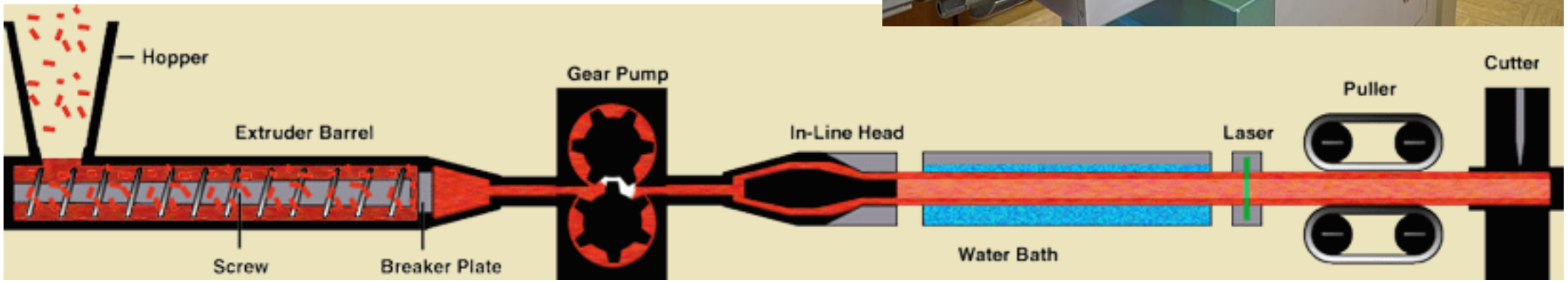

- Animated Schematic video property of docsity.com, used for knowledge transfer purpose only.

7.1 RECYCLING

PREVENT

- Extrusion machine products

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BRAZILIAN PILOT PROJECT

PREVENT

Challenges:

1. There are potential off-takers of recycled e-waste plastics in the country but recyclers can neither deliver to the expected purity level nor supply stable quantities.

2. The knowledge on how to separate different polymers, and especially those contaminated with hazardous substances like BFRs, is missing. Majority of companies use very simple, harmful to human health technique, i.e. burning and sniffing.

3. The size of the country and the very scattered recycling infrastructures make transport cost very high, thus negatively impacting any reverse logistics undertakings.

BRAZILIAN PILOT PROJECT

PREVENT

Solutions:

- **Aggregation** - Think Circular, software developed by Circular Brain, aggregates data on streams and volumes treated by Brazilian recyclers.
  - Volumes treated by different recyclers can be bundled together so that tonnages sufficient for off-takers are achieved.
  - The software can also act as a clearing house and offer credits (certificates) to producers searching for environmental initiatives
- **Searching for a compounder willing to use recyclates. – In progress.**
  - Initial idea: compounder producing packaging for the cosmetics industry, proved not viable due to high quality standards imposed by the specifics of the industry (contact with skin)
  - Another idea: producer of EEE equipment
    - Slightly lower quality standards (but still ambitious because some products, i.e. fridges, have contact with food)
    - Producer's global strategy is to use 50% of recyclates in their products by 2030 (vs. ~5% as of today in Brazil)

NEEDS OF MANUFACTURER

- Manufacturers have developed technical specifications which determine the minimum requirements required for the supply of material such as PP compounds that are used in injection molding processes to manufacture parts in general.

5. REQUISITOS PARA DESENVOLVIMENTO

5.1 - TIPO A - POLIPROPILENO + 55 % Ca CO_3

Propriedades	Unidades	Método de Teste ASTM	Valores
1 - Densidade	g / cm^3	D 792	1,42 ± 0,01
2 - Resistência à Tração	kgf / cm^2	D 638	200 (min.)
3 - Módulo de Flexão	kgf / cm^2	D 790	31000
4 - Dureza Rockwell	R	D 785-A	71
5 - Impacto Izod	J / m	D 256-A	20 (min.)
6 - Índice de Fluidez	g / 10 min.	-	10 a 15
7 - Teor de Cinzas	%	-	55 ± 5

Material típico: PX 5729 - PPH

NEEDS OF MANUFACTURER

PREVENT

5.6 - TIPO F - POLIPROPILENO + 20% DE TALCO

Propriedades	Unidades	Método de Teste ASTM	Valores
1 - Densidade	g /cm³	D 792	1,03-1,05
2 - Resistência à Tração (Força Max)	MPa	D 638	30-37
3 - Resistência à Tração (Escoamento, 0,2%)	MPa	D 638	22-30
4 - Módulo de Flexão (1% Secante (0,05 pol./min.))	MPa	D 790A	2000-2700
5 - Resistência ao Impacto Izod Com Entalhe, 23 °C Sem Entalhe, - 20 °C	J / m	D 256 0,4 pé-lb/pol. 10 pé-lb/pol.	 25-35 25-35
6 - Índice de Fluidez (230/2,16)	g / 10 min.	D 1238	13-23
7 - Along. Escoamento (2 pol./min.)	%	D 638	6-15
8 - Temperatura Deflexão Térmica - 66 lb/pol² - 264 lb/pol²	°C	D 648	 122-129 71-76
9 - Dureza Shore D	%	ASTM 2240	70-74
10 - Teor de Cinzas	°C	--------	18-22
11 - Temperatura Processamento (típ.)	°C	--------	215-260
12 - Envelhecimento		Vide item 5.6.1	

Materiais típicos: PP 1222F (EXXON CHEMICAL USA), PX 1717 (OPP) e mistura do concentrado PP 40% talco natural (PX1994) + H503 (50% / 50%) - TC158, OU MISTURA TERMOCOLOR DE H107 + H503 + MO3 CODIGO 59001364.

- Type F and V
- H 301 (PP HOMO) Homopolymer.
- H 301 is a medium melt, general purpose additivated polypropylene.
- It is suitable for injection molding and fiber extrusion processes.
- This product features excellent processability with good melt stability, good stiffness/impact balance, and low odor and taste transfer.

5.22 - TIPO V - POLIPROPILENO HOMOPOLÍMERO NATURAL – PPH

Propriedades	Unidades	Método de Teste ASTM	Valores
1 – Densidade (23°C)	g /cm³	ASTM D792A	0,905 ±15%
2 - Resistência à Tração no escoamento	Mpa	ASTM D638	32 ±15%
3 - Alongamento no Escoamento	%	ASTM D638	11 ±15%
4 - Módulo Flexão 1% Secante	Gpa	ASTM D790B	1,13 ±15%
5 - Resistência ao Impacto IZOD a 23°C	J / m	ASTM D256A	34 ±15%
6 - Índice de Fluidez (230°C/2,16 kg)	g / 10 min.	ASTM D1238 - L	10 ±15%
7 - Dureza Rockwell	Escala R	ASTM D785A	93 ±15%
8 - Temperatura Distorção Térmica (HDT) à - 455 kPa - 1820 kPa	°C	ASTM D648	 90 ±15% 59 ±15%
9 - Temperatura Amolecimento Vicat - 1 kg	°C	ASTM D1525	154 ±15%

Materiais típicos: H 301 -

PP RECYCLED SPECS

PREVENT

5. REQUIREMENTS FOR DEVELOPMENT

5.41 - TYPE AP - POLYPROPYLENE COPOLIMER 20 % TALCUM RECYCLED

Properties:	Method	Unit	Reference Values
Melt flow index (230°C/2,16 kg)	ASTM D 1238	g/10 min	7 - 13
Dust Content	ASTM D 2584	%	20 - 24
Elasticity Modulos	ASTM D 638	MPa	Min. 500
Tensile Strength	ASTM D 638	MPa	Min. 5
Tensile Strength at Yield	ASTM D 638	MPa	Min. 10
Elongation at Yield	ASTM D 638	%	Min. 5
Hardness	ASTM D 2240	Shore D	60 a 70
Impact (Izod w/ noched)	ASTM D 256	Kj/M²	Min 2

Typical Material: PP 22% TALCUM COPO 01396 RP – SUPPLIER

MATERIAL TESTING – AGING TEST

PREVENT

ILO (Oxidative Induction Time) Standard: ASTM D 3895

- The test is started in a nitrogen (N2) atmosphere by heating the sample to 200°C and maintaining this temperature throughout the test. Then the atmosphere is switched to oxygen (O2) at a specific flow and the evolution of enthalpy is evaluated. A sudden change in enthalpy defines the oxidative induction time (O.I.T.).
- Approval requirement: Must withstand at least 100 minutes without showing oxidation.

THERMO-OXIDATIVE AGING

- Aging in an oven at 150°C according to ASTM D 3012 standard.
- Approval requirement: Measure loss of mechanical properties of specimens compared to specimens that have not undergone aging. The measured values must respect the limits established below:
- Tensile strength at breakage and flow: maximum variation ± 30%
- Flexion Module: maximum variation ± 30%
- Izod impact: maximum variation ± 30%

MATERIAL TESTING – AGING TEST

PREVENT

CHEMICAL RESISTANCE

- Immersion in a 1% detergent solution (detergent formula according to ASTM D-2248), temperature at 70ºC for 500 hours, evaluating the loss of mechanical properties after tests.
- Approval requirement: Measure loss of mechanical properties of specimens compared to specimens that have not passed the test. The measured values must respect the limits established below:
- Tensile strength at breakage and flow: maximum variation ± 30%
- Flexion Module: maximum variation ± 30%
- Izod impact: maximum variation ± 30%

MORE TESTING

PREVENT

1 – Density (at 23°C) (g /cm3) ASTM D792A

2 - Tensile strength in flow (Mpa) ASTM D638

3 - Elongation in Flow (%) ASTM D638

4 - 1% Secant Flexion Module (Gpa) ASTM D790B

Measurement of a material's elasticity

5 – Resistance to Impact IZOD a 23°C (J / m) ASTM D256A

A pivoting arm is raised to a specific height and then released. The arm swings down hitting a sample, breaking the specimen. The energy absorbed by the sample is calculated from the height the arm swings to after hitting the sample.

6 – Melt flow index (230°C/2,16 kg)(g / 10 min) ASTM D1238 – L

Defined as the mass of polymer, in grams, flowing in ten minutes through a capillary of a specific diameter and length by a pressure applied via prescribed alternative gravimetric weights for alternative prescribed temperatures.

7 – Rockwell Hardness (R Scale) ASTM D785A

The Rockwell test measuring the depth of penetration of an indenter under a large load (major load) compared to the penetration made by a preload (minor load)

8 - Thermal Distortion Temperature (HDT) at 455 kPa, at 1820 kPa (°C) ASTM D648

A measure of polymer's resistance to distortion under a given load at elevated temperature

9 - Vicat Softening Temperature - 1 kg (°C) ASTM D1525

The temperature at which a flat-ended needle penetrates the specimen to the depth of 1 mm under a 1 Kg load.

HOW TO REPLICATE THE SOLUTION IN YOUR COUNTRY?

PREVENT

- Have you identified any off-takers for recycled e-waste plastics in your country?
  - producers of EEE?
  - compounders working for producers of EEE?
- What quality and quantity requirements do they have?
- What do you need to do to improve the quality of your output fraction?
  - Sorting
  - Cleaning (contaminated by soil, oils, other?)
  - Removing impurities and contamination (BFRs)
  - Securing steady supplies to the compounder, i.e. securing also steady collections at your end
  - Anything else?

- Should I invest in a shredder? Volumes needed? Or may be just become a https://preciousplastic.com/ entrepreneur and create stuff.
  - Volume here doesn't look as an issue.
  - Mechanical recycling process: shred, agglomerate in new products. Attention: potential toxic emissions? To be checked. Permits?

7.2 ELIMINATION

PREVENT

Plastic discarded

Two types of plastics:

The one with no value, or that cannot be recycled locally

And the hazardous ones with persistent organic pollutants, heavy metals

- e.g. :
- With Cadmium used as dyes in ABS providing red/orange color,
- With lead in plastic from some cables,
- With brominated fire retardants

Process	Description	What do we get?
extrusion	pellets production	new objects
mechanical recycling	Adhesive pressing, grinding and compression molding, injection moulding	new objects
chemical processing	transformation in fractions for oil production/ elements for new plastics, process limited to some types of plastics.	oil, new plastics
thermal processing	pyrolisis, gasification (fluidized bed) for methanol production	fuel, energy, new chemical
energy recovery	incinerator, cement kiln	energy

INCINERATION

PREVENT

Risks

- Smoke toxicity
- Requires units with adequate pollution reduction controls for heavy metals, dioxins and furans.
- Flame retardant containing plastics burning + copper as a catalyst can lead to emissions of dioxins and furans.
- A controlled emissions site is required.
- Ideally with energy recovery.

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ALTERNATIVES TO PROPER INCINERATION OF HAZARDOUS WASTES

PREVENT

- Cement kiln?
- Municipal waste incinerator?

- Do their permits allow it?
- Would they take the risk to damage their infrastructures to take BFR plastics?
- Would they take the risks to generate toxics emissions in their neighborhood?
- Kind reminder: No open air burning.

- These options will need careful review with authorities and potential takers.

Polymer	Description	Examples
Polymers containing Carbon and Hydrogen	High heating values. Good for fuel production. Produce clean exhaust gas.	PE, PP, PS
Polymers containing Oxygen	Lower heating value than polymers containing C and H2	PET, POM
Polymers containing Nitrogen or Sulphur	Potential source of hazardous components, Nox, Sox. Need serious pollution abatement devices.	PA & PU for N2
Polymers containing Halogens (Chlorine, Bromine, Fluorine)	Potential source of hazardous and corrosive molecules in the combustion gas. Need very serious pollution control system, but the corrosivity maybe a "no go" factor for the cement kiln owners.	PVC, BFR plastics

- Other options:
- Stock and Export? Expensive!
- Reuse in low value products? Risks? Create poles and benches.
  - Long term issue: losses of traceability of these materials
  - Degradation in nature, burnt by owners?

7.2 ELIMINATION

PREVENT

- If there is no possibility to get incineration with energy recovery, landfill of hazardous waste protected and controlled for underground pollution.
- Check the validity of the license of the site. Verify its internal controls.
- Make sure the trash reaches its destination.
- Avoid uncontrolled landfills, with direct contact to the ground. Too risky for potential water sources, especially if BFR plastics is discarded.
- Secure landfill with double HPDE liners and enough compacted clay between membranes.

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LET'S DISCUSS!

PREVENT

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PREVENT Waste Alliance E-Waste Working Group

PREVENT
Waste Alliance

www.prevent-waste.net

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