

Waste Plastics Industry Standards

A Submission to the Department of
Agriculture, Water and the
Environment

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Glossary

Terminology	Definition
ABS	Acrylonitrile Butadiene Styrene
ASA	Acrylonitrile Styrene Acrylate
ACOR	Australian Council of Recycling
APCO	Australian Packaging Covenant Organisation
CDS	Container Deposit Scheme
COAG	Council of Australian Governments
EPS	Expanded Polystyrene
HDPE	High-Density Polyethylene
ISRI	Institute of Scrap Recycling Industries, Inc.
LDPE	Low-Density Polyethylene
LLDPE	Linear Low-Density Polyethylene
MRF	Materials Recycling Facility
NWRIC	National Waste and Recycling Industry Council
PET	Polyethylene Terephthalate
PP	Polypropylene
PS	Polystyrene
PU	Polyurethanes
PVC	Poly-vinyl Chloride
SAN	Styrene Acrylonitrile
SPI	Society of Plastics Industry

Executive Summary

The Department of Agriculture, Water and the Environment engaged MRA Consulting Group ('MRA') to identify domestic and international specifications that Australian exporters are likely to use to process waste plastics once the waste export ban comes into effect. This work is in preparation for the two phases of the waste export ban for plastic to be in effect from 1 July 2021 and 1 July 2022 respectively. Exporters will be prohibited from exporting waste plastic without a licence and will be required to meet certain conditions set out in the licence and the legislation. This includes conditions requiring the waste be processed according to a specification prior to export. The appropriate specification will depend on the phase of the ban. The two phases of the ban are:

- From 1 July 2021, waste plastic will need to be sorted into a single resin or polymer type before export; and
- From 1 July 2022, waste plastic will need to be further processed, for example into flake or pellets, before export.

From 1 July 2021, processed engineered fuel that includes waste plastic will also need to meet certain requirements before export.

The following information was reviewed and discussed with relevant stakeholders for both phases of the ban:

- Standards and specifications used in the industry for waste plastics, including for different plastic polymers;
- Equipment and processing operations required to process waste plastics to specifications;
- The reuse and remanufacturing markets for the waste plastics overseas and their requirements for recycled plastic material; and
- Market information regarding pricing and contracts between exporters and importers.

While standards exist for plastic bales, flake and pellet, stakeholders indicated that specifications used are those set by individual customers. Institute of Scrap Recycling Industries specifications could serve as a best practice guide; however industry specifications are not commonly used in agreements with customers. The options for customer specifications for waste plastic vary widely due to the large number of variables that affect its recyclability overseas:

- Source of input plastic;
- Overseas customer plant equipment and processing;
- Form and colour of product required; and
- Reuse/remanufacture product.

All processors and exporters consulted expressed support for licencing the export of waste plastic and for developing the plastic recycling sector in Australia. All stakeholders, however, expressed concern regarding licencing based on set specifications. Stakeholders emphasised that multiple variables should be considered during assessment of licence applications, including the source of the waste plastic, processing of the waste, the customer agreement/specifications, operations/equipment in place at the receiving site and end use of the product.

1 Introduction

1.1 Waste Export Ban

In March 2020 the former Council of Australian Governments (COAG) announced a ban on the export of waste plastic, paper, glass and tyres. The purpose of the ban was to prevent the export of unprocessed waste which will likely have a negative environmental or health impact in the importing countries; to encourage Australian companies to take greater responsibility for the waste produced in Australia; and to develop Australia's capacity to recycle material and produce high value products with recycled content. The ban was legislated under the *Recycling and Waste Reduction Act 2020* and the waste plastic export ban is also an action under the National Plastics Plan 2021.

The ban will require exporters to obtain a licence to export waste plastics. Exporters will be required to meet certain conditions set out in the licence and the legislation. This includes conditions requiring the waste be processed according to a specification prior to export. The ban on the export of waste plastic will be implemented in two phases:

Phase 1: from 1 July 2021, it will be a condition of a licence that waste plastic is (at a minimum) sorted into a single resin or polymer type before export. It will also be a condition of a licence that the waste plastic meets an appropriate specification, nominated by the exporter. This specification will require a degree of processing. This may include, for example, requirements to remove contaminants.

Phase 2: from 1 July 2022, it will continue to be a condition of a licence that waste plastic be sorted into a single polymer or resin and meet an appropriate specification. However, in this phase, the appropriate specification will require the waste plastic be more extensively processed, for example into flake or pellets, before export.

From 1 July 2021, exporters will also need to obtain a licence to export processed engineered fuel that includes waste plastic, and meet processing requirements set out in an appropriate specification prior to export as a condition of that licence.

1.2 Scope

In preparation for the waste plastics export ban, the Department of Agriculture, Water and the Environment engaged MRA Consulting Group ('MRA') to identify domestic and international standards that Australian exporters are likely to use to process waste plastics in both Phases 1 and 2 of the export ban. MRA performed a desktop review and industry consultation to gather information regarding the following:

- Standards and specifications used in the industry for recycling/reprocessing waste plastics;
- The operations, such as equipment and facilities, required to process waste plastics to the standards identified;
- Likely reuses and remanufactures of processed waste plastics in overseas countries;
- Market information regarding prices, margins and trading dynamics for waste plastics;
- Overseas importer requirements to confirm quality assurance of waste plastic products; and
- Any overlap between regulated waste plastics and 'hazardous waste' as defined in the *Hazardous Waste (Regulation of Exports and Imports) Act 1989*.

This information would serve as background information for the assessment of waste plastic export licence applications.

A list of consulted stakeholders is provided in Table 1.

Table 1 Stakeholders consulted

Industry Section	Stakeholder
Industry bodies and working groups	National Waste and Recycling Industry Council (NWRIC)
	Australian Council of Recycling (ACOR)
	Vinyl Council of Australia
	Australian Packaging Covenant Organisation (APCO) Materials Circularity Working Group
Waste plastics aggregators and exporters	Oatley Resources Australia
	Vanden Recycling
	Cleanaway
Waste plastics processors and equipment suppliers	Olympic Polymers
	Polymer Processes
	Cryogrind
	Resitech Industries
	Astron Sustainability
	Martogg Group of Companies
	Telford Smith Engineering
	CEMAC technologies
	Interface

2 Waste Plastics

Plastics are key components in a wide range of materials and products used in every industry. There are many types of plastic, each made up of a different polymer with certain properties suited to different applications. In 1988, the Society of Plastics Industry (SPI) established a classification system based on the polymer types and a number:

- 1 Polyethylene Terephthalate (PET)
- 2 High-Density Polyethylene (HDPE)
- 3 Poly-vinyl Chloride (PVC)
- 4 Low-Density Polyethylene (LDPE) /Linear LDPE (LLDPE)
- 5 Polypropylene (PP)
- 6 Polystyrene (PS)/ Expanded PS (EPS)
- 7 Other plastic¹

Polymer types 1-6 and some of 7 are thermoplastics and can be melted, extruded and recast into new products without substantially changing the chemical structure of the material. This process is referred to as mechanical recycling and it is the dominant form of recycling plastics globally. There is also 'chemical recycling', whose application is relatively new, which does alter the chemical structure of the plastic.

During mechanical recycling, a small proportion of the polymer may degrade (normally less than 5%). This reduces the physical properties of the polymer, including its viscosity and tensile strength. To compensate for this reduction in physical properties, virgin polymer is added. Alternatively, an energy-intensive treatment can be conducted (solid state polymersation) to recover the original properties of the polymer.. Contamination with different polymers and other material also affects the physical and mechanical properties of the recycled product, limiting its function and end-use. These contaminants must also be removed to be comparable to virgin material. A comparison of recycled and virgin properties for PET is provided in Appendix A, however details of reprocessing were not provided. In Australia, over 3.4 million tonnes of plastic were consumed in 2018–19, of which 394,000 tonnes were recovered (11.5%)². Post-consumer waste plastic is collected through kerbside household recycling systems and container deposit schemes (CDS) and sorted at materials recycling facilities (MRF). Further processing may take place at a secondary facility. Post-industrial and pre-consumer waste plastic is collected from commercial and industrial (C&I) and construction and demolition (C&D) sources and is processed at dedicated plastics processing facilities.

Waste plastics for export are currently sorted and processed to different specifications in Australia before being shipped overseas for more processing and re-manufacturing into new products. In 2018–19, 191,000 tonnes (48%) of the recovered waste plastic were exported.

2.1 Plastic Polymer Types and Products

Table 2 outlines some of the common product forms/sources for each polymer, tonnes of material processed domestically or exported, and recovery rates as reported in the Australian Plastics Recycling Survey (2020). Australian based reprocessing is defined as conversion into either a finished or semi-finished product where further reprocessing is not required, e.g. size reduction, before manufacturing new product. It does not include the baling and compaction of plastics. For exported plastic, reprocessing is defined as collection and exportation for re-processing.

¹ Other plastics include acrylonitrile-butadiene-styrene (ABS) / styrene acrylonitrile (SAN) / acrylonitrile styrene acrylate (ASA), polyurethanes (PU), nylons (polyamides) and unknown polymers.

² 2018-19 Australian Plastics Recycling Survey (2020) Envisage Works for the Department of Agriculture, Water and the Environment.

The list of product forms/sources provided is not comprehensive.

Table 2 Export tonnes³ and common product forms by plastic polymer types

Polymer Number and Name	Recovery rate 2017–18	Tonnes reprocessed and recycled locally 2017–18	Tonnes exported not reprocessed 2017–18	Tonnes exported reprocessed 2017–18	Common product form (source)
1 PET	21%	20,000	55,800	600	Post-consumer bottles (CDS)
					Post-consumer bottles (MRF)
					Post-consumer packaging (CDS/MRF)
2 HDPE	20%	51,000	52,400	25,500	Post-consumer milk jugs (MRF)
					Post-consumer packaging (CDS/MRF)
					Post-industrial construction material
3 PVC	2%	5,600	900	1,500	Post-consumer packaging (MRF)
					Post-industrial piping
					Post-consumer medical products
					Pre-consumer and post-consumer vinyl flooring

³ 2018–19 Australian Plastics Recycling Survey (2020) Envisage Works for the Department of Agriculture, Water and the Environment.

Polymer Number and Name	Recovery rate 2017–18	Tonnes reprocessed and recycled locally 2017–18	Tonnes exported not reprocessed 2017–18	Tonnes exported reprocessed 2017–18	Common product form (source)
4 LDPE/ LLDPE	17%	33,400	14,000	13,400	Post-industrial film
					Post-consumer film
5 PP	9%	24,400	18,500	1,900	Post-consumer packaging (MRF)
					Post-consumer plant pots and crates
					Post-industrial building material
6 PS	12%	2,000	6,000	900	PS rigid packaging (MRF)
6 EPS	12%	1,500	3,200	1,900	EPS Packaging
7 Other plastic:	1%	700	2,400	0	Variable
ABS / SAN / ASA	8%	800	5,900	200	Vehicles
					Electrical devices
					Packaging

Polymer Number and Name	Recovery rate 2017–18	Tonnes reprocessed and recycled locally 2017–18	Tonnes exported not reprocessed 2017–18	Tonnes exported reprocessed 2017–18	Common product form (source)
Polyurethanes (PU)	9%	6,900	0	600	Vehicles
					Building material: insulation and carpet underlay
Nylons (polyamides)	7%	100	8,400	200	Clothing
					Carpet
					Vehicles
					Building material
Unknown polymer	7%	5,000	23,200	5,000	Variable
Total	12%	151,300	190,700	51,800	

The other major exported material containing plastic is processed engineered fuel (PEF) or resource derived fuel (RDF) for use as an alternative to fossil fuels (e.g. in a cement kiln). PEF is made up of mixed combustible material, such as recyclable plastic, cardboard and waste timber, from household waste, C&I and C&D waste sources. PEF is currently exported from Australia into South-East Asian countries such as Malaysia, Singapore and the Philippines.

2.2 Export Regulations

The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (“the Basel Convention”) was identified as an international agreement covering the export of plastics.

The Basel Convention is an agreement between member countries for the control of transboundary movement of hazardous waste and its disposal. The primary aim of the Basel Convention is to minimise the impacts of hazardous waste on human health and the environment by placing controls on the export, import and transit of hazardous wastes.

Under the Basel Convention, the export, import and transboundary movement of hazardous wastes requires the prior informed consent (PIC) of all countries involved in the movement before it can proceed. Consent is only provided if it is demonstrated that the waste will be transported and processed in an environmentally sound way.

In May 2019, amendments were made to the Basel Convention to clarify and expand the regulation of plastic wastes to improve the effectiveness of the Basel Convention in managing these wastes, in particular plastic wastes that lead to marine pollution.

Australia implements its obligations under the Basel Convention through the *Hazardous Waste (Regulation of Exports and Imports) Act 1989*. The Hazardous Waste (Regulation of Exports and Imports) Amendment Bill 2021 was introduced to Parliament on 18 March 2021, and if passed, will amend the *Hazardous Waste (Regulation of Exports and Imports) Act 1989* to implement the amendments to the Basel Convention in relation to plastic. This is likely to expand the scope of overlap with waste plastics under the *Recycling and Waste Reduction Act 2020*.

2.3 Standards and Specifications

National and international standards and specifications identified regarding waste plastics are listed in Table 3. The standards and specifications establish quality and composition requirements to be considered for the recovery of waste plastic. They provide guidelines for buying and selling waste plastics in different forms for the purpose of recycling and converting into products.

Standards labelled “BS EN” were published by British Standards and have been adopted as European standards.

For those specifications that are publicly available, a link has been provided. All others require a membership or fee to access.

Table 3 Plastic specifications

Specification Title	Publisher	Location	Plastic Polymer Type to	Relevant to Phase 1 or 2?
ISO 15270 Plastics – Guidelines for the recovery and recycling of plastics waste	International Organisation for Standardisation (ISO)	International	All plastics	1, 2
Model Bale Specifications: PET Bottles	The Association of Plastic Recyclers (APR)	International	1	1
Model Bale Specifications: HDPE Natural Bottles	APR	International	2	1

Specification Title	Publisher	Location	Plastic Polymer Type to	Relevant to Phase 1 or 2?
Model Bale Specifications: HDPE Coloured Bottles	APR	International	2	1
Model Bale Specifications: LDPE Coloured Film	APR	International	4	1
Model Bale Specifications: PP Small Rigid Plastics	APR	International	5	1
Model Bale Specifications: Solid Polystyrene	APR	International	6	1
Model Bale Specification: Densified Depot Grade Foam Polystyrene	APR	International	6	2
Scrap Specifications Circular	ISRI	United States	1-7	1, 2
BS EN 15347 Plastics - Recycled Plastics - Characterisation of plastics waste	British Standards (BS)	Europe	All plastics	1, 2
BS EN 15342 Plastics – Recycled Plastics – Characterisation of polystyrene (PS) recyclates	BS	Europe	6	1, 2
BS EN 15344 Plastics – Recycled Plastics – Characterisation of polyethylene (PE) recyclates	BS	Europe	2, 4	1, 2
BS EN 15345 Plastics – Recycled Plastics – Characterisation of polypropylene (PP) recyclates	BS	Europe	5	1, 2
BS EN 15346 Plastics – Recycled Plastics – Characterisation of poly (vinyl chloride) (PVC) recyclates	BS	Europe	3	1, 2
BS EN 15348 Plastics – Recycled Plastics – Characterisation of	BS	Europe	1	1, 2

Specification Title	Publisher	Location	Plastic Polymer Type to	Relevant to Phase 1 or 2?
poly(ethylene terephthalate) (PET) recyclates				
Regulation EC 282/2008 on recycled plastic materials and articles intended to come into contact with foods	European Commission	Europe	1, 2	2
BS EN 15414 Solid Recovered Fuels – Determination of moisture content	BS	Europe	PEF	1
BS EN 15415 Solid Recovered Fuels – Determination of particle size distribution	BS	Europe	PEF	1
BS EN ISO 21646 Solid recovered fuels – Sample preparation	BS	Europe	PEF	1
PET container specifications	ACOR	Australia	1	1
HDPE bottle recycle feedstock specifications	ACOR	Australia	2	1
Post-consumer PVC bottles bale specifications for recycle feedstock	ACOR	Australia	3	1
LLDPE and LDPE film recycle feedstock specifications	ACOR	Australia	4	1
AS 2070 Plastics materials for food contact use	Australian Standard	Australia	1, 2	1, 2

APCO/NWRIC surveyed NWRIC plastic aggregator and processor members and found that the following specifications were used (percentage of respondents):

- Customer specifications (67%)
- ISRI Scrap Specifications Circular (39%)
- Australian Council of Recycling (ACOR) specifications (33%)
- European standards (28%)
- Other (17%)

- None (0%)

Consultation by MRA revealed that MRFs may reference APCO/ISRI specifications as a minimum for the quality of product they are selling, however this was only mentioned by one secondary reprocessor. Plastic processors, traders and exporters, however, said these or other international specifications are not generally used or cited in agreements between overseas buyers and Australian exporters, as is commonplace with other waste products such as paper.

Instead, specifications for exported plastics were reported to be customer-driven based on a large number of variables for each polymer, listed in Table 4.

Table 4 Variables affecting customer-driven specifications

Variables	Option examples	Definition
Sources of input plastic	Pre-consumer/post-industrial	Plastic collected during the manufacturing stage of life of a product, generally from C&I and C&D streams. 'Pre-consumer' and 'post-industrial' are often used interchangeably. Considered a clean stream of waste.
	Post-consumer	Plastic collected through kerbside household recycling systems and CDS after being consumed by the public. Considered a dirty stream of waste and may require more thorough washing in the recycling process compared to pre-consumer/post-industrial waste.
	Container Deposit Scheme (CDS)	Eligible containers (post-consumer) are collected and customers receive a partial refund to encourage recycling and reduce litter. Considered a relatively clean stream of waste compared to post-consumer waste coming from MRFs.
	Materials Recycling Facility (MRF)	Kerbside recycling material (post-consumer) is sorted at a MRF into different categories for secondary processing. Varying levels of contamination and heterogeneity occur.
Overseas customer plant equipment and processing	Decontamination and washing equipment, optical sorting, etc	The customer specifications will vary depending on the equipment available at the destination facility. Refer to Section 2.4 for descriptions of processing flow and equipment.
Form and colour of product required	Bottles	Bottles are generally traded in bales sorted by polymer type. Levels of acceptable contamination vary depending on source and processing.
	Scrap	Waste plastic before it is processed, i.e. no size reduction or washing has been performed.
	Flakes	Scrap waste plastic is shredded into flakes. Washing and removal of contaminants may be performed.

Variables	Option examples	Definition
	Pellets	Flakes are melted down and extruded into pellets ready to be re-melted and remanufactured into plastic products.
	Natural/clear/transparent	Natural/clear/transparent plastic is more valuable than coloured plastic as it can be dyed with greater flexibility. 'Natural', 'clear' and 'transparent' are often used interchangeably.
	Coloured/jazz	Coloured/jazz plastic is less valuable as it is more difficult to dye when processing into new products. Black plastic may also absorb light used by many optical sensors and fail to get sorted by polymer. Light colour material is more valuable than dark colour material. Mixed and dark colour material are typically used to manufacture products with less emphasis on appearance and colour.
Re-use/re-manufacture product	Food grade	Products that serve as packaging for foodstuffs. Currently, HDPE and PET are the only plastic polymers recycled for food grade purposes. Specifications for recycled plastic for food-grade reprocessing are stricter than non-food grade reprocessing.
	Non-food grade	Packaging products that do not come into contact with food.
	Downcycled products	Recycled plastic used for non-plastic applications to displace other virgin material, such as wood and asphalt, in industrial and construction projects. E.g. road base.

Product specifications that may be included in agreements between buyers and sellers for unprocessed single polymer plastics (Phase 1), e.g. baled bottles, and for processed single polymer plastics (Phase 2), e.g. flakes and pellets, are described in Table 5.

Table 5 Description of specification aspects

Specification aspect	Relevance	Applicable to Phase 1 or 2?
Polymer type	Different polymers have properties suitable for different applications.	1, 2
Total contamination	Is the overall allowance for any forms of contamination. Contaminants of any kind can affect the physical and mechanical properties causing degradation of the recycled plastic, limiting its function and end-use.	1, 2

Specification aspect	Relevance	Applicable to Phase 1 or 2?
	Contamination is often reported as a ratio of the specified polymer to contamination, e.g. 90:10 equates to a batch of product with 90% of the specified polymer and 10% contamination. Alternatively, it may be described as '90% pure'.	
Polymer contamination	<p>Is the allowance for different polymers. Polymers have different melting temperatures and therefore contamination will affect its physical and mechanical properties during the extrusion process and contribute to degradation.</p> <p>Polymers with similar densities are harder to separate with traditional methods such as a float-sink step and therefore limits for these polymers may be specified. E.g. PET and PVC.</p> <p>Polymer contamination is often specified as parts per million (ppm).</p>	1, 2
Other contamination	<p>Is the allowance for different colours of the same polymer and for other materials that can be sorted and/or removed during processing, e.g. labels, sleeves, seals, and other materials such as metal, glass, dirt, food particles, residual liquid.</p> <p>Colour contamination can reduce the value of the product, especially natural plastic.</p> <p>Some contaminants such as wood, paper, rubber and silicone are potential sources of odour in recycled plastic products as these materials may burn slightly during extrusion and transfer odour to the plastic⁴.</p> <p>Contamination with specific materials is often specified as ppm.</p>	1, 2
Moisture content/humidity	Moisture acts as a contaminant during processing and can affect the physical and mechanical properties of the plastic.	1, 2
Bale density	Compression of bottles/containers increases transportation efficiency however over-compression may affect the ability to separate, sort and reprocess the material.	1
Bale measurements	Together with bale density, bale measurements demonstrate the quantity of product being traded.	1
Size of flake/pellet	Size of flake/pellet may affect its ability to be processed, e.g. required particle size for sorting by an optical sorter and extrusion.	2

⁴ Erema website: <https://www.ereima.com/en/refreshher/>

Specification aspect	Relevance	Applicable to Phase 1 or 2?
Bulk density	Bulk density can affect the flow of the product during reprocessing. This is important when blending recycled and virgin plastic.	2
pH value	pH can contribute to the degradation of the plastic product.	2
Melt flow index	The melt flow index measures the ease of flow of melted plastics as grams/10mins. It can be used to assess batch-to-batch variations and for comparison to virgin material.	2
Tensile strength (at yield/break)	Measures the performance of the product under stress.	2
Crystallinity	The degree of structural order of the polymer. A lower crystalline temperature compared to the virgin polymer may indicate lower molecular weight, more defective molecules and lower purity ⁵ . This can impact the tensile strength.	2

Examples of specifications for different plastic products, including bottle bales, flake and pellet are at Appendix B.

2.3.1 Stakeholder Commentary

Thresholds for most of these specifications were not reported as they vary greatly between customers, however Table 6 includes the comments provided by stakeholders (for both Phase 1 and 2).

Table 6 Stakeholder comments about specifications

Polymer	Specification comments
General	<ul style="list-style-type: none"> • Specification requirements should simply be to grade the bale/batch according to contamination level e.g. 90:10 or 99:1 grade. • Listed standards for export should be a very broad range. The APCO/NWRIC specs are a good start but exporters should be able to nominate others. • The allowed specification should just state resin or flake free of waste and then all other aspects of the spec should be customer based. There is no risk of flake or pellet going to landfill overseas. • In China: ≤3mm size difference allowed. • Some buyers request laboratory tests to show purity of flake/pellet. • No general specs for pellet and flake: end users want it as close to virgin material as possible. • There are EU and American standards regarding food grades. • Specifications for food grade flake are based on equipment for processing • Currently dealing with over 20 customers, each with their own specs (processor of PP, LDPE, LLDPE, HDPE, ABS).

⁵ Mechanical properties of recycled plastic fibres for reinforcing concrete (2013) Y. Shi et al., Fibre Concrete.

Polymer	Specification comments
	<ul style="list-style-type: none"> Washing and optical sorting may be done if needed. This is determined by the feedstock quality and the customer requirements. It is important to ensure residual contamination of exported material is kept at a minimum to avoid the negative environmental impacts associated with disposal in third world countries.
PET	<ul style="list-style-type: none"> For CDS PET, would expect 95% pure flake. For kerbside PET, would expect 85% purity. Want to minimise HDPE product in PET for bottle recycling. For food grade PET, needs to be about 99% clean. Current contamination agreements with customers are an average across different batches: e.g. for an agreed contamination level of 5%, some batches might have 2%, some might have 7% contamination. For bottle recycling, <1% coloured polymer in a clear batch allowed. 0% of PVC and PLA as it is difficult to separate from PET. 2-5% of HDPE/LDPE/PP may be allowed as these can be easily separated. Food grade recycled PET resin is exported as virgin PET, not under waste codes, as it is equivalent to virgin product.
HDPE	<ul style="list-style-type: none"> Milk bottles used for decking board or pipe: the customer doesn't care about colour contamination from lids, etc. Want to minimise PET contamination in HDPE product. Food grade HDPE resin should be 99% pure. For bottle recycling, <1% coloured polymer in a clear batch allowed.
PVC	<ul style="list-style-type: none"> Not aware of any consistent specifications for PVC. Manufacturers will have specific requirements.
LDPE	<ul style="list-style-type: none"> One particular customer requires a very high melt flow index and additives, such as wax, are added to reach this.
PP	<ul style="list-style-type: none"> There is not a strict food grade standard for PP. Depending on the end product, PP can take up to 10% polyethylene so polymer contamination levels might be more relaxed.
Other	<ul style="list-style-type: none"> PEF customer specs will include chloride content, flake size, density, etc.

Contamination was indicated as the only variable possibly suitable for a defined specification, although a one-size-fits-all approach would not be appropriate, and the above variables would need to be considered. It was found that exporters held a view consistent with the APR and ISRI Scrap Specifications: contamination levels determine the grade/quality of the product (e.g. 99/1 grade product is 99% pure and 1% contamination) and this determines the price of the product. This method allows lower quality products to still have a commercial value and be recycled.

Agreements between sellers and different buyers each have their own specifications based on the processing and equipment requirements in the buyer's plant. For example, different extrusion equipment can handle different levels and types of contamination and this will determine the customer specification. It was also reported by Australian plastic traders that some overseas processors prefer less processed products, such as bottles, as it allows them to ensure quality assurance processes from start to finish. For example, contaminants can be more easily removed when whole bottles are delivered via bales of product than through the use of an optical sorter for flake. For more processed product, such as flake or

pellet, it is harder to determine consistent quality without the use of laboratory testing or a strong trust between the buyer and seller.

It was suggested that a commercial agreement between buyer and seller and the details of such agreements, including overseas processing flow and end-use of product, should be more important than nominated specifications in export licence applications. The recent changes to the Basel Convention were cited as effective: exporters must be registered and must provide an import permit from the customer they are selling to, demonstrating the agreement to accept the specified export material.

2.4 Equipment and Processing

Phase 1

Processing plastics for export under Phase 1 of the ban will predominantly involve:

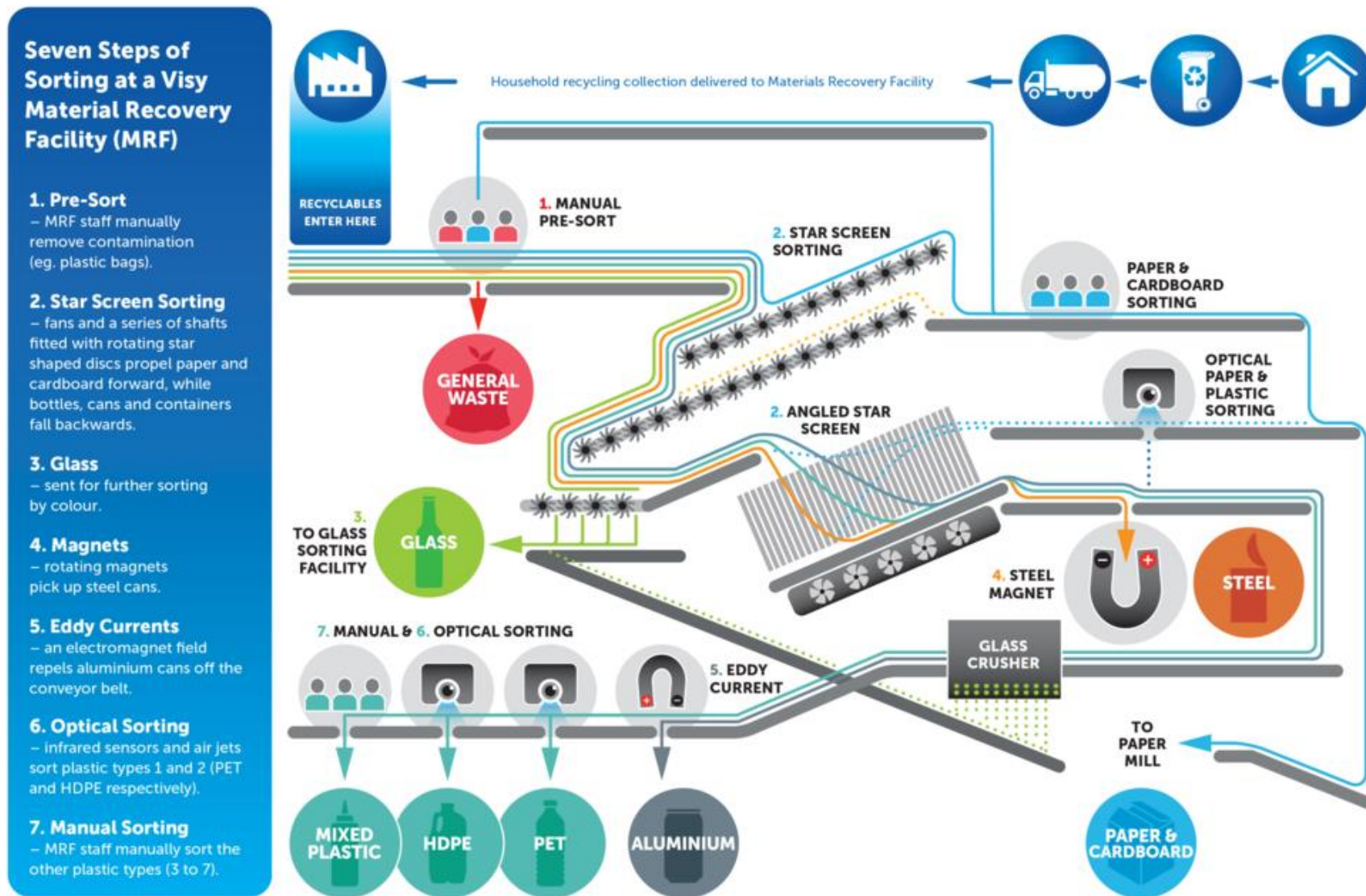
- Separation of plastic packaging (rigid PET, HDPE & PP) from kerbside recycling material, sorting by polymer type and baling at a MRF or secondary processor.
- Sorting and baling of clean post-consumer soft plastics (LDPE, HDPE & PP), such as pallet wrap.
- Sorting, shredding and extracting combustible material for PEF.

MRF equipment to remove other material includes a number of screens such as trommel and star screens to separate paper and cardboard, disc screens to break and separate glass, magnets to separate steel, eddy currents to separate aluminium and an optical sorter, as shown in Figure 1. Optical sorters use infrared lasers and sensors to identify the colour and type of material (polymer) based on absorption of light. A jet of compressed air separates the material.

Currently, MRFs may use several optical sorters (between 1 and 6) or manually sorting may be performed. The number of optical sorters is generally dependent on the number of plastic categories being sorted and throughput, e.g. sorting natural and coloured PET and HDPE from mixed plastics may require five optical sorters: one machine to separate clear PET, one machine to separate coloured PET, and so on. These separated products are then baled for transport.

To process PEF, contaminants such as glass, ceramics, PVC and concrete are removed prior to shredding. Shredded materials are then separated by density and baled.

Figure 1 Example of plastic separation flow at a MRF

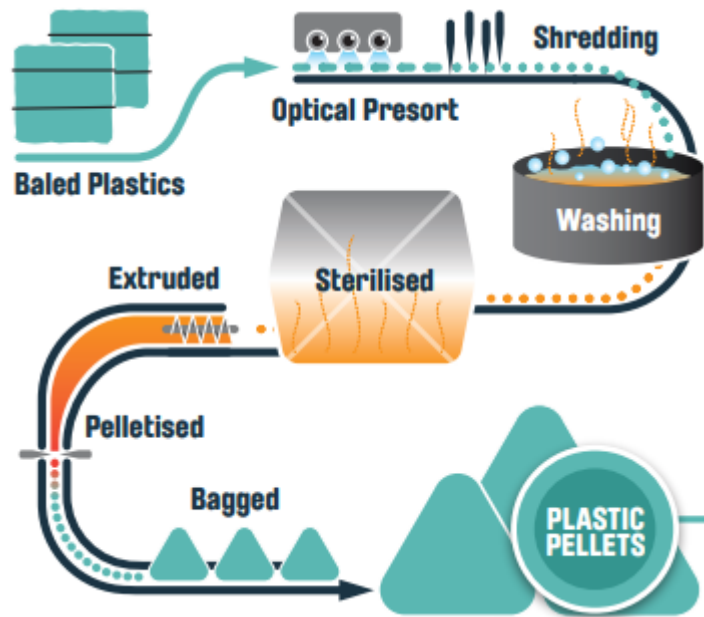


Source: Visy Australia

Phase 2

A general overview of recycling plastic and processing it into flake and pellet is shown in Figure 2. This is commonly used for PET, HDPE, PVC, LDPE, PP and PVC. The process involves: bale breakage, removal of contaminants, sorting by polymer type, shredding and/or granulation into flake, extrusion and pelletising. Other processes such as sorting by colour, cold and hot washing of the flake, drying, further decontamination, filtration and degassing may be performed depending on the source of the plastic, customer specifications and end use.

Figure 2 Example of plastic recycling process flow into pellet



Source: Visy Australia

Collection, removal of contaminants and sorting by polymer type is similar to the processing required under Phase 1 of the ban however there are a number of post-industrial and pre-consumer waste plastic sources for flake and pellet product. These may be made up of single stream sources which require minimal sorting.

Generally, pre-consumer and post-industrial waste sourced from the manufacturing phase is cleanest and may only require a cold wash or no washing before granulation. Other post-industrial waste considered more contaminated, such as PVC piping from the ground contaminated with dirt, may require more rigorous washing in a friction washer or a hot wash before size reduction.

Bales of post-consumer PET, HDPE and mixed plastics sourced from a MRF require a bale breaker. Mixed plastics are sorted by polymer type, consultation did not reveal a market for blended mixed polymer pellet.

Size reduction of plastics into a particular sized flake is achieved using a shredder and/or granulator. A shredder may be used for initial size reduction to pieces between 20 and 100mm. A granulator can further reduce size into flake between 6 and 20mm, according to customer specifications. Different shredders and granulators should be used according to the application, e.g. rigid or flexible plastic.

Post-consumer waste plastic requires a hot washing line which may involve chemicals to remove surface residues such as labels, glue, drink and food residues, odour. A caustic hot washing step was described for food grade material involving sodium hydroxide to remove resistant residues. Material is then dried in

a mechanical or thermal dryer to achieve a specified moisture content and sieved to remove contaminant and product fines.

Flakes may be further sorted at this stage to remove other colour flakes or polymer types before extrusion. An optical sorter can be used to sort flakes by colour and polymer types and remove contaminants. Separation processes involving density differences can also be used to separate polymer types. A floatation/sink washing step separates materials by density: PET and PVC sinks while polyolefins (HDPE/LDPE/PP including plastic film and bottle caps) float. Separation of plastics with close density values, such as PVC and PET, can be achieved by modifying the density/salt content of the separation liquid.

An example process line for separation, size reduction and washing of bottles into flake is at Appendix C. It is suitable for food grade PET as well as non-food grade plastics: PET, HDPE, LDPE and PP. An example of an optical sorter suitable for flake is at Appendix D.

During extrusion, the clean dry flakes are fed into an extruder and heated to melt them. The different polymer types have different melting temperatures and these will determine the extrusion temperature. The molten resin forms a continuous polymer strand and can be passed through screens to filter out any remaining contaminants. Technically, the same extrusion line can be used to process different plastic polymers however purging will need to be performed between polymer types. It is therefore more efficient to use separate lines. An example of an extrusion processing line suitable for HDPE, PP and LDPE/LLDPE flake is at Appendix E.

A pelletiser is used to cut the polymer strand into pellets. After pelletising, a bagging station may be used to load product into bags.

For food grade PET and HDPE product, there are a limited number of processors in Australia. It was advised during the consultation that only three equipment manufacturers (Starlinger, Erema and one other) produce United States Food and Drug Administration (FDA)-approved extrusion lines, which decontaminate the flake to remove oils, odours and other contaminants. These turn-key equipment solutions require very specific infeed sources, form and quality (examples at Appendix B). FDA approval can also be obtained for other variations of equipment used and is dependent on the entire production process, including the source of the material.

2.4.1 Processes for recycling less common plastics

EPS (#6): Recycling EPS involves granulation into millimetre particles and compression into continuous lengths via a thermal compaction machine to reduce bulk density. Bulk density can be reduced from 20g/L to 200-400g/L. Following granulation and compression, EPS material is extruded to produce a denser product and pelletised into general purpose polystyrene (GPPS) pellets. Product is then bagged for export.

Nylon (#7): nylon is difficult to recycle as it melts at low temperature, making it more difficult to remove contaminants. Nylon must therefore be from a clean source before shredding and extrusion.

ABS (#7): the process for processing ABS is similar to other rigid plastics as described above. It has a low melting point so no high heat applications.

PU (#7): PU is granulated and blended with a binder.

PC (#7): waste is shredded and granulated before extruded. There is a risk of BPA leaching as the plastic degrades so this type of plastic is increasingly unpopular for use.

2.5 Staffing

Numbers of employees were provided by some processors:

- A facility processing 7,000 tonnes of relatively clean pre-consumer and post-industrial LDPE, HDPE and PP per year, has seven employees on the day shift, four on the night shift and one manager.
- A facility processing post-industrial LDPE, HDPE, PP and nylon into resins, is currently operating 2 or 3 machines with 15 staff on the floor for 2 shifts per day, 5 days a week to generate 10,000-12,000 tonnes per year. Two years ago, it was operating 4 machines 24/7 with 33 staff on the floor to produce 20,000 tonnes per year.
- A facility processing post-consumer and pre-consumer scrap plastics (HDPE, LDPE, PP, ABS) into 5,000 tonnes of recycled resin per year, 24 members of staff are employed to operate the facility 24 hours a day, five days a week.
- For 24/7 operation of a proposed recycled food grade PET processing plant, 42 staff are to be employed to process 25,000 tonnes per year.

2.6 Reuse and Re-manufacturing Markets

The reuse and re-manufacturing markets for recycled plastics include any manufacturers of plastic products. Manufacturers purchase recycled plastic processed according to the specifications required for their manufacturing methods and product applications. These may include a specific melt flow rate, product suitable for the specific moulding method, contamination levels handled by the processing equipment, colour of the end-use product and whether it is food grade. Some recycled products may not be considered virgin plastics. Their specifications may determine their suitability for different products and the extent to which they can replace virgin content in the manufacture of new products, according to the manufacturing process. PET and HDPE are currently used to manufacture products with 100% recycled content, substituting all virgin input. This is not the case for other polymers.

Products that serve as packaging for foodstuffs are termed food grade and must be obtained from food grade recycled plastic, i.e. food grade PET and HDPE, that has undergone thorough decontamination. PP is not used for food grade products however can be used for cosmetic products depending on the processing performed. The major and minor uses of recycled polymers, as per the 2018–19 Australian Plastics Recycling Survey⁶, in Australia are shown in Appendix F. The uses overseas are expected to include these and others.

The main methods for manufacturing key plastic products are outlined in Table 7.

Table 7 Plastic manufacturing methods

Plastic manufacturing method	Common products
Tubing extrusion	Pipes, tubes
Extrusion through a spinneret	Polyester, fibres
Injection moulding	Solid materials including packaging, bottle caps, computers, car interiors
Blow moulding	Hollow materials including bottles and containers
Film blowing	Bags, film, sheets

⁶ 2018–19 Australian Plastics Recycling Survey (2020) Envisage Works for the Department of Agriculture, Water and the Environment.

The top ten importing countries for Australian waste plastic and their tonnages are provided in Table 8.

Table 8 Top ten importing countries of Australian waste plastics

Country	Tonnes	Percentage of plastic exported
Malaysia	112,973	43%
China	15,931	14%
Indonesia	11,397	10%
Thailand	9,552	8%
Taiwan	6,842	6%
Vietnam	3,684	3%
Latvia	2,079	2%
Romania	2,054	2%
Republic of Korea	2,018	2%
Philippines	1,453	1%

Source: Australian Bureau of Statistics⁷

Some stakeholders provided feedback regarding the importance of the export ban in preventing the negative environmental impacts associated with processing waste in developing nations where disposal is cheap and not regulated to a high environmental standard. It can be more economical for Australian exporters to sell material with high residual contamination levels to these countries than to dispose of the residual contamination in Australia.

Some Australian traders of plastics reported having in-house compliance teams to inspect the facilities and processes of overseas customers to ensure suitable waste management including the treatment of wastewater and disposal of residual material. This practice was not reported by plastic processors. Technology tracking the movement of recycled product, such as GS1 systems tracking the manufacturing, distribution and consumption of products, may offer a future solution to ensure product is being exported to a bonafide reprocessor and/or manufacturer⁸.

2.7 Testing, Quality Control and Importer Requirements

Phase 1

Overseas buyers of sorted bales of plastic do not require any testing to be performed prior to receiving product. Trading companies reported that high resolution photographs and/or videos of loads for export are used to display quality to customers. Other information may be requested by customers such as whether hand sorting or optic sorting is performed and what contaminants may be present and at what levels, e.g. glass or aluminium.

⁷ Australian Bureau of Statistics Waste Data Export Australia 2019–20:
<https://www.environment.gov.au/protection/waste/publications/waste-exports>

⁸ GS1 Global Traceability Standard: <https://www.gs1.org/standards/gs1-global-traceability-standard>

Phase 2

Visual analysis of flake and pellet product is more difficult for flake and pellet compared to unprocessed plastic bottles. Photos and videos may be used as well as a description of the product like Phase 1 of the ban however these methods have limitations. Plastic trading companies stated that customers buy from them due to the increased level of trust compared to buying direct from processors as traders are recognised as providing product of consistent quality. It can take up to three months for traders to approve an Australian supplier as suitable: an audit of the processing facility and regular testing of materials is performed.

Another trading company reported that some customers do not rely on photos for flake and pellet products and instead ongoing laboratory tests on samples of product are necessary. Laboratory tests reveal the purity percentage of the product and the percentage of contaminants as well as other tests such as melt flow index and impact resistance/rigidity performance tests. Using the results of these tests, the buyer deems the product on offer as suitable/unsuitable according to the down-stream processing and machinery of their facility. If the testing does not meet the agreed specifications, it may be rejected or the price renegotiated. Some customers may request a certificate of analysis (COA), especially for food grade material. Certification from a National Association of Testing Authorities (NATA) accredited facility was not found to be requested by buyers.

Some buyers may request samples to be sent to them for testing.

3 The Plastics Market

3.1 Pricing

The product price ranges shown in Table 9 are estimates provided by stakeholders at the time of consultation. Different rows for the same products represent ranges provided by different stakeholders. Often local or export prices were not specified; when they were, it has been indicated.

Table 9 Market prices for different plastic products

Polymer type	Product	Price (\$/tonne)
PET	Clear bottles (CDS)	300-400
		300-500
	Clear bottles (MRF)	250
	Clear flake	700-800
	Clear pellet	1,200-2,000
		1,500-3,000
HDPE	Natural bottles	600-900**
	Coloured bottles	300-400
	Natural pellet	Up to 2,000
		1,400-1,700*
	Coloured pellet	1,000-2,000
		1,500
		1,200-1,300*
	Partially processed (e.g. shredded)	800
	Scrap (prior to processing)	450-650
PVC	Unprocessed rigid bale	350
LDPE	Partially processed (e.g. shredded)	150-450
	Scrap (prior to processing)	100-450
	Pellet	800-1,200
	Natural/white pellet	1,500-1,700*
	Jazz/black pellet	1,100-1,200*

Polymer type	Product	Price (\$/tonne)
PP	Bottles	200-300
		300-700
	Pellet	1,200-1,600
		1,000-2,500
		900-1,100*
	Granulate	650-700
	Flake	1,400
	Partially processed (e.g. shredded)	600
	Scrap (prior to processing)	600
PS	EPS	250-800
Other	Natural nylon pellet (SPL product) (not exported)	900-1,000*
	Jazz/black nylon pellet (SPL product) (not exported)	800-900*

* Prices indicated to be local, export prices estimated to be half these prices by one stakeholder.

** Stakeholder noted that HDPE pellet (light blue) from milk bottles can be sold for \$900/t with lids and labels or up to \$2,000/t with additional processing, e.g. with a sanitiser and gasifier to remove contaminants.

3.2 Trading Contracts

Large processors of plastic are more likely to go through trading companies, such as Vanden Recycling and Oatley Resources Australia, to sell their product to overseas customers. Traders are then responsible for inspecting the product and/or processing facilities to determine quality and consistency prior to selling it. Customers may have more trust in buying from traders as they are confident they will receive a product of consistent quality.

One processor generating approximately 12,000 tonnes of pellet product per year reported selling direct to customers with another stating that they deal with a total of 20 to 25 local and overseas customers. However, the proportion of overseas customers was not shared.

Spot trading is currently and traditionally more common for recycled plastic products than ongoing contracts due to the nature of demand for the product, the large variety of specifications and the volatility of virgin material prices, i.e. oil. This may change in the future to more of a mix of spot and ongoing contracts.

4 Conclusion

All processors and exporters consulted expressed support for licensing the export of waste plastic and for developing the plastic recycling sector in Australia. Processors and recyclers have invested in operating equipment and supply chains to produce material that is of economic value to their customers, domestic or international, to be recycled into new products and diverted from landfill. All stakeholders, however, expressed concern regarding licensing based on set specifications noting that industry specifications are rarely used in agreements with customers or other trading partners.

A number of standards exist internationally, and ISRI specifications could potentially serve as a best practice guide. However, in practice, for plastic bales, flake and pellet, stakeholders indicated that the specifications used are those set by individual customers. Unlike glass which has more limited processing methods and reuse pathways, the options for customer specifications for waste plastic are numerous due to the many variables that affect its recyclability overseas, including:

- Source of input plastic;
- Customer plant equipment and processing;
- Form and colour of product required; and
- Reuse/remanufacture product.

Stakeholders emphasised that multiple variables should be considered during assessment of licence applications, particularly the agreement with the customer on what quality they require as specifications are demand related i.e. requirement of export should be that the material has been processed into a product for beneficial reuse with minimal contamination.

Importer requirements on quality assurance of the export material are not standardised and depend on the customer. To gauge the quality of exported plastics, some customers rely on photographs and video footage and a description of the material while others may request lab test results and product samples to be sent.

Different operations and equipment are necessary for processing different products under Phase 1 and 2 of the ban. Additionally, PET and HDPE food grade products require stricter and more thorough processing of recycled material, such as hot washing and contamination filtration. As a result, PET and HDPE can substitute 100% of virgin material in some applications.

For Phase 1, industry specifications exist which could be expected to be used by Australian exporters of baled plastic as a baseline to meet waste export licencing requirements. However, for Phase 2, aside from US FDA specifications for food grade recycled PET and HDPE, research and industry consultation have not identified similar industry specifications commonly used for reprocessed plastic products, such as flake and pellets. It is more likely that customer specifications or each individual company's product data information would be nominated as the specification in use.

Many of the re-processors of plastic described similar processing operations. Essentially, the level of processing related to the 'cleanliness' of the infeed material and quality required of the output material, with extra processing steps required for infeed material with higher contamination levels and to produce higher quality material. Much of the variation related to whether a cold and/or hot washing process was used. Assessment of processing operations and export licence applications in general should be performed with consideration of the source of the waste plastic feedstock, the customer agreement, operations/equipment in place at the receiving site and end use of the product.

Appendix A Properties of recycled and virgin plastic

Table 10 compares the melting temperatures (T_m) and crystallinity (%) for different blends of virgin PET and recycling PET (rPET), including food grade and non-food grade PET⁹. Note: detail of reprocessing was not provided.

Table 10 Comparison of crystallinity and melting temperature of PET blends

Recycled content of PET (%)	Crystallinity (%)	Melting temperature (°C)
100% virgin PET	33.01	250.0
90% virgin PET:10% rPET	30.84	250.0
80% virgin PET:20% rPET	27.21	249.8
70% virgin PET/30% rPET	32.03	249.9
50% virgin PET/50% rPET	32.04	249.7
100% rPET (food grade)	34.03	251.2
100% rPET (non-food grade)	36.39	251.6

⁹ Thermal and mechanical properties of recycled PET and its blends (2005) P. Pattabiraman, I. Sbarski & T. Spurling, ANTEC.

Appendix B Example Specifications

Figure 3 Example specification for different plastic products

Product description	Specification aspect	Specification value
PET bottle bale specification for input into size reduction and washing process (food grade)	Maximum bale dimensions	1200 x 1100 x 1300mm
	Max. bale density	150 ÷ 350 kg/m ³
	Bottles/containers	must be in crushed form, 500-5000cc
	Non PET containers	max. 5%
	PVC from bottles	0.5%
	PVC from gaskets and seal	Not allowed
	Bottles with PVC labels	1%
	PA from multilayer barrier	Not allowed
	PETG sleeves labels	1%
	Tetrapak	Not allowed
	Aluminium from caps and cans	0.1%
	Iron	0.5%
	Inert not metallic	0.5%
	Rubber Tire	0.1%
	Labels PP, PE, Paper	Allowed
	Caps PP, HDPE	Allowed
	Residual liquids inside the bottles	5%
	Coloured bottles	1%
	Refillable bottles	max. 5%
	Paper	0.1%
PET flake specification for	Surface moisture	max. 1.0 %
	PVC (flake, label) content	max. 50 ppm

Product description	Specification aspect	Specification value
input into food grade extrusion process	Glue content	max. 4.000 ppm (flakes included)
	Yellow flakes (UV-degraded, blocker, oil bottles)	max. 4.000 ppm
	PA content	max. 50 ppm
	pH value	neutral (pH+/- 0,5)
	HDPE / PP content	max. 20 ppm
	PET dust (particle size < 1mm)	max. 1 %
	Metal content	max. 50 ppm
	Wood, paper, cellulose	max. 20 ppm
	Silicone, rubber content	max. 20 ppm
	Other contamination	max. 10 ppm
	Flake size	4 - 14 mm
	Bulk density	min. 290 g/l
HDPE natural pellet (food grade) for extrusion and blow moulding, compounding and sheet extrusion.	Melt flow index 2.16kg/190°C	0.5 - 0.7 g/10 min
	Melt flow index 21.6kg/190°C	40 - 55 g/10 min
	Density	0.950 - 0.964g/cm ³
	Bulk Density	580 – 640kg/ m ³
	Tensile strength @ yield	20 – 34MPa
	Tensile elongation @ yield	10 – 15%
	Pellet size (diameter)	3.0-4.9mm
	Particulate filtration (100µm mesh)	100% retained
PP flake specification for input into optical sorter and then	Input material should be de-dusted, sieved and wind shifted	
	Flake size	2-12mm

Product description	Specification aspect	Specification value	
wash and extrusion process (non-food grade)	Bulk density	~320kg/m ³	
	Labels contamination	<50ppm	
	Contamination specifications for different quality grades (as classified by the optical sorting equipment specifications):	Input	Output
	Quality A to A+		
	PVC	≤ 30 ppm	≤ 10 ppm
	Metal	≤ 20 ppm	≤ 5 ppm
	Transparent colour impurities	≤ 50 ppm	≤ 10 ppm
	Opaque impurities	≤ 100 ppm	≤ 10 ppm
	Quality B to A		
	PVC	≤ 200 ppm	≤ 30 ppm
	Metal	≤ 100 ppm	≤ 10 ppm
	Transparent colour impurities	≤ 200 ppm	≤ 70 ppm
	Opaque impurities	≤ 600 ppm	≤ 130 ppm
	Quality C to B		
	PVC	≤ 600 ppm	≤ 150 ppm
	Metal	≤ 300 ppm	≤ 50 ppm
	Transparent colour impurities	To be determined (TBD)	TBD
	Opaque impurities	TBD	TBD

Appendix C Bottle to flake processing flow example

An example of processing equipment flow for processing of bottles to flake is provided in Figure 4. It is suitable for food grade PET as well as non-food grade plastics: PET, HDPE, LDPE and PP.

Figure 4 Separation, size reduction and washing equipment line example



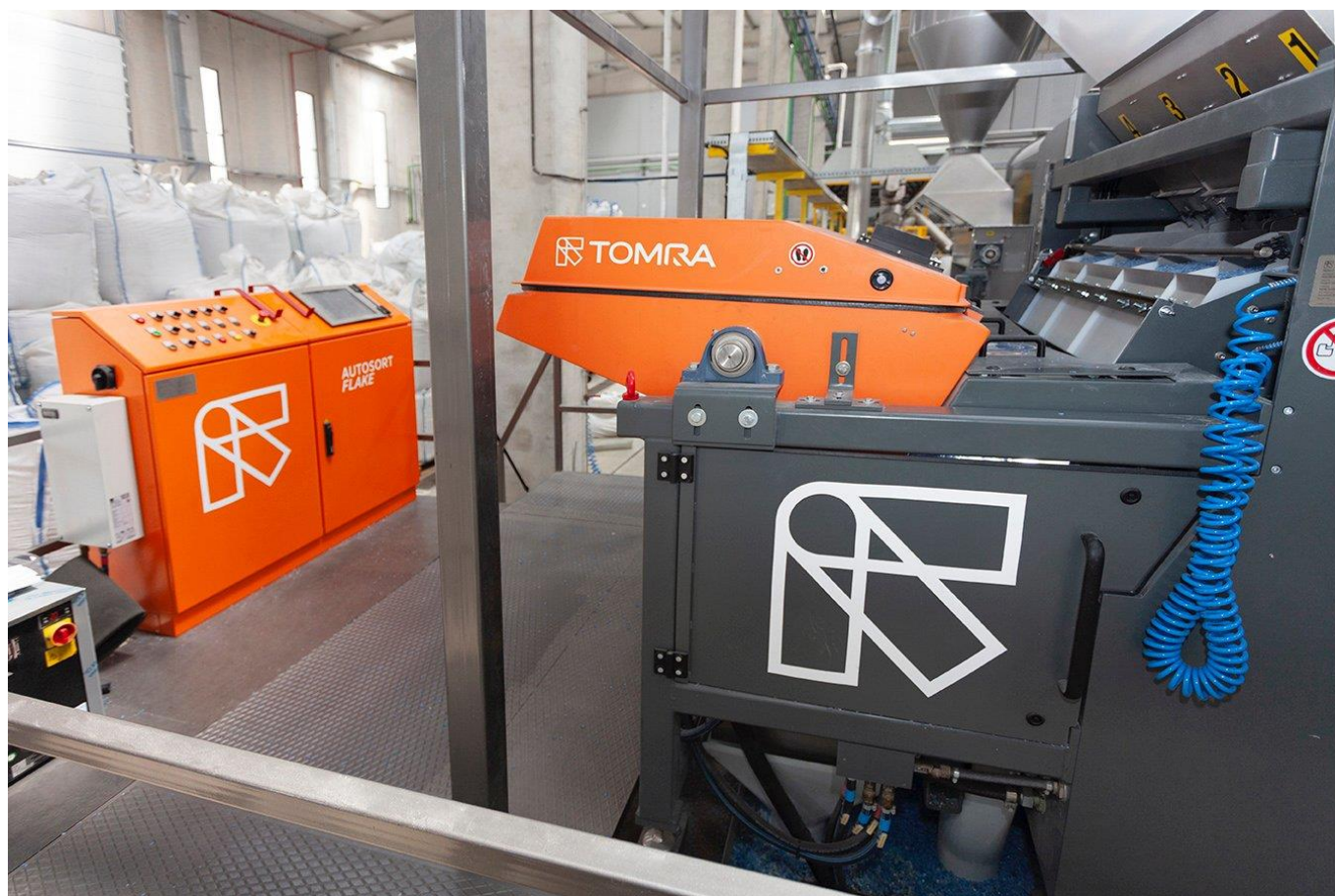
Source: Telford Smith Engineering
Department of Agriculture, Water and the Environment / Waste Plastics Industry Standards

Appendix D Optical sorting equipment example

Figure 5 is an example of an optical sorter, the TOMRA AUTOSORT® FLAKE, used to sort PP flake from post-consumer mixed HDPE and PP plastic. It can also be used to sort other polymer types such as PET, HDPE and PVC. The machine specifications are:

- Width: 1,900mm
- Length: 2,300mm
- Height: 2,000mm
- Weight: 1,850kg
- Power consumption: 10kW
- Flake size range: 4-12mm

Figure 5 Optical sorting equipment example

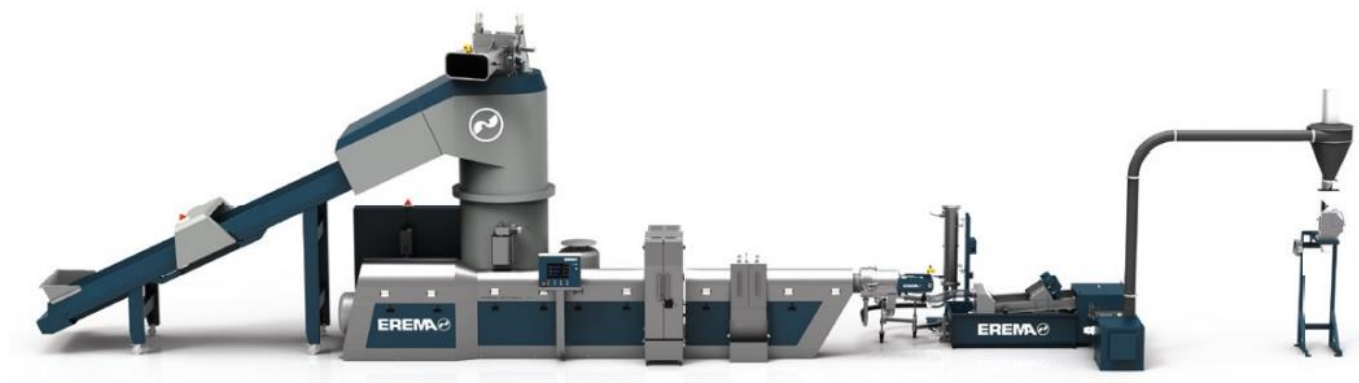


Source: TOMRA

Appendix E Extrusion processing equipment example

Figure 6 is an example of an extrusion and pelletising processing line, the EREMA INTAREMA® TVEplus®, suitable for HDPE, PP and LDPE/LLDPE flake. Material is fed into the machine where it is cut, mixed, heated, dried and pre-compacted before being degassed, filtered and extruded into pellets.

Figure 6 Extrusion equipment example



Source: EREMA

Appendix F Remanufacture Products

Table 11 Major and minor uses of recycled plastics in Australia¹⁰

Polymer	Major uses of recycled polymer	Minor uses of recycled polymer
PET	Beverage bottles	Timber substitutes, geo-textiles, pallets and fence posts.
PE-HD	Films, pallets, wheelie bins, irrigation hose and pipes	Cable covers, extruded sheet, moulded products, shopping and garbage bags, slip sheets, drip sheets for water, wood substitutes and mixed plastics products (e.g. fence posts, bollards, kerbing, marine structures and outdoor furniture), materials handling and roto-moulded water tanks.
PVC	Pipe, floor coverings	Hose applications and fittings, pipes including foam core pipes, profiles and electrical conduit, general extrusion and injection moulding, clothing, fashion bags and shoes.
PE-LD/LLD	Film (incl. builders' and agricultural film, concrete lining, freight packaging, garbage bags, shopping bags), agricultural piping	Trickle products, vineyard cover, pallets, shrink wrap, roto-moulding, slip sheets, irrigation tube, timber substitutes, cable covers, builders' film, garbage bags, carry bags, and other building industry applications.
PP	Crates boxes and plant pots	Electrical cable covers, building panels and concrete reinforcement stools (bar chairs and shims), furniture, irrigation fittings, agricultural and garden pipe, drainage products (such as drain gates) and tanks, builders film, kerbing, bollards, concrete reinforcing and a wide variety of injection moulded products.
PS	Bar chairs and industrial spools	Office accessories, coat hangers, glasses, building components, industrial packing trays, wire spools and a range of extrusion products.
PS-E	Waffle pods for under slab construction of buildings	Synthetic timber applications (including photo frames, decorative architraves, fence posts), XPS (extruded polystyrene) insulation sheeting, and lightweight concrete.

¹⁰ 2018–19 Australian Plastics Recycling Survey (2020) Envisage Works for the Department of Agriculture, Water and the Environment.

Polymer	Major uses of recycled polymer	Minor uses of recycled polymer
ABS/SAN/ASA	Injection moulded products	Automotive components, laminate edging, sheet extrusion, coffin handles, drainage covers, auto parts and a range of injection moulded products.
Polyurethane	Carpet underlay	Mattresses.
Nylon	Injection moulded products	Furniture fittings, wheels and castors and a range of injection moulded products.
Other and mixed	Timber substitute products in general and piping	Fence posts, bollards, garden stakes, kerbing, marine structures, post and rail systems, scaffold pads, piggery boards, shipping dunnage, rail bridge transoms.

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