Volume III: Guidelines

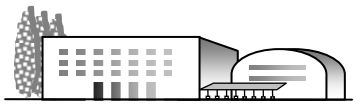
1. Recycling Guidelines for Waste Generators

1.1 Introduction

The Recycling Guidelines for Waste Generators are prepared for the individuals and entities that generate waste in their everyday life or business activities. Such individuals and business entities include:

1. Households

2. Business entities (offices, commercial, industry, and service establishments)



3. Institutions

The waste generators play significant roles in the recycling activities as their effort to segregate recyclable materials from waste stream, and pre-treat the recyclables will greatly affect the efficiency of recycling processors, i.e. dealers and end-users of recyclable materials.

Thus, this Guideline will focus on what can be recycled, why we need recycling, and how those resources can be recycled from household, business entities and institutions. The contents of the Guideline are:

1. Target recyclable materials
2. Key roles of waste generators
3. Proper handling of each recyclable materials

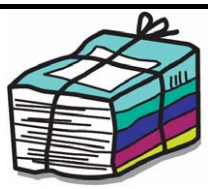
The guidelines are prepared as the result of joint works between JICA Study Team and the Technical Working Groups that are organized under the Study in the Philippines by the representatives from the government, industry as well as other key organizations in promoting recycling activities.

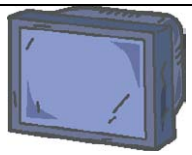
We really hope that the guidelines will help and assist the household, business entities, and institutions, and enhance their recycling activities and contribute to the realization of a material-recycle society in this country.

1.2 Target Recyclable Materials

Target materials included in this Guideline are, papers, metals (tin and aluminum), glass containers, plastics, and electric/electronic home appliances (cell phone batteries, PC and its parts, TV and refrigerator).

Pictures below illustrate some of the typical forms of those recyclable materials.

<table>
<tr><td rowspan="3">Papers</td><td> 
Newspaper</td><td> 
Magazines</td><td> 
Copy/printing paper</td></tr>
<tr><td> 
Mixed paper</td><td> 
Cardboard</td><td> 
Used brown Kraft paper, and Old corrugating cartons</td></tr>
<tr><td> 
Other papers</td><td></td><td></td></tr>
<tr><td>Metals</td><td> 
Tin cans</td><td> 
Aluminum cans</td><td></td></tr>
<tr><td>Glass containers</td><td> 
Amber (Brown)</td><td> 
Flint (Clear)</td><td> 
Emerald green (Green)</td></tr>
<tr><td>Plastics*</td><td> 
PET</td><td> 
PE/PP Rigids</td><td> 
PE/PP Films & Bags</td></tr>
</table>

	 Foam PS	 EPS	 PVC
Electronic/ home appliance	 PC and its parts	 TV	 Refrigerator
	 Cell Phone Battery		

Plastic types have been grouped according to the following:

1 PET	PET – Polyethylene Terephthalate which are used for many bottles application because they are inexpensive, lightweight and shatter-resistant. (e.g. Mineral/Drinking Water Bottles)

3 PVC	PVC- Polyvinyl Chloride products which are used for pipes and fittings. It is noted that over 80% of PVC used in applications have service lives of more than 10 years, thus, there is usually minimal PVC in municipal wastes.

2 HDPE	PE/PP Rigids – Polyethylene and Polypropylene products which are used in rigid applications such as bottles, pallets, crates, drums and other hard plastics.
4 LDPE	PE/PP Films and Bags – Polyethylene and Polypropylene products which are used in flexible applications such as bags, liners, and other single or mono-component soft plastics.
5 PP	

6 PS	Foam PS – Polystyrene products which are used in food service packaging. EPS – Polystyrene products which are used as cushioning materials for fresh produce, electronic or appliance industries, among other products.

1.3 Key Roles of Waste Generator

Recycling activities can only succeed when all relevant parties play their respective roles. In this sense, waste generators, i.e. households, business entities, and institutions, are expected to follow the following roles and responsibilities:

(1) Households

- Segregation and handling of recyclable materials at sources in accordance with the Recycling Guideline (if applicable).
- Actively participate and give support to the recycling activities and programs organized
- Sharing of households information in relation to wastes and recycling
- Educating households particularly the children on recycling practices
- Practicing recycling at premises away from home such as working places and public premises

(2) Business Entities and Institutions

- Segregation and handling of recyclable materials at sources in accordance with the Recycling Guideline (if applicable).
- Actively participate and give support to recycling activities and organized programs
- Awareness raising among recycling industry workers
- Sharing information and raising awareness on recycling through networks such as business associations
- Inclusion of recycling guidelines and practices in the educational curricula
- Promoting the use of the plastics coding system to facilitate identification, segregation and recycling.

(3) Industries and Retailers

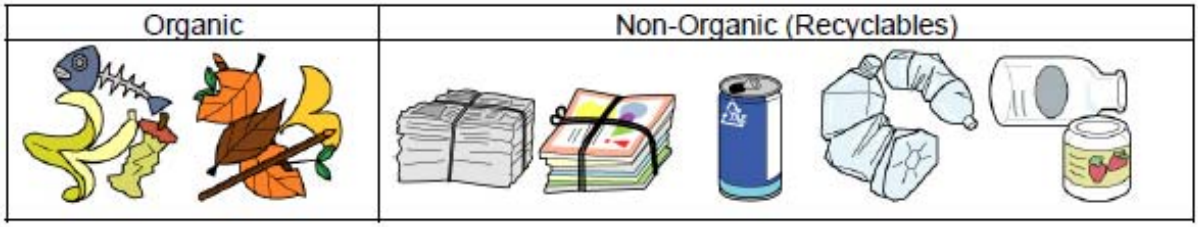
- Participating and supporting recycling activities and programs organized
- Designing and manufacturing eco-friendly products with recyclable materials
- Promoting in-house segregation and implementing in-house recycling activities and establishing a network of recycling stakeholders
- Strengthening and publicizing the existing network of waste traders

- Sharing industrial information related to waste and recycling to relevant associations and/or the Government
- Awareness raising among recycling industry workers
- Carrying out daily operation while following the Recycling Guidelines (if applicable)

1.4 Proper Handling of Each Recyclable Material

The waste generated from households, business entities, and institutions can be segregated into compostable waste and non-compostable waste (recyclable materials).

- Organic (compostable): Kitchen wastes, Garden wastes
- Non-Organic (Recyclables): Paper, Aluminum cans, Plastic, Glass bottles, etc.



Recyclable materials can be further classified and pre-treated according to characteristics of the materials and local requirements. The followings are examples of typical handling methods for each type of target recyclable materials in this Guideline.

1.5 Papers

Segregate and bale by types of papers.

Newspapers/add leaflets

Corrugating cartons

Magazines

Impurity should be separated from papers before discharging from the sources, especially organic wastes (e.g. kitchen waste) or plastic films, as they are hard to segregate once mixed.

Further, there are types of paper that are hard to recycle. Those types of papers should not be

mixed with other scrap papers for proper recycling.

- Thermal papers
- Plastic or aluminum coated papers
- Paper printed with dark colors (black, red, blue, green)
- Used tissue papers
- Photos

Following care should also be taken for when discharging:

- Do not mix paper with other materials, such as staples.
- Do not use packing tapes.
- Dirty paper should be discarded as municipal waste.
- Small pieces of paper that might easily scatter should be placed in a paper bag or envelope.

1.6 Metals

Metals can be segregated into tin cans and aluminum cans. Rinse with water to remove organic matters, and for aluminum cans, crash to reduce volume.

Tin cans

Aluminum cans

Example of tin can and aluminum can segregation and impurities to be avoided is shown below:

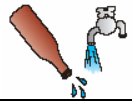
Types	Example	Segregation method	Impurities to be avoided
Steel can	Food container, cookie can, etc. 	Wash and dry 	Plastic/paper labels, organic matter
Aluminum can	Beverage can 	Wash, dry, and crash 	Organic matter

The following table lists the steel/aluminum cans that need special attention, and are not dealt in this Guideline.

Hard to recycle steel/aluminum cans				
Types	Example	Segregation method	Impurity	
			to be avoided	accepted
Steel can	Spray can 	Use up all content then discard	Plastic nozzle	
	Paint can 	-	-	No need to clean residue
	Oil can 	-	-	No need to clean residue
Other steel products				
	Cooking pot / pans 	-	-	
	Silverwares 	-	-	
	Knifes 	-	-	
	Others			

1.7 Glass Containers

Glass bottles can be categorized as ‘one-way bottle’, and ‘returnable bottle’. Both of them should be rinsed off with water and segregated by color, i.e. amber (brown), flint (clear), and emerald green (green). Broken glass bottles and other containers may be accepted for glass culet, depending upon the local dealers. Broken bottles and other *containers* should also be segregated by colors, i.e. amber (brown), flint (clear), and emerald green (green).

Types	Example	Segregation method	Impurity to be avoided
Glass bottles (one-way bottle)	Jam jar, beer bottle, and wine bottle. 	By color, Wash and dry 	Plastic/paper/ aluminum coated labels, cap, organic matter, ceramics
Glass bottles (returnable bottle, can be used about 30 times)	Jam jar, beer bottle, and wine bottle. 	By color, Wash and dry 	Organic matter, cap, other
Others -accepted if content is lime -culets are accepted -no glass pellets	Broken bottle, glass (accepted at San Miguel Packaging for glass culets. Colored bottles are accepted but should be segregated) 	(Placed in bag)	Plastic/paper/ aluminum coated labels, cap, organic matter, ceramics, other foreign materials
	Cosmetic / vitamin drink bottles 	By color, Wash and dry Flint (clear) or amber (brown)	Plastic/paper/ aluminum coated labels, cap, organic matter, ceramics
	Tempered glass 		Organic matter, foreign materials

- Rinse off with water and remove food residue. Be careful not to brake it.
- Remove cap and labels.

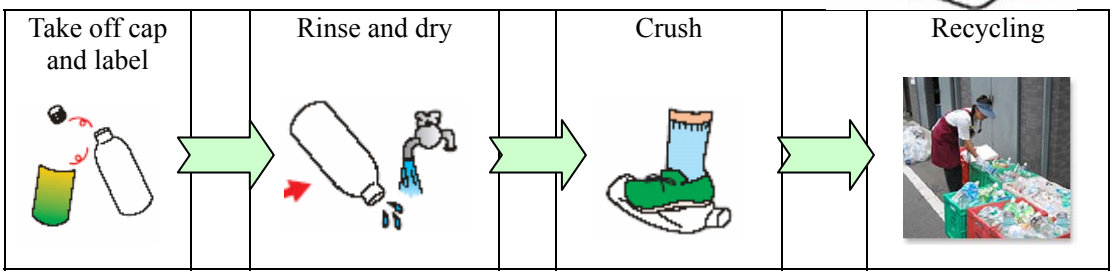
Some local dealers will not accept broken glass and other special types of glass as shown in the following table.

Glass that needs special attention			
Flat glass (e.g. window glass such as jalousy)		-	-
fluorescent bulb		-	-

1.8 Plastics

Plastics are used in forms of bottles, food trays, food packaging, various films, caps, cushioning, and other applications.

Among them, PET (Polyethylene Terephthalate) bottle is one of the most frequently used plastic beverage and other liquid containers in everyday life. For proper recycling, take off cap and label from the bottle, then rinse off the content with water. Then, crush it to reduce volume. Finally, discharge to recycling according to local conditions.



Recycling PET is done as follows:

Segregate

Compress/ crush

Grind

Place in Sacks

Export or Bottle-to-Bottle Recycling

As for the other types of plastics, the recycling practice involves:

CLEANING → **COMPRESSING/ CRUSHING** → **GRINDING** → **PELLETIZING & COMPOUNDING**

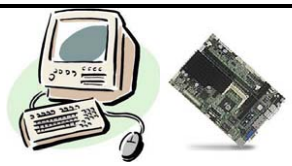
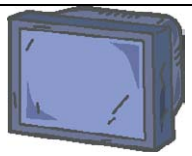
Following are examples of forms of other types of plastics and segregation methods.

Plastic type	Example	Segregation	Impurity to be avoided
PET		Wash and dry	Cap, label, residue
PE/PP Rigids		Wash and dry	Foreign contaminants
PE/PP Films and Bags		Wash and dry	Foreign contaminants
Foam PS		Wash and dry	Food residue and foreign contaminants
EPS		Wash and dry	Food residue and foreign contaminants
PVC		Wash and dry	Foreign contaminants

- Plastic containers that store hazardous materials should be treated according to local requirements.
- All plastic recyclables have to be cleaned
- Whenever possible, PET recyclables must be separated by color
- Plastic bags should be torn on the sides

1.9 Electric/electronic Home Appliances

Electric/electronic home appliances that can be recycled include PC and its peripherals, television set, refrigerator, and cell phone battery.

Types	Example	Segregation method	Impurity to be avoided
PC and peripherals		Not to mix with municipal waste	Dirt or other foreign materials
TV set			
Refrigerator			
Cell Phone Battery			

- Proper storage: Electric/electronic appliances should be kept indoor wherever possible as dirt or rust caused by rain will reduce the quality, thus, buy back price of the materials.
- Cell phone/ cell phone batteries should be handled with care to avoid breakage and as much as possible cover the ends/ electrical contacts with insulating tape. Cell phone batteries should also not be mixed with municipal waste.

2. Recycling Guidelines for Dealers of Recyclable Materials

2.1 Introduction

The Recycling Guidelines for Dealers of Recyclable Materials are prepared for the individuals and entities that deal with recyclable materials as their business or non-business activities. Such individuals and business entities include:

- Traders of recyclable materials
- Junkshops and junk dealers
- Material recovery facility (MRF)
- Other individuals and entities dealing with recyclables as valuable and tradable materials

The dealers of recyclable materials play significant roles in keeping the current recycling performance in the Philippines through active collection and trading of valuable waste materials. They also provide job opportunities to the socio-economically weak people through creating jobs in relation to collection, sorting and primary processing of recyclable materials.

On the other hand, due to no existence of technical guidance on proper collection, handling and primary processing of recyclable materials, they are sometimes not well prepared to meet the quantity or quality requirement of end-users or exporters. Also, in terms of working safety and hygiene as well as environment management, there are some junkshops and junk dealers that improperly handle and process the collected recyclables.

To address these issues, the Guidelines consist of the following:

1. Quality Standard for Acceptance of Recyclable Materials by Dealers, which specifies, by each recyclable item, the quality standard to meet requirement of end-users or exporters;
2. Facility standard for storage or warehouse of recyclable materials;
3. Data management of trading activities at the level of individual dealers such as inventory control and bookkeeping.

The guidelines were prepared as the result of joint works between JICA Study Team and the Technical Working Groups that are organized under the Study in the Philippines by the representatives from the government, industry as well as other key organizations in promoting recycling activities.

We really hope that the guidelines will help and assist the dealers to develop and enhance their recycling activities and contribute to the realization of a material-recycle society in this country.

2.2 Quality Standard for Acceptance of Recyclable Materials

2.2.1 Scrap Papers

(1) Scope of the Quality Standard to be Applied

The quality standard for scrap paper to be provided below will be applied to old newspaper, cardboard, old magazine, office paper, used brown Kraft and old corrugating carton, and miscellaneous papers, of which the definitions are given below.

Table 2.2.1 Definitions of Scrap Papers

Category	Description
Newspaper	Newspapers discarded from households, offices, government institutions and others including advertisement leaflets folded in the newspaper. Six months old newspaper must be segregated and classified as lower grade quality.
Cardboard	Cardboards discarded from cardboard and paper container manufacturers as well as from households, offices, government institutions and others. This is classified as white cardboards and grayback or chipboard.
Magazine	Magazines and books discarded from households, offices, government institutions and others such as those returned from bookstores and dead stock.
Office paper	Paper and paper products discarded from offices, mainly unbound printing paper including used copy paper. More specifically, it includes used copy paper, leaflet/pamphlet, name card, envelope, package paper, paper containers, etc.
Miscellaneous paper	Paper, cardboard, or other paper products not categorized above. Carbonless paper and Thermo sensitive paper, papers laminated with plastic film and aluminum foil can also be recycled. However, recovery is only about 50% or lower
Used Brown Kraft paper and Old corrugating carton	Consists of old corrugated containers having liners of either test liner, jute or Kraft, and old brown Kraft bags free of objectionable liners or contents, and brown Kraft cuttings from supermarkets, households, offices and government institutions

Regarding office paper and miscellaneous paper, some of the paper and paper products must not be mixed with recyclable scrap paper as shown in the table below.

Table 2.2.2 Non-Recyclable Scrap Paper

- Waterproof paper (paper cup, paper plate, paper container for cup noodles, yogurt or other food products, grease paper, etc.
- Carbon paper
- Pressure-bonded postcard
- Sensitive paper (photographic, photo-sensitive)
- Papers laminated by plastic film, aluminum foil, etc.
- Iron-on printed papers
- Papers stamped with metal foil.
- Papers having odorant (paper container/box for soap, detergent, etc.)
- Braille papers (papers used for braille typewriting)
- Synthetic paper
- Wet papers or the dirty papers contaminated by oil, food leftover, etc. (used tissue paper, paper towel, toilet paper, etc.)
- Other papers not suitable as raw material for paper production

(2) Unwanted Materials Not to Be Mixed with Scrap Papers ~~(Taboo Items)~~

Unwanted materials that are prohibited to be mixed with scrap papers are divided into two categories, Category A and B as shown below.

1) Category A: Heterogeneous/foreign items that bring ~~serious disruption~~ obstruction? to recycling

- Stone, glass, metallic material, earth and sand, woodchip.
- Plastic materials
- Resin-impregnated paper, parchment paper, fabrics
- Tarpaulin paper, paraffin paper, paper-made building materials such as gypsum board
- Iron-on printing paper, Braille paper, Synthetic paper, bonded material
- Papers having contact with infectious waste
- Other papers that disturb recycled process or products

2) Category B: Unwanted items not to be mixed with scrap paper for proper recycling

- Carbon paper
- Carbonless Copy Paper (CCP)
- Resin-coated paper and laminated paper
- Adhesive tape (except for recycling of cardboards)
- Thermo-sensitive paper, aromatic/perfumed paper and papers having odorant
- Other papers that are not suitable as raw materials for paper manufacturing

(3) Quality Standard for Acceptance of Scrap Papers by types

The quality standard for acceptance of scrap paper can be determined as follows:

1) Office Paper

Item	Quality Standard
1. Mixture of unwanted items	
(1) Category A	Not allowed
(2) Category B	Not allowed in principle. Even though it is unavoidable, it should not exceed 0.5% of mix rate by colors.
2. Water content	Not exceed 12%

2) Magazine

Item	Quality Standard
1. Mixture of unwanted items	
(1) Category A	Not allowed
(2) Category B	Not allowed in principle. Even though it is unavoidable, it should not exceed 0.5% of mix rate.
2. Mixture of non magazine	Not exceed 5% of mix rate.
3. Water content	Not exceed 12%

3) Brown Kraft Paper

Item	Quality Standard
1. Mixture of unwanted items	
(1) Category A	Not allowed
(2) Category B	Not allowed
2. Mixture of non brown Kraft paper	Not exceed 0.5% of mix rate
3. Water content	-

4) Cardboard

Item	Quality Standard
1. Mixture of unwanted items	
(1) Category A	Not allowed
(2) Category B	Not allowed in principle. Even though it is unavoidable, it should not exceed 0.3% of mix rate.
2. Mixture of non cardboard	Not exceed 3% of mix rate.
3. Water content	Not exceed 12%

5) Newspaper

Item	Quality Standard
1. Mixture of unwanted items	
(1) Category A	Not allowed
(2) Category B	Not allowed in principle. Even though it is unavoidable, it should not exceed 0.3% of mix rate.
2. Mixture of non newspaper	Not exceed 1% of mix rate. (exc. Leaflets folded in the newspaper)
3. Water content	Not exceed 12%

6) Miscellaneous Paper

Item	Quality Standard
1. Mixture of unwanted items	
(1) Category A	Not allowed
(2) Category B	Not allowed in principle. Even though it is unavoidable, it will not exceed 0.5% of mix rate.
2. Water content	Not exceed 12%

(4) Style of Packing

The style of packing scrap paper is provided as follows:

- In principle, scrap papers are required to be in the form of pressed bale package.
- Unwanted items are not allowed to be utilized for tare. (The use of string and metal wire for baling is allowed.)

(5) Sub-Standard Articles

The following scrap papers are defined and dealt with as sub-standard articles.

- Degraded/deteriorated scrap papers
- Sunburned scrap papers

- Scrap papers contaminated by soil/dirt, rust, etc.
- Other Scrap papers that are not in compliance with the quality standard defined above.

2.2.2 Tin Can

(1) Scope of the Quality Standard to be Applied

Tin can that is subject to the Guidelines is generally defined as an air-tight sealed container for the distribution or storage of goods, composed of tin metal, and requires cutting or tearing of the metal as the means of opening. Cans hold diverse contents, but the overwhelming majority preserve food by canning. No cans presently in wide use are composed primarily or wholly of tin; that term rather reflects the near-exclusive use in cans of tinplate steel, which combined with the physical strength and relatively low price of steel with the resistance to corrosion of tin. The pictures below show the examples of tin cans, of which, all are subject to collection for recycling.



(2) Quality Standard for Acceptance of Tin Cans by Dealers

General quality standard for acceptance of tin cans by dealers will be described as shown in the table below.

Table 2.2.3 General Quality Standard for Acceptance of Tin Cans by Dealers

Item	Quality Standard
1. Removal of contents	▪ Contents must be rinsed out by water. (except for spray can)
2. Mixture of non-tin cans	▪ Not allowed.
3. Labels	▪ To be removed to the utmost extent.
4. Spray cans	▪ Contents must be finished up ▪ Pressurized gas must be released by piercing a hole in cans or removing the caps, spray buttons, etc.

Item	Quality Standard
5. Aluminum top	▪ Not necessary to be removed.
6. Volume reduction	▪ To be compressed if possible.
7. Lithograph can (printed can)	▪ Maybe cut off the top and bottom part for easy compaction
8. Motor oil can	▪ No washing needed (residue oil maybe collected for reuse)
9. Cooking oil can	▪ No washing needed (residue oil maybe collected for reuse)
10. Paint can	▪ (Residue maybe collected for resale)

The above general quality standard may be subject to change in accordance with the requirement of final receivers of tin cans, the end-users or exporters. Therefore, it is essential to have common understanding on the acceptable quality of tin cans between dealers and end-users or exporters.

2.2.3 Aluminum Can

(1) Scope of the Quality Standard to be Applied

Aluminum can discussed here is the aluminum containers that are widely utilized to hold a single serving of a beverage including carbonated beverages.

(2) Quality Standard for Acceptance of Aluminum Can by Dealers

General quality standard for acceptance of aluminum cans by dealers will be described as shown in the table below.

Table 2.2.4 General Quality Standard for Acceptance of Aluminum Cans

Item	Quality Standard
1. Removal of contents	▪ Contents must be rinsed out by water.
2. Mix with non-aluminum cans	▪ Not allowed, but depending upon the separate collection system applied at the relevant localities
3. Labels	▪ To be removed to the utmost extent.
4. Pull tab or pull top	▪ Not necessary to be removed or separated from the cans
5. Volume reduction	▪ To be compressed if possible
6. Unwanted aluminum containers	▪ Aerosol can ▪ Tooth paste containers (Difficult to remove all the contents)

The above general quality standard may be subject to change in accordance with the requirement of final receivers of aluminum cans, the end-users or exporters. Therefore, it is essential to have common understanding on the acceptable quality of aluminum cans between dealers and end-users or exporters.

2.2.4 Glass Bottles

(1) Scope of the Quality Standard to be Applied

The quality standard for glass bottles to be provided below is applied to the glass bottles used as the containers for food drinks or any other inhalable thing. The following glass or glass bottles are not subject to the guidelines and not collected as recyclable materials.

Table 2.2.5 Non-Recyclable Glass and Glass Bottles

Types of glass and glass bottles	Reasons for non-collection
Scrap glass (non-bottle)	▪ Due to the different chemical composition, it cannot be utilized as raw material for producing glass bottles
Refractory glass	▪ It will not be completely melted in the manufacturing process of glass bottles.
Ceramics	▪ It will degrade the quality of glass bottles if mixed.
Glass bottles contaminated by sand, stone or dirt	▪ It will degrade the quality of glass bottles if mixed.
Lactescent bottle	▪ Due to the different chemical composition, it cannot be utilized as raw material for producing glass bottles.
Glass bottles used for pesticides or harsh drugs	▪ Risk of remaining hazardous substances.

(2) Quality Standard for Acceptance of Glass Bottles by Dealers

The quality standard for acceptance of glass bottles can be determined as shown in the table below.

Table 2.2.6 Quality Standard for Acceptance of Glass Bottles

Category of Foreign Materials	Maximum Acceptable Amount of Foreign Materials Mixed per 1 ton of Glass Bottles		Reference of Acceptable Amount
Bottle cap	Aluminum	0g	About 20 aluminum caps of 28mm diameter
	Steel	0g	About 10 steel caps of 50mm diameter
	Other metals	0g	-
	Plastic	0g	About 130 plastic caps of 28mm diameter
Ceramics		0g	A large piece of a broken tea cup
Stone, concrete, sand, soil		0g	Same as above
Colored bottles in flint bottles		0g	One bottle of 720ml

Category of Foreign Materials	Maximum Acceptable Amount of Foreign Materials Mixed per 1 ton of Glass Bottles	Reference of Acceptable Amount
Colored or flint (clear) bottles in different colored ~~ones~~ bottles	depends	-
Remaining contents and contamination	0g	Bottles should be rinsed.
Glass with different composition from glass bottles	0g	Kitchenware, tableware, crystal glass, light bulbs, and lenses should not be mixed.
Plastics, PET bottles, cans, and papers	0g	No foreign material should be mixed.

2.2.5 Scrap Plastics

(1) Scope of the Quality Standard to be Applied

The types of scrap plastics subject to the guidelines are PET bottles and other plastic containers and packages. The pictures and figures in the next table show their examples.

Table 2.2.7 Types of Scrap Plastics covered in the Guidelines

 PET/ PC (Polycarbonate)	 PE/PP Rigids	 PE/PP Films and Bags
 Foam PS	 EPS	 PVC

Plastic types have been grouped according to the following:

	PET – Polyethylene Terephthalate which are used for many bottles application because they are inexpensive, lightweight and shatter-resistant. (ex. Mineral/Drinking Water Bottles)

	PVC- Polyvinyl Chloride products which are used for pipes and fittings. It is noted that over 80% of PVC used in applications have service lives of more than 10 years, thus, there is usually minimal PVC in municipal wastes.

	PE/PP Rigids – Polyethylene and Polypropylene products which are used in rigid applications such as bottles, pallets, crates, drums and other hard plastics.
	PE/PP Films and Bags – Polyethylene and Polypropylene products which are used in flexible applications such as bags, liners, and other single or mono-component soft plastics.
	

	Foam PS – Polystyrene products which are used in food service packaging. EPS – Polystyrene products which are used as cushioning materials for fresh produce, electronic or appliance industries, among other products.

(2) Quality Standard for Acceptance of Scrap Plastics

1) PET Bottles

Whenever possible, PET bottles must be compressed and baled by dealers before transferring to end-users. In addition, bottles must be separated into clear and colored.

(a) Required Properties of Baled PET Bottles

Item	Required Properties
Stability	No collapse during transfer or transport of bales
Easy handling	Easy to be unbundled

(b) Required Properties of PET Bottles transported in caged or enclosed trucks (not baled)

Item	Required Properties
Stability	Collected PET bottles should have canvass covers

(c) Size, Weight and Bundling Material

Considering load efficiency by truck and standard size of cargo pallets, the following three types of bales are highly recommended.

Size	Weight	Bundling Materials
600*400*300 mm	15 – 20 kg	Polypropylene or PET band
600*400*600 mm	30 – 40 kg	Ditto
1,000*1,000*1,000 mm	180 – 230 kg	Wire
Or as specified by Recycling Companies		

Remark:

- The size above indicates that of a press mold; therefore, the size of baled PET bottles may be slightly larger than the numbers indicated in the table above.
- To avoid contamination by rust, galvanized steel wire is recommended when using wire for baling.

(d) Quality Standard for Baled PET Bottles

[To obtain higher quality of recyclable materials at the lowest cost, the following quality standards are recommended as the target for baled PET bottles.]

Item	Target Quality Standard
Mixing rate of bottles with caps	Less than 10%
Mixing rate of bottles including vinyl chloride	Less than 0.5%
Mixing rate of PE or PP bottles	Less than 0.5%
Mixing rate of glass bottles	None
Mixing rate of aluminum or steel cans	None
Mixing rate of paper containers	None
Mixing rate of other foreign materials	None

2) Other Plastic Containers and Packages

Non-PET plastic containers and packages are also required to be compressed and baled by dealers before transferring to the final users.

a Required Properties of Baled Plastic Containers and Packages

Item	Required Properties
Stability	No collapse during transfer or transport of bales
Sanitation	No odor is generated from bales. Organic materials capable of rotting/ decaying should not be attached or remain.
Easy handling	Easy to be unbundled (Bulk specific gravity of 0.25t/m^3 is highly recommended for the baled and bundled plastics.

b Required Properties of Plastic Containers and Packages transported in caged or enclosed trucks (not baled)

Item	Required Properties
Segregation	Plastic Container and Packages should be properly segregated or compartmentalized according to the classification stated in Item 2.5.1
Sanitation	No foul odor is generated. Organic matter producing foul odor should not remain or should not be attached.

3) Size, Weight and Bundling Material

Considering load efficiency by truck and standard size of cargo pallets, the following three types of bales are highly recommended.

Size	Weight	Bundling Materials
600*400*300 mm	18 – 20 kg	Polypropylene or PET band
600*400*600 mm	36 – 50 kg	ditto
1,000*1,000*1,000 mm	250 – 350 kg	Wire

Remark:

- The Size above indicates that of a press mold; therefore, the size of baled PET bottles may be slightly larger than the numbers indicated in the table above.
- To avoid contamination by rust, galvanized steel wire is recommended when using wire for baling.

4) Quality Standard for Baled non-PET Plastic Containers and Packages

To obtain higher quality of recyclable materials at the lowest cost, the following quality standard is recommended as the target for baled non-PET plastic containers and packages.

Item	Target Quality Standard	Remark
Minimum percentage of non-PET plastic containers and packages in the bale	More than 90%	
Mixing rate of PET bottles	Not allowed	
Mixing rate of non-plastic containers and packages	Not allowed	Mixing of metal, glass, or paper containers and packages is strictly avoided.
Mixing rate of other plastic types	Not allowed	A particular type of plastic must be segregated from all other plastics
Other foreign materials not listed above	Not allowed	Other foreign materials such as knives, glass and metal scraps other containers and packages, cloth, ceramics, sand and stone, food leftovers, woodchips, paper, leather, rubber, etc. are all forbidden to be mixed in the bale.
Water content	No drip of water from the bale	

(3) White Food Trays/Packages (Modify with PPCP)

Food trays and packages are required to be properly stacked (by size) in a transparent bag.

a Required Properties of Baled Food Trays

Item	Required Properties
Sanitation	The bag containing white food trays should be tightly sealed, transparent, and free from contamination by foul odor-generating substances especially food leftover as well as sand and soil.

2) Size, Weight and Bundling Material

The following two sizes of bags are recommended considering load efficiency and workability.

Size	Weight
1500*1200 mm (25 μ thickness)	2.3 – 3.0 kg
1200*1000 mm (25 μ thickness)	1.7 – 2.0 kg

3) Quality Standard for PSP (Styrofoam) Food Trays/Clamshells/Packages

To obtain higher quality of recyclable materials at the lowest cost, the following quality standard is recommended as the target for baled white food trays and packages.

Item	Target (weight %)	Remark
Minimum percentage of white food trays/packages	More than 90%	-
Foreign materials	Not allowed	-
Non-white food trays made from expanded styrene		Colored trays, trays with patterns
Trays other than above	Not allowed	PE, PP, PET, etc.
Plastic containers other than trays		Cups for instant noodles, etc.
Organic materials such as food leftovers		Food waste, woodchips, paper, leather, rubber and those containing any of these organic materials
Other		Knife, glass, metal, ceramics
Water	No drip of water from the baled bags	-

2.2.6 Used/Surplus Electrical and Electronic Home Appliances

(1) Cell phone batteries

1) Required Physical Properties

Item	Required Criteria
Proper Separation	▪ Cell phone batteries should be sorted by material (Nickel-Cadmium (Ni-Cd), Lithium-Ion, Lithium-Polymer, and Nickel-Metal Hydride)  **Recycling mark of batteries by types of metals used in Japan**
Dismantling from the cell phones	▪ Cell phone batteries must be dismantled from cell phones at the time of their disposal. Once removed, batteries should be managed with care to avoid breakage. While they are not fragile, they may break in rough handling.
Mix with other types of batteries	▪ It is not allowed to mix cell phone batteries with other types of batteries such as primary dry cells (alkaline batteries, manganese batteries, zinc carbon batteries), car batteries, etc.

Item	Required Criteria
Avoidance of accidental heat generation or ignition	▪ Batteries should be treated as if they still contain electrical charge. Their electrical contacts/ ends should be covered with insulating tapes in order to avoid heat generation, short circuits and ignition which may cause fire.

2) Quality Standard for Acceptance of Cell Phone Batteries

So far, there is no formal collection and recycling mechanism for cell phone batteries available in the Philippines. Therefore, the quality standard will be determined when formal collection and recycling mechanism for cell phone batteries in the Philippines based on the quality requirement of the final receivers to be designated.

(2) Other Used/Surplus Electric and Electronic Home Appliances (Personal Computers, Refrigerators, and TV sets)

For other used/surplus electric and electronic home appliances mentioned above, the quality standard for acceptance by final users should be determined in accordance with the quality requirement by the final receivers in the Philippines. However, the Dealers must at least comply with the following basic requirement.

Item	Requirement
Labor safety	▪ It is prohibited to apply unsafe methods for dismantling the appliances as well as for extracting valuable materials such as use of hazardous chemical substances, burning of non-valuable parts without any license or permission by the relevant authorities.
Pollution Control	▪ Dealers must comply with the relevant laws and regulation in relation to environment protection if they generate residual materials of any forms (gaseous, liquid, or solid) by processing and treating the appliances within their premises.

2.3 Storage Standards for Recyclable Materials

2.3.1 Purpose of Storage Standards

The purpose of storage standard is:

- To guide dealer's proper storage of recyclable materials to prevent depreciation of recyclable materials and
- To guide dealer's efforts to protect environment and workers health and safety on the dealer's premises.

2.3.2 Storage Standards

(1) General Standard for Storage Facility

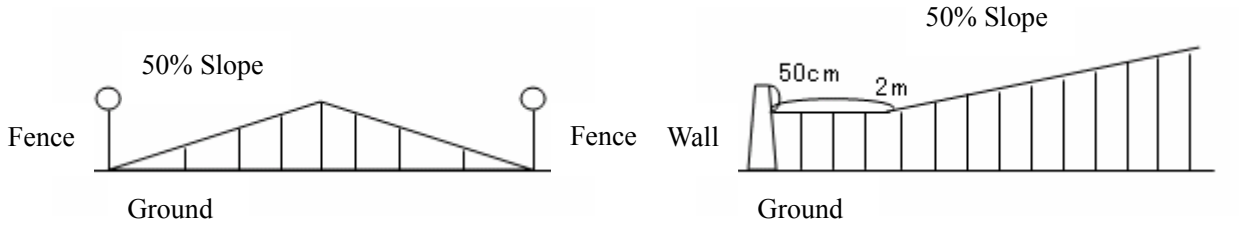
General standard for storage or warehouse of recyclable materials are provided as shown in the table below.

Item	General Standard
Location of the storage/warehouse	▪ The storage facility should be located at sufficient distance from ~~s~~ residential areas and food preparation/consumption facilities.
Structure of storage/warehouse	▪ The storage facility should have a fence or wall (when recyclable materials directly contact the fence or wall, the fence or wall should have enough structural strength and stability to withstand). ▪ The storage facility should have a roof and walls to avoid recyclable materials being wet by rain and deteriorated by sunlight. ▪ The storage facility should have a proper ventilation system. ▪ When rinsing of recyclable materials are conducted at the premises, the premises should have drainage and a wastewater treatment facility to prevent water pollution and a floor covered with impermeable materials such as concrete.

(2) Proper Operation of Storage/Warehouse of Recyclable Materials

The storage/warehouse of recyclable materials must make sure that

- The storage facility should be secured against access by rats, mosquitoes, and other vermin.
- When recyclable materials are not stored within containers, a pile of recyclable materials should be kept below the following height.



2.4 Data Management

2.4.1 Purpose of Data Management

The purpose of data management by the dealer is to plan for efficient collection and sales of recyclable materials and minimize loss of and storage spaces for recyclable materials collected.

2.4.2 Standard Practice

(1) Management of Data

1) Micro Data Collection

Data on the following items should be collected to identify the flow of inbound and outbound

recyclable materials through the transaction.

- Type of recyclable materials
- Date of purchase/sale
- Volume/quantity and buying/selling price of recyclable materials
- Name and contact address of sellers and buyers
- Quality of recyclable materials (levels of sorting, rinsing, compressing, etc. by sellers and required by buyers)

2) Compilation and processing of Data

Micro data collected above at the level of individual dealers can be managed in a table format by material as shown below.

Material Name:							
Transaction No.	Date	Volume/ Quantity (A)	Price (B)	Unit Price (B/A)	Name of seller (or buyer)	Address/telephone of seller (or buyer)	Quality Required (sorting level, etc.)

Collected data can be used for identifying the trend of supply/demand, the trend of unit price (buying/selling), large sellers/buyers, quality required by buyers, and stock of recyclable materials and available storage capacity as follows.

- Trend of supply/demand: if the volume/quantity is aggregated by month or year, it may show a seasonal or historical trend of supply/demand volume/quantity.

- Trend of unit price (buying/selling): if the unit price (price divided by volume/quantity) is averaged by month or year, it may show seasonal or historical trend and a range of fluctuation of the unit price.

- Large sellers/buyers: if the volume/quantity of recyclable materials is sorted by seller/buyer, it may provide information about who are large sellers/buyers.

- Quality sellers: if the quality of recyclable materials is evaluated based on certain criteria, it may provide information about who are quality sellers (those who can provide recyclable materials properly sorted, rinsed, compressed, baled, etc.).

- Quality required by buyers: if the conditions of recyclable materials required by each buyer is consolidated and prioritized based on the frequency of buyers needs, the information may constitute the future acceptance criteria.

- Stock of recyclable materials and available storage capacity: the stock can be identified by inventory taking and calculation based on inbound and outbound flow of materials. Available storage capacity can be calculated based on the total capacity and stock volume/quantity.

3. Technical Guidelines for Recycling Industries

3.1 Necessary Requirements for Recycling Facility

Facilities that are going to treat and recycle wastes materials should be compliance with national safety and health regulations/codes, in addition to the environmental requirements. The facilities are also required to be inspected periodically by the governmental authority and/or their representatives.

The following section describes essential technologies and necessary information for the recycling industries.

3.1.1 Facility for Waste Paper Recycling

(1) Typical recycling process

The recycling of waste paper has almost identical process as manufacturing virgin papers except raw materials, which are either waste papers or woods (pulps). The followings are typical waste recycling process integrated with a paper production.

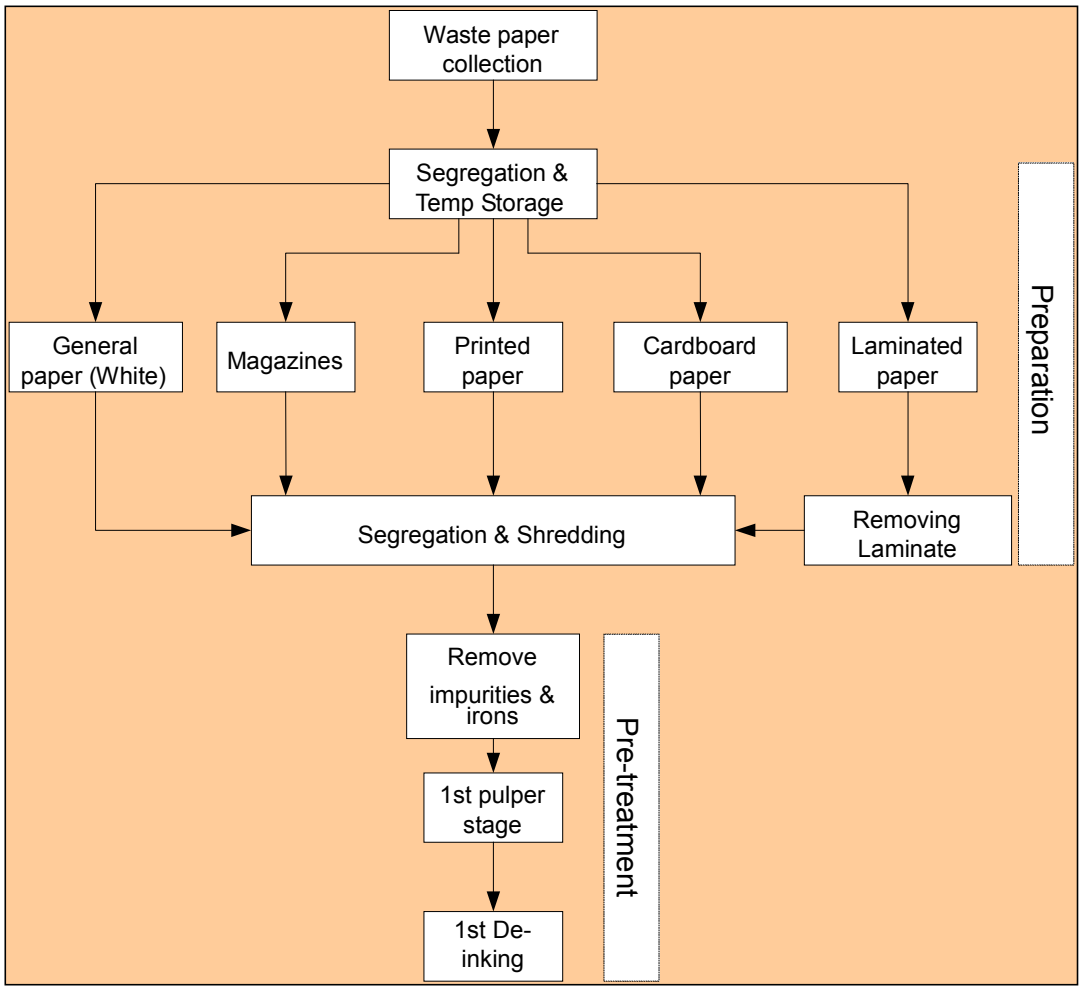


Figure 3.1.1 Pre-treatment of Paper Recycling Process

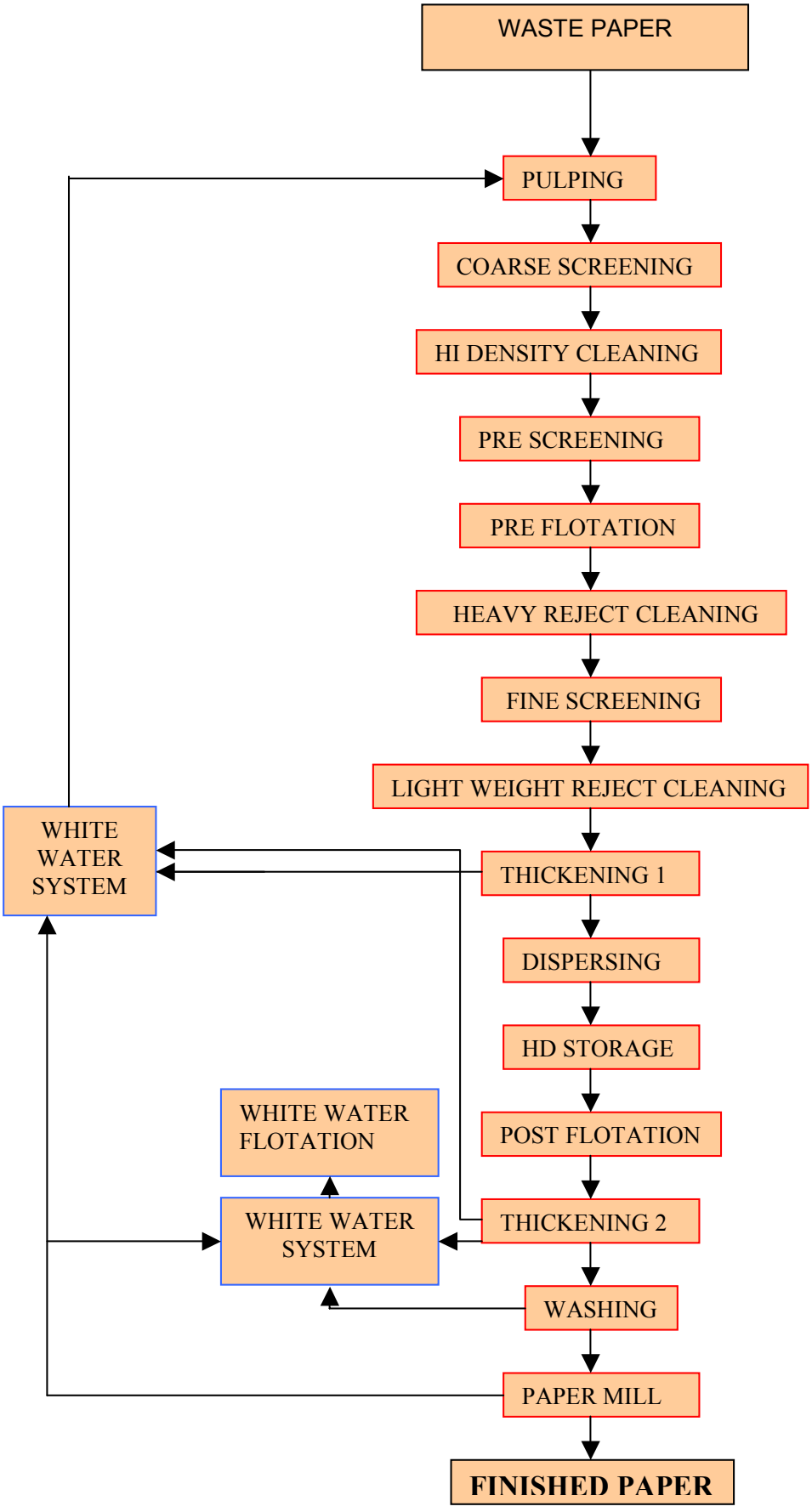


Figure 3.1.2 Paper Manufacturing Process using Scrap Paper as Raw Materials

(2) Required facility and main equipment

Followings are facilities and equipment required for paper recycling facility.

- Waste paper receiving area
- Wight scale and record station
- Temporary storage area
- Segregation area
- Roofed stock yard (or storage room)
- Pulping tank
- De-inking & bleaching system
- Paper manufacturing system
- Wastewater treatment system
- Sludge treatment system
- Process water recycling system

(3) Environment Protection

Full compliance of environmental laws and regulations are essential during the operation of the facility.

Large amount of process water is required for the paper manufacturing process, and as a result, the paper production generates enormous amounts of the wastewater. The wastewater is heavily polluted through de-inking, bleaching, pulping, diluting and paper milling processes. Consequently the wastewater cannot be directly discharged into the environment without proper treatments. In order to prevent the environmental damages from these wastewater effluents, the recycling facility is strictly required with installing appropriate wastewater treatment process (system). In addition, sledges that are discharged from the wastewater treatment facility are also contaminated with hazardous impurities, including chemicals and odors. The sludge, therefore, is also needed to be properly treated to avoid generating another pollution.

(4) Safety and health measures

1) Safety measures

As a nature of paper, it is easily burned and also becomes smolders under a lack of air (oxygen). There are some cases where the wastepaper is spontaneously ignited while in storing under particular conditions, such as mixing of organic matters with adequate amount of moistures. In order to protect such accidental fires, providing fire extinguishers and/or fire fighting equipment in the waste paper storage facility are required.

For emergency, including fires and/or chemical accident, signboards indicating evaluation routes and a warning siren are also required to be installed in the facility area.

2) Health care and protection

Process water from pulping process and diluting of waste papers may be contaminated with caustic soda, therefore, eye washing fountains and water basins are recommended to install at the process areas as such water (chemicals) may cause irritating eyes and/or skins if splashed. In addition, the first aid kit should be provided at the same working area.

3.1.2 Facility for Waste Metal (Scrap) Recycling

(1) Recycling process for typical steel scraps

Wide varieties of waste metal have being discharged into a market as scrap steels, which come from industries of iron mill, foundry, casting, metal machining, automobile, consumers and etc. However those steel scraps are commonly bulky, mixed with other metals, striped, or grinded. In order to effectively utilize these scraps, it is necessary to be separated, segregated, consolidated as well as bundled in prior to smelt at the factory.

The following are typical pre-treatment process for steel scarp recycling.

1) Bushy, stringy metal scraps (machined scraps)

The scraps need to be crushed or shredded into smaller chips to satisfy with following requirements:

- Effective extraction and reclamation of cutting fluids from machined scraps
- Reduce particle size (i.e.: max 75mm)

2) Bulky steel scraps

Should be crushed or shredded in shoveling sized chip to satisfy handling and transportation.

3) Segregation of steel alloy scraps

By adding other types of metals or material elements, such as chromium or carbon, during the manufacturing process, different types of steel alloys can be produced. These types of steel include stainless steel, which resists corrosion, and certain alloy steels has high tensile and/or thermal resistance characteristics. Those steel alloys must be segregated prior to smelting and can be recovered from products and recycled.

4) Magnetic separation

Scrapped steels can easily be separated and sorted out from other waste stream by using magnetic. In order to obtain high quality steel scraps, recycled steel scraps are required to uniform as mono steel nature.

3.1.3 Waste Aluminum Cans Recycling Process

The aluminum materials used for beverage cans are specified with different type of alloys for both body and cup, as shown on the following table.

Body	Aluminum-Manganese Alloy	Approx.1-1.5%
Cap	Aluminum-Magnesium Alloy	Approx. 4-5%

Reasons to use different types of alloys are that the body material requires rather flexible and strengthen characteristics so that the drawing method can be applied in manufacturing cans. The cap material, on the other hand, requires easier breakage by shearing force as the pull-top mechanism to open.

Accordingly those types of materials should not be mixed if the scrap aluminum cans are going to be used to re-manufacture new cans in "Cans-to-Cans" process. However, if the scrap aluminum is utilized for die-casting method for general-purpose, such as cast frames, furniture parts, handles, trays, general household products and etc., mixing those two may be acceptable.

The following figure shows typical aluminum recycling process.

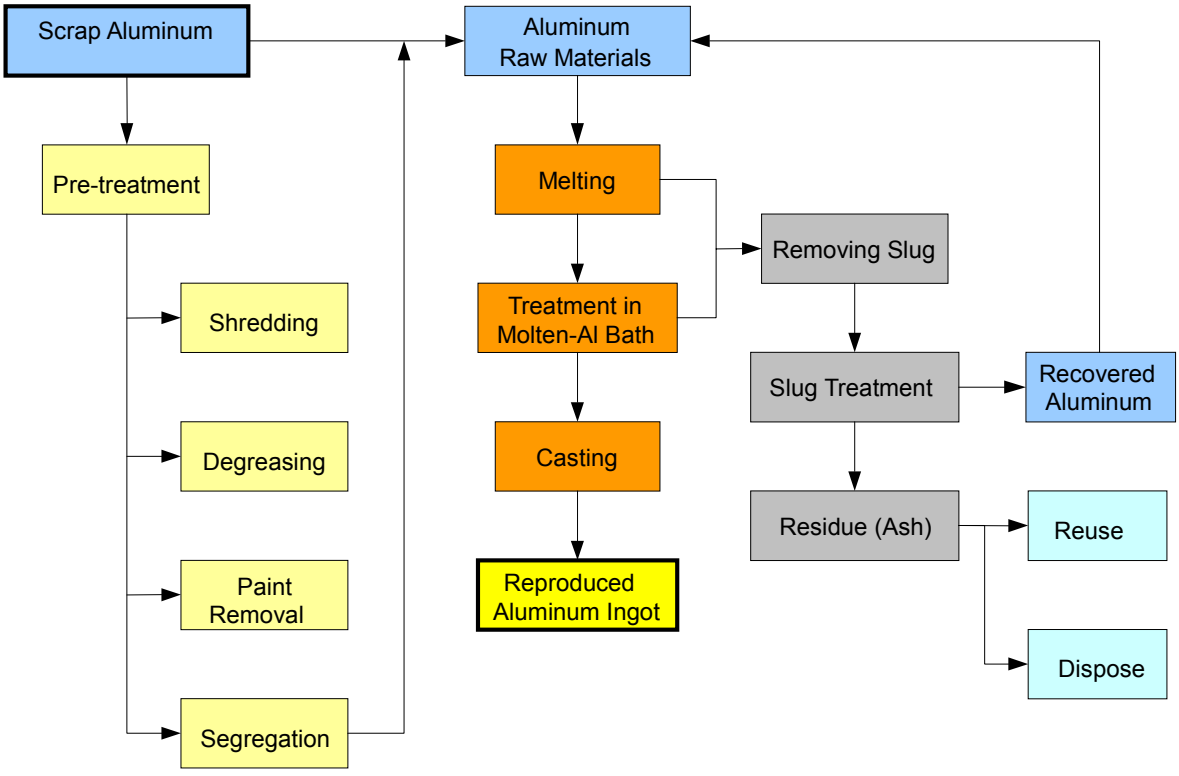


Figure 3.1.3 Typical Aluminum Recycling Process

3.1.4 Required Facility and Main Equipments

Facilities and equipments required for metal recycling facility is as follows:

- Waste aluminum-cans receiving facility
- Magnetic separator (remove steel-cans)
- Shredder
- Degreasing system
- Paint removing system
- Segregating system
- Melting furnace
- Molten bath
- Casting system
- Ingot remover
- Slug treater
- Ash treater
- Dust collector

3.1.5 Environmental Protection

(1) Air quality control

Iron (steel) and aluminum metals are basically stable, safe, and non-hazardous materials. However, it requires fuels – oil, in melting process, which in turn give out flue gases and/or smokes which may be contaminated with dusts/ashes. Therefore, a dust collector is must be installed to remove fine dust to prevent the air pollution, in compliance with the environmental laws and regulations.

(2) Water and soil protection:

Scrap metals may be contaminated with waste oils, especially irons/steel discharged from machining process. These kinds of scrap metals require to careful handling while storing. The waste oils can easily pollute the soil and water, or storing area. In such cases, the floor surface of the storage area should be paved by non-penetration materials to prevent from oil seepage.

3.1.6 Safety and Health Protections

(1) Safety requirements

Scraps metals may be contaminated with small amount of chemicals such as alkalis or acids, which could cause irritations and/or burns to skins or eyes. Therefore, it is recommended to equip the first aid and washing fountains in the working area.

When the aluminum powder is stored as waste metals, a signboard "**Do Not Use Water**" must be installed at the storage area.

(2) Health care and protection

1) For iron scraps

As described above, both irons (steels) and aluminum metals are safe materials. However, the scrap iron can generate considerable heat when oxidized with adequate amounts of moisture and oxygen (air). Especially, fine grinded irons powders, which are discharged from machining processes, are required with special care to keep the moistures away, because they can easily generate high temperature under certain conditions of the moistures and air.

2) For aluminum scraps

Similar to iron scraps, aluminum scraps are safe and non-self activated. However, the aluminum powder can generate hydrogen gas when the water is added. If aluminum powder is moisturized, it is converted into aluminum hydroxides, which generate hydrogen gas and then can be ignited by a presence of sparks or other igniting sources. Therefore, the aluminum powder must be to stored in the isolated from moisture, water or rain.

3.1.7 Facility for Waste Glass Recycling

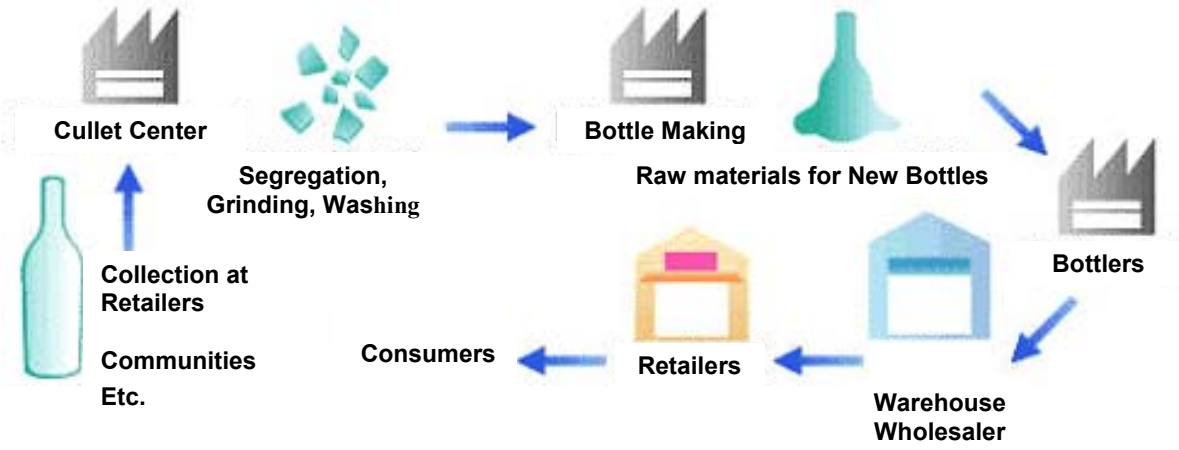
(1) Typical recycling process

The glass bottles, like beer bottles, have often seen as a typical example of recycling materials; however, use of "one-way bottle" has been increasing in recent years, which result in expanding cullet production.

In a cullet production, it is very important to segregate all bottles by colors as well as types in prior shredding process. To date, a technology to automatically segregate the bottles by colors has been developed, however installing such device requires considerable investment. Therefore, a manual segregation process is still favorable process in Philippines and other Asian nations.

By using recycled cullet, high efficiency in terms of energy usage and resource conservation can be realized though less energy consumptions and virgin materials in bottle manufacturing process. This also reflects saving cost as well. Nonetheless, costs for 'venous physical distribution' – i.e. waste glass bottle collection necessary before bottle manufacturing begins, and pre conditioning – i.e. washing and proper segregation, requires sizeable cost. Thus, the key to successful glass bottle recycling is how those cost can be minimized. This is true especially for beverage bottles as they requires high quality, and as a result, requires high cost for washing and segregation.

On the other hand, glass can be utilized for low quality applications such as pavement, aggregates and concrete board materials. Beside the use in construction materials, the mixed cullet (with variety of colors) can be recycled to mold mix color glass bottles (base or ash trays, etc).



Source: Japanese Glass Bottle Recycling Association

Figure 3.1.4 Recycling Flow of Returnable Bottles

(2) Facility and main equipment

Facilities and equipments necessary for glass bottle recycling facility are as follows:

- Waste bottle receiving area
- Wight scale and record station
- Color segregation area (or bin)
- Cullet shredder machine
- Cullet storage bin by colors
- Cullet washing system

(3) Environmental protection

Most of returned glass bottles are contaminated with organic materials (residues), or in some cases, contaminated by harmful chemicals and/or similar materials with high COD levels. In order to protect the environment, the wastewater discharged from washing/rinsing processes must be treated in compliance with the environmental laws and standards. In addition, the floor surface of washing/rinsing area is recommended to be paved by materials.

(4) Safety and health measures

1) Safety requirement

To protect skin and/or eyes, goggles and groves are strictly required to provide to all workers.

2) Health protection

In order to avoid irritation on skins or eyes from accidental splashing of the washing/rinsing water and other hazards such as contaminants or small pieces of glass, eye washing fountains and basing

should be equipped in the working area.

3.1.8 Waste Plastics Recycling Facility

(1) Typical recycling process

There are mainly 3 types of process for recycling waste plastics, depending on its purpose. They are; 1) re-use or recycle the plastics by shredding or grinding with mechanical/physical process, 2) use the waste plastics as raw material by chemical processes through monomerization or reducing in a blast furnace, or 3) recover energy by utilizing as fuel agent, i.e. thermal recycle.

Categories	Recycling Methods		Recycling Process
Mechanical recycling	• Convert into raw materials • Make a products		Material recycling
Feedstock recycling	• Monomerization • Blast furnace reducing agent • Coke oven chemical feedstock recycling		Chemical recycling
	• Gasification • Liquefaction	Chemical feedstock Fuel	
Energy recovery	• Cement kiln • Waste powder generation • RDF		Thermal recycling

In the mechanical recycling process, the collected plastic wastes are transferred to a recycling factory in which impurities like papers and metals are removed. The waste plastics are then send to shredding process. After shredding, the plastics are washed to completely remove impurities in purifying process. Finally, those plastic materials are turned into flakes and/or pellets (flakes are granulated after heated) as using for raw materials. Those plastic materials are melted to utilize at textile and/or sheet manufacturing factories and also fabricated products. Figure below is a typical recycling flow for PET bottles.

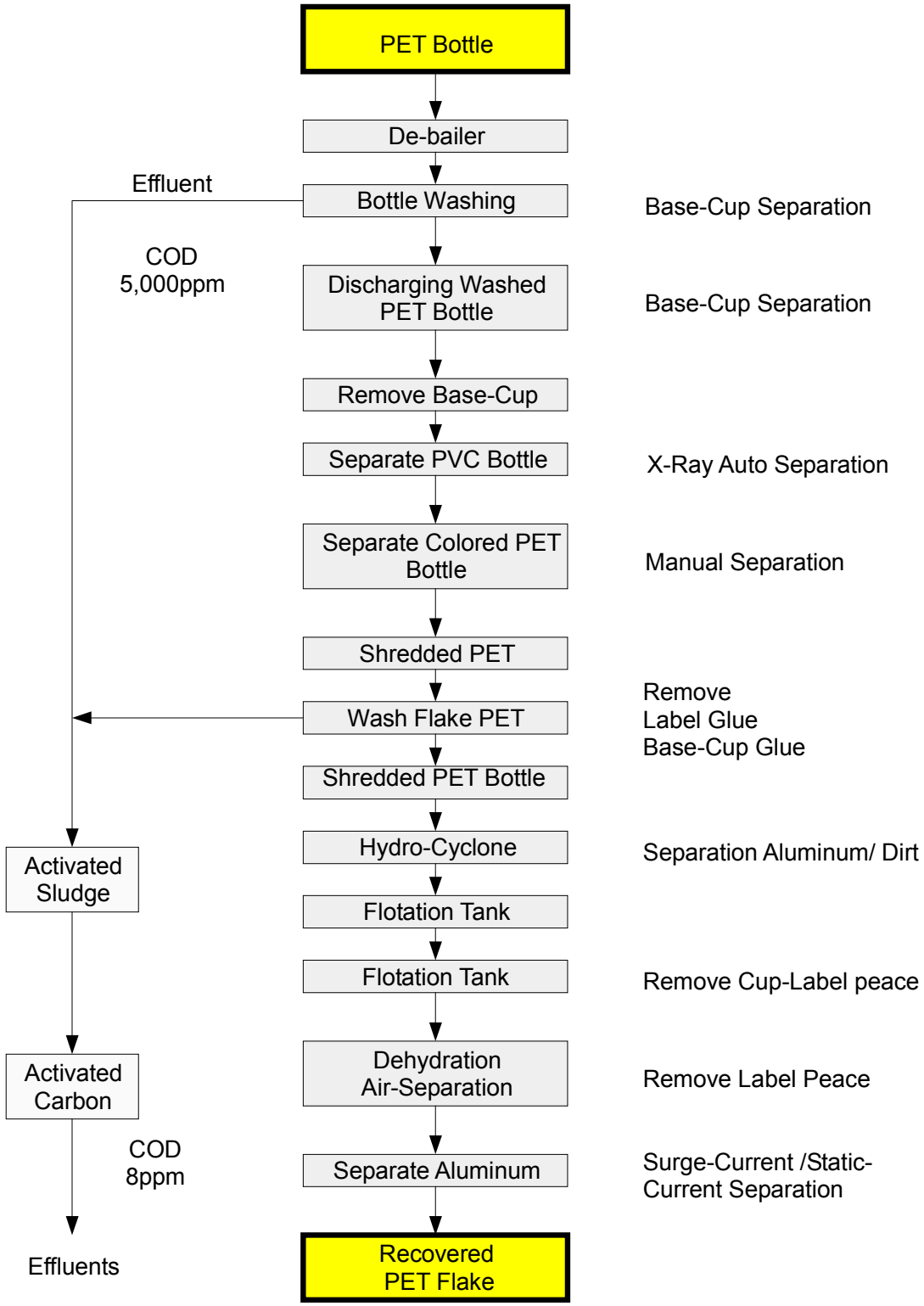


Figure 3.1.5 Typical PET Recycling Process

(2) Facility and main equipment

Facilities and equipments required for plastic recycling are as follows:

- Bailed waste plastics receiving area
- Wight scale and record station
- De-bailer/breaker machine
- Bottle washing system
- Base cup cutting machine
- PVC separator
- Colored PET separator
- Bottle shredder
- Flake washing system
- Hydro-cyclone (separate Aluminum and dirt)
- Floatation tank (remove labels)
- Air separator (remove light materials)
- Aluminum separator (static-current separator)
- Wastewater separator
- Sludge separator
- Wastewater treatment system

(3) Environmental requirements

No environmental standards particularly targeted for PET recycling facility have been established. However, the cleaning process in PET bottles recycling process requires large volume of washing and rinsing water, which result in discharging large volume of effluent with high CODs caused by use of alkaline detergents. Therefore, the wastewater cannot be discharged without treatment.

In addition, there are cases where shredder dusts and odors are generated depending upon type of machine in shredding process. If amount of dusts is exceeded environment standards, a dust collector is required to be installed.

(4) Safety and health measures

1) Safety requirement

Plastics are combustible material and could smolder under lack of oxygen. Burning of plastics normally generates harmful gases with strong odors. In order to prevent such accidental fires, the storage facility for waste plastics (i.e. PET) is required to install fire extinguishers and/or fire fighting equipments. The goggles and masks, are required to protect eyes and a nose of workers in shredding facility.

2) Health care and protection

In washing and rinsing processes, the process water may be contaminated with alkaline detergents. The detergent water thus may become a cause of irritating eyes and/or skins.

Consequently eye washing fountain, water basin and first aid kit are required at the working area. In addition, periodical health check for dust infections is required.

3.1.9 Facility for Recycling Used Cell Phone

In this section, recycling facilities and employed process for cell phone recycling in Japan will be presented here. In Japan, "recycling-box" is placed in cell phone retailers, dealers, repair shops, and service providers' offices in order to effectively collect used cell phones. The deposited used cell phones are periodically collected by recyclers and send to recycling facilities. Recycling company stores collected used cell phones until it reaches enough quantity to process for recycling.

(1) Recycling process of cell phones

Cell phone is consisted of a handset, containing electrical circuit board and push-pad, lithium-ion battery and its charger as an accessory. Fist of all, components are manually separated and stored until adequate amounts for recycling is accumulated. The electrical components normally contain some quantities of precious metals, such as gold, silver, platinum, palladium and etc. A simple estimation reveals approximately 150g of the gold can be recovered from 1,000 kg of used cell phones. This amount is considerably high considering only 10g of gold can be produced from 3,000kg of gold ore. Therefore, used cell phones are sometimes called as a gold mine. In recent years, however, advancing technology permits reducing the use of such precious metals per a handset drastically. On the other hand, the copper and cobalt can be recovered from the lithium-ion battery. Also fine-wires, non-ferrous metals, irons and waste plastics can be recovered from battery chargers, if properly separated.

The typical recycling process is shown below.

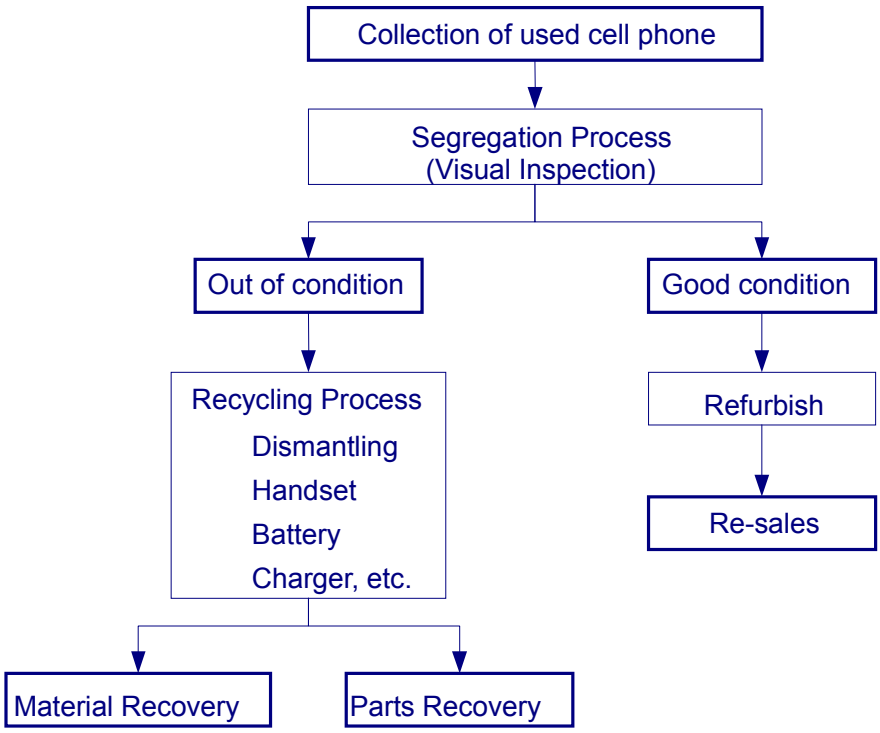


Figure 3.1.6 Recycle Flow of Used Cell Phones and Accessories

(2) Recycling process of lithium battery

Technology to recycle/recover lithium metal from the used lithium batteries is still under development, and no process has been found to economically recover the precious metal yet. Following processes are some experimental processes for recovering lithium.

1) Incineration (baking) process

The used lithium batteries are fed into an incinerator for baking, after which a magnet separator can separate cobalt and lithium metals. Alternatively leaching method can be applied to separate cobalt and lithium after cooling down process has been completed.

2) Floatation separation process

The used lithium batteries are shredded and grinded until they become fine powders, which makes cobalt acid lithium and graphite (black color) powder. The black powders are heated up to approximately 500℃ to burn the binders, which have been fixed on the surface of the cobalt acid lithium powder. When the binders are completely removed, the mixed powder becomes a hydrophilic characteristic that is, then, precipitated by using coagulator and/or foaming agents. More than 92% of the cobalt acid lithium can be recovered with over 93% purity in the whole process.

(3) Provisional measures in recycling facility

The waste lithium batteries must be stored in isolated areas and/or facilities until effective or practical recycling methods are developed. In order to achieve this, battery manufacturers and/or their authorized dealers should be responsible for collecting and storing the used batteries without causing another pollution. The storage facilities are recommended to comply with the local environmental regulations and laws.

(4) Safety and health measures

1) Safety issues

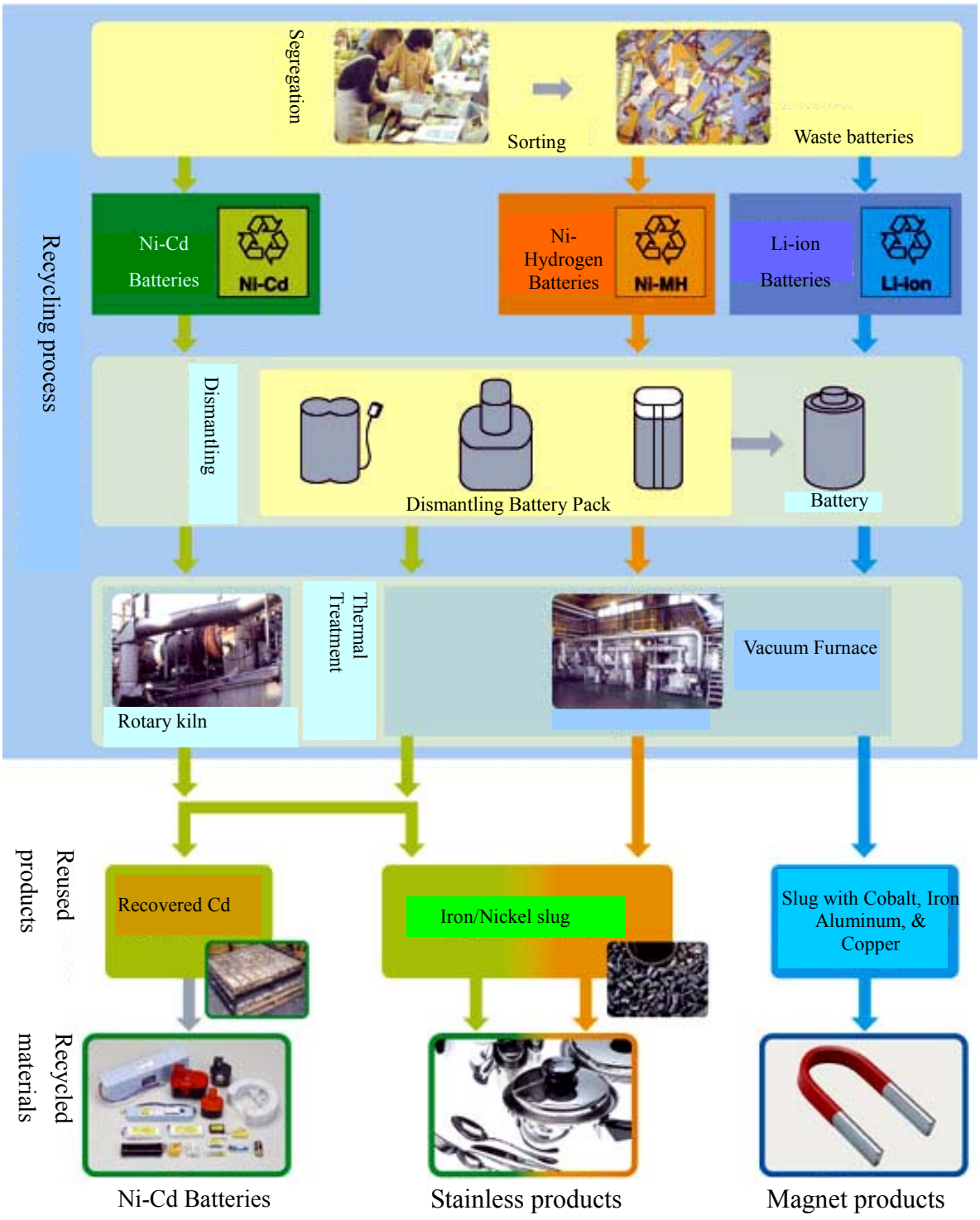
Lithium metal reacts with the water and oxygen to generate heat and hydrogen gas, which could be ignited easily. Thus it can be said that lithium batteries should not be placed in areas where water can come into contact.

- Do not use water in case of fires
- Keep moisture away when storing

2) Health requirement

- Do not breath air contaminated with lithium metals and/or powder
- If breathed, quickly move to a location where is available with the fresh air, and rest.
- If swallowed, wash throughfully with fresh water.
- If gotten into eyes, wash throughfully by clean water and see a doctor as soon as possible.
- If it come into contact with skin, wash throughfully by clean water
- When clothes are contaminated, wash the clothes as soon as possible.
- Any exposure to lithium must be consulted by a doctor

(5) Typical recycling flow



Source: Japan Portable Rechargeable Recycle Center

Figure 3.1.7 Recycle Flow of Small Rechargeable Batteries

3.1.10 Facility for E-Wastes recycling

(1) Typical components of PC

PC is composed of a display, electronic components, and a cabinet that holds the peripherals. Following figure shows typical components/materials that can be recovered/recycled from used PCs.

Waste PC is manually dismantled to separate it into 3 major components, which are then segregated to re-usable parts and recyclable materials.

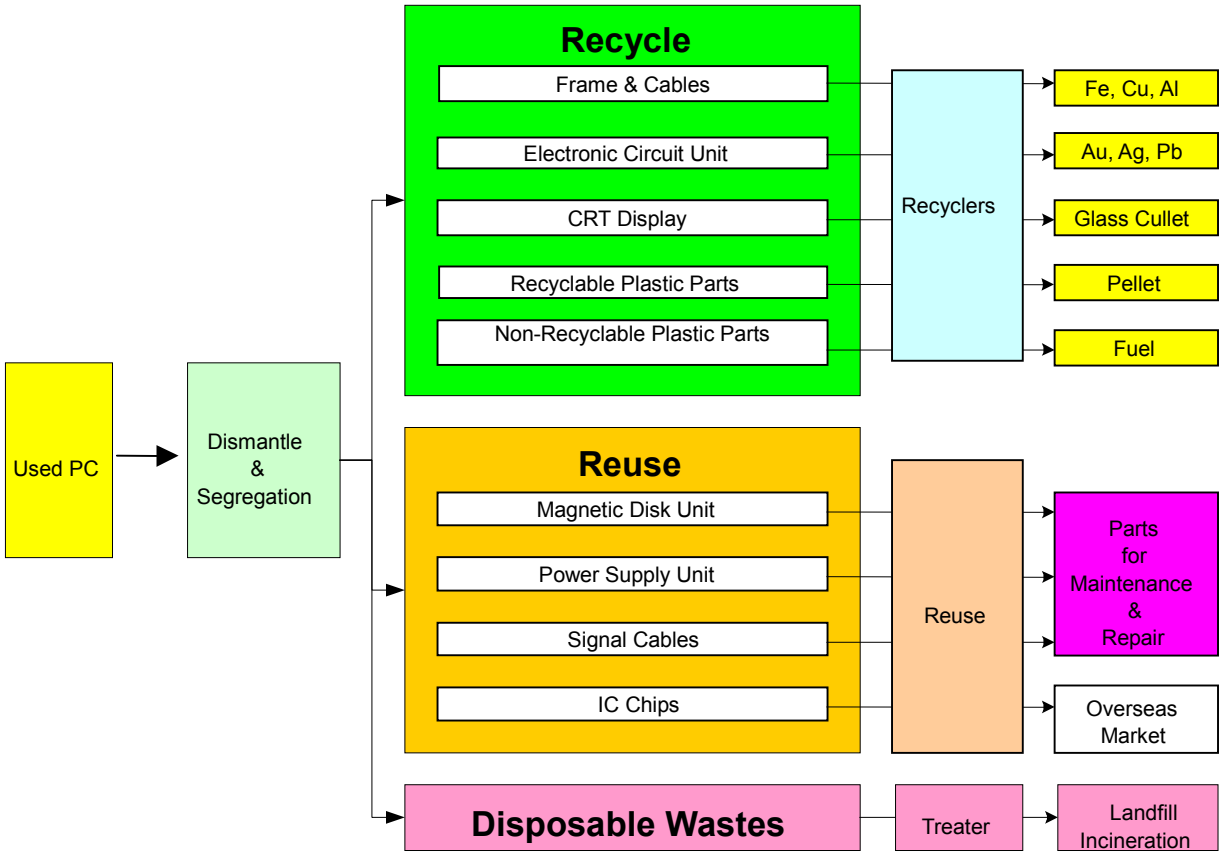


Figure 3.1.8 Recycle Flow of PC and its Components

(2) Typical components of TV

Similar to PCs, TV is also consisted of 3 major components as shown in the table below. Recyclable materials are iron, normal glass, lead glass and plastics.

Table 3.1.1 Major Components of TV set

Conponents	Major recycled meterials
TV Tuve (CRT) • Shadow mask • Electric gun • Anti-maget band	Iron, Normal glass, lead glass
Electric parts • Circuit board • Cable	Copper, Silver, Plastics
Cabinet	Plastic materials

Used TV also requires manual dismantling to separate into several main components. The separated components go though shredding and washing process before recovering valuable materials.

When the electronic circuit boards are compounded with plastics and metals like copper, such circuit boards should not be shredded in prior to separation process. In such case, plastics materials, which are basically thin films or sheets, should be peeled off from the circuit boards so that copper materials are remained on the boards. This process have been found to be the most easy method to separate the two, and accordingly use less cost and energy than if tried to separate after shredding.

(3) Typical components of refrigerator

Refrigerators are generally consisted with following 4 major components as described in the teble below. Recycled materials are iron, copper, aluminum and plastics.

Table 3.1.2 Major Components of Refrigerator

Components	Major recycled materials
Cabinet	Iron, Plastics
Compressor	Iron, Copper, Plastics
Electric parts	Copper, Silver, Plastics
Inner parts	Plastics, Alminum

(4) Dismantling of electrical and electronics components

Basic technologies required in E-waste recycling can be categorized into the following 3 processes.

1) Low temperature shredding/separation process

Plastics materials are segregated with “brittle temperature” characteristics of the target materials. This process utilized the characteristics that each material has different “embrittle” depending on the temperature. The plastic materials are shredded and then segregated into “embrittlement” and “non-embrittlement” materials.

2) Eddy Current (EC) separation process

By providing of rotational magnetic field (the eddy current) onto mixed metal materials, ferrous and non-ferrous materials can be separated into two kinds of the metals by repelling force.

3) Anti-dissolution process

Shredder dusts, incinerated ashes, fly ashes and dust particles, which might be contaminated with heavy metals, are kneaded with water and some chemicals. Then, these heavy metals can be converted into non-soluble compounds in the alkaline solutions.

(5) Required facility and main equipment for E-waste recycling

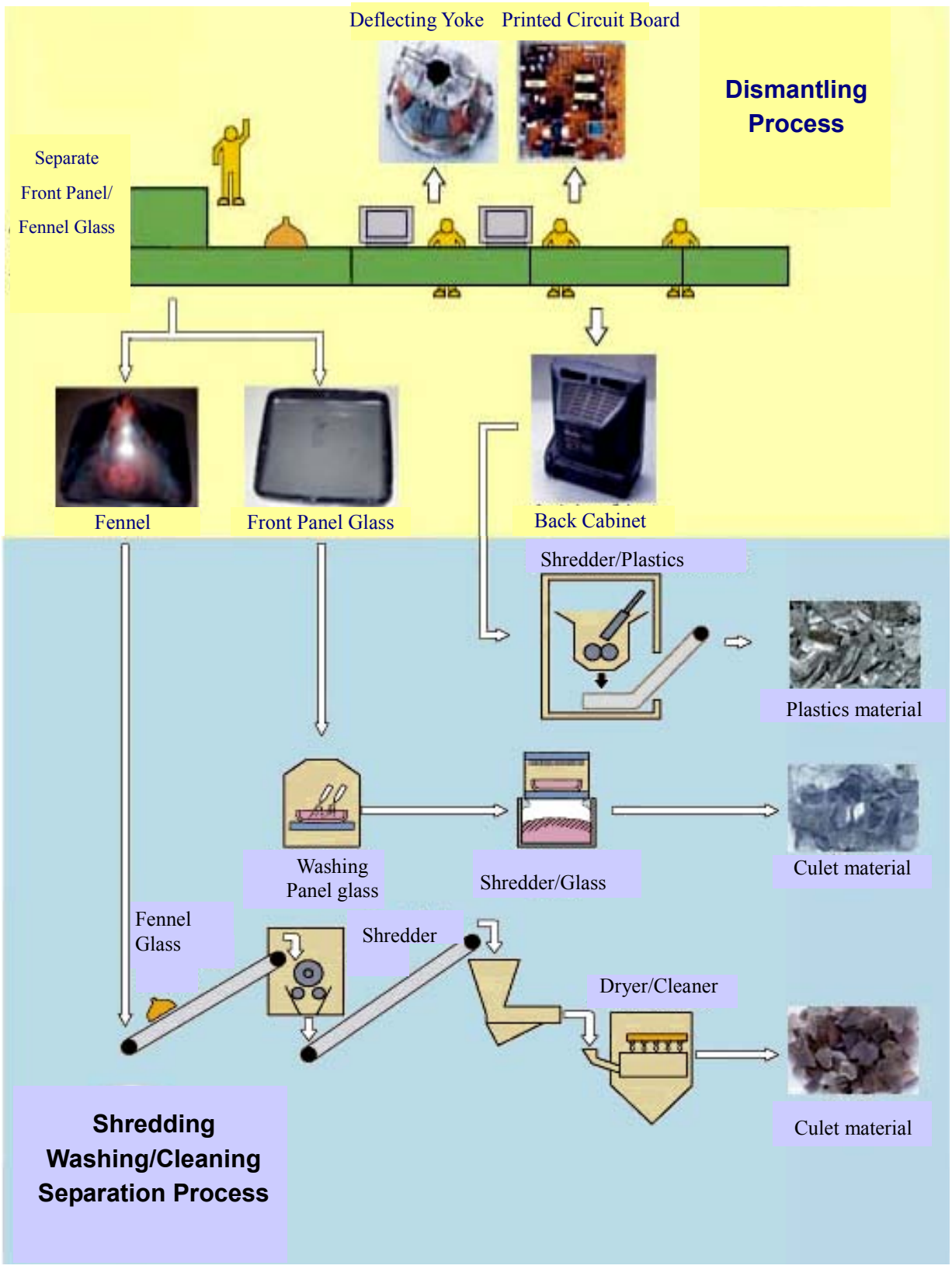
Facilities and equipments required for E-waste recycling facilities are as follows.

- E-waste receiving area
- Examination and recording
- Segregation by model, size and etc.
- Manual dismantling work area
- Separated storage facilities (for plastic cabinet, display, electronics parts)
- Shredder for plastics
- Shredder for circuit board
- CRT breaker system
- CFC recovering system
- Dust collector

(6) E-waste dismantle and mechanical recycling

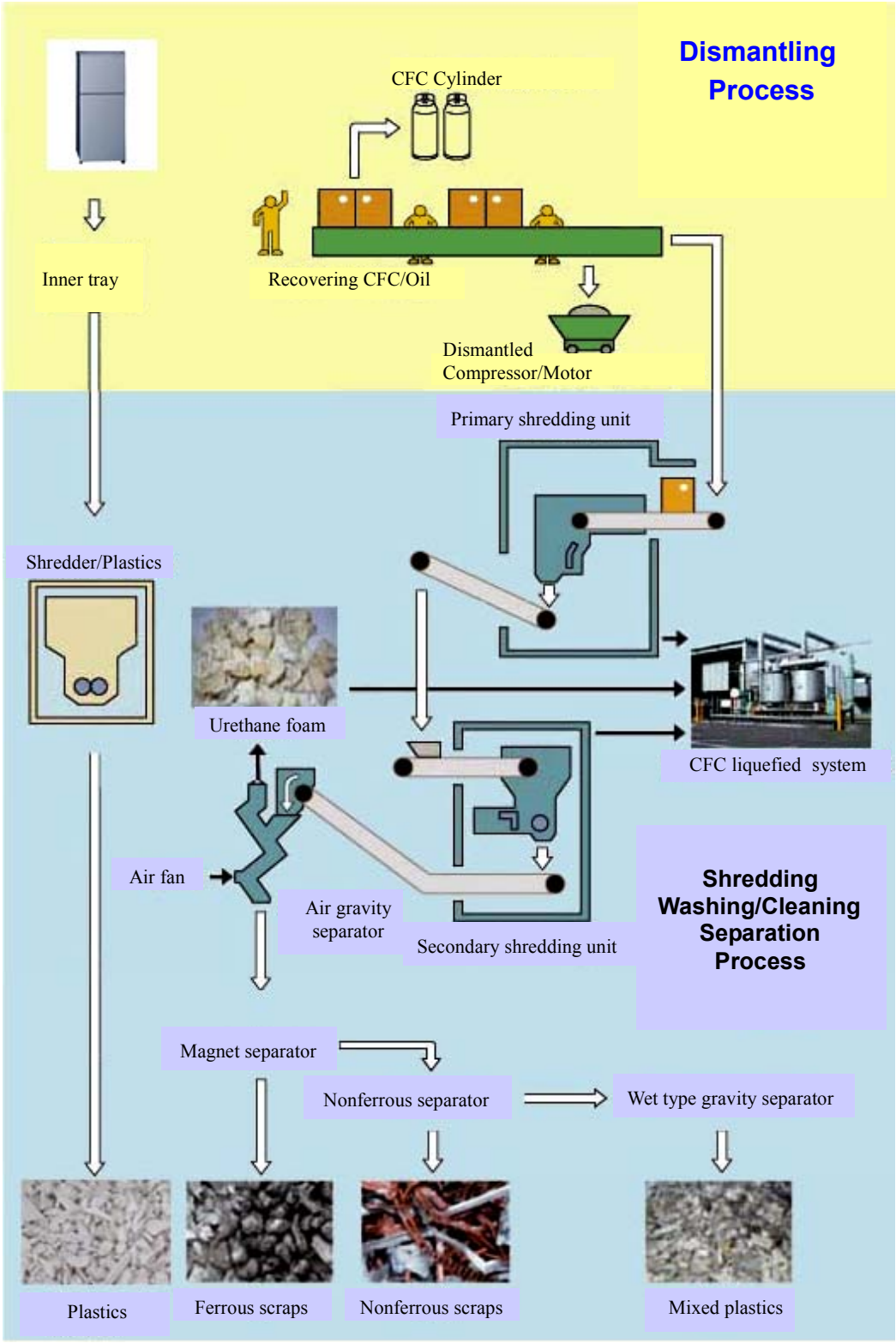
The following figure shows typical TV and refrigerator recycling system.

Although there have not been environmental standards set particularly for E-waste recycling facilities, it is necessary to install air quality control systems for gases/dust generated during shredding or CRT dismantles. Also, careful handlings are necessary when each part is taken apart from electronics boards to prevent breakage. Furthermore, dust collector must be installed for shredding/grinding electronic parts as they often contain hazardous substances. As for dismantling refrigerators, CFC must be completely removed before dismantling compressor.



Source: Home appearances recycle association

Figure 3.1.9 Recycle Process of Used TV Set



Source: Home appearances recycle association

Figure 3.1.10 Recycle Flow of Used Refrigerator

(7) Safety and health protection

Eyes and skins are required to be covered by goggles, masks and gloves in working area because grinding dusts may be irritants to skins and eyes. Washing water fountain and first aid kits are strictly required at working area. In some cases, shredding causes heavy noises so that earplugs should also be provided to workers.

3.2 Technology Requirements in Recycling Industries

3.2.1 Technology Required in Recycling Waste Papers

From its inheriting characteristics, paper can be easily recycled, and technologies for recycling waste paper have been well established over the years. Paper manufacturing system is consisted with simple processes such as soaking by water, pulping, screening of produced pulps, drying, and then finally papers are made. Consequently, the most effective recycling system is almost identical to a process to make new papers, beside where raw materials come from.

Realizing effective and economical recycling system for waste papers is depending upon how consistent the quality of wastes papers can be collected from the market. The following recycling network shows a typical and simplified system; however an actual system can be more complicated, reflecting local conditions.

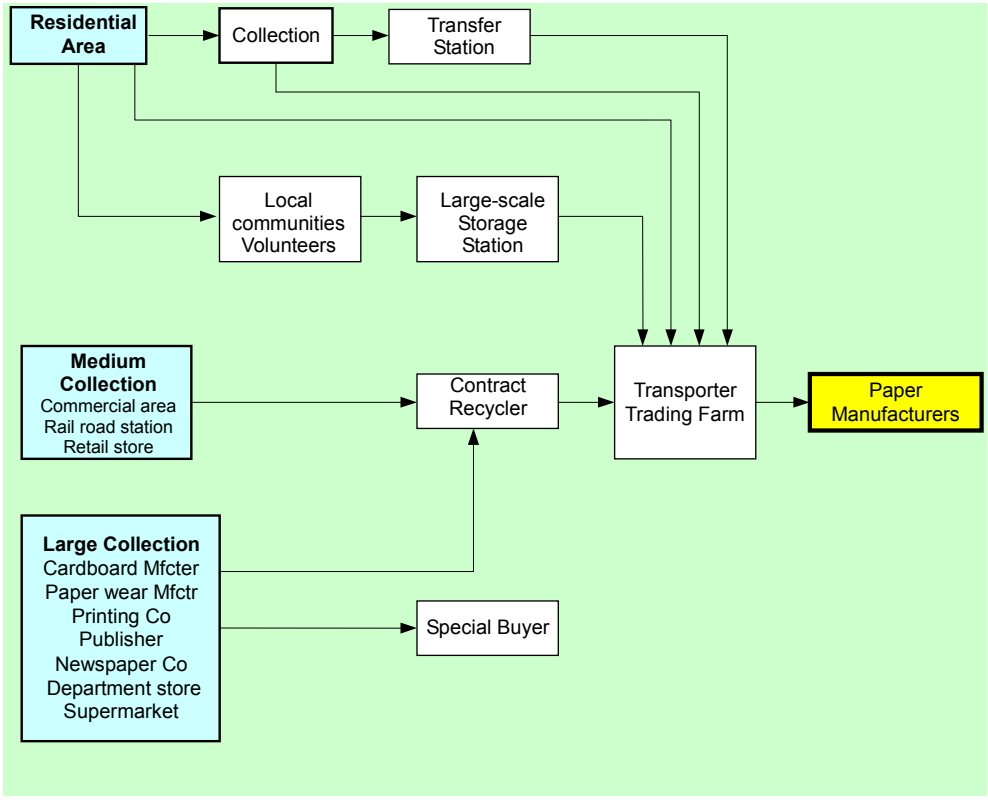


Figure 3.2.1 Collection Flow of Waste Papers

(1) Reception and storage

Requirements for waste paper reception and their storage are as follows.

- Delivered waste papers are measured for their volume and weight, and then recorded
- Storage area must be kept out of any fire sources
- Keeping away from moistures is recommended
- Long term storage is recommended under a roofed area
- Storage should be free from dirt/dust

(2) Segregation

In order to manufacture papers with certain quality from the waste paper, there are some important processes and conditions – i.e. proper segregation and pre-treatment plays critical role. In general, pre-treatment and/or pre-segregation is necessary before typical paper manufacturing process begins if waste papers are used as raw materials. Segregation of waste papers should be done according to types of papers. They are:

- Printed, non-printed papers
- Newspapers, magazines
- Cardboard, corrugate papers
- Office papers, non-office papers
- General-purpose papers, wrapping papers
- Special art papers, high quality papers
- Plastic laminated papers, coated paper
- Mixed or other particular type of papers

(3) Sorting

In prior to pulping and/or diluting process, sorting process is required depending on types of papers. Either de-inking or bleaching process is required depending on quality of finish products as well as conditions of raw waste papers.

(4) Pulping and/or diluting of waste paper

All impurities, such as small plastic flakes and strings, dirt/earths, pieces of metals (iron, aluminum, or others), other rejections are required to be completely removed while the wastes papers are in pulping/diluting or preparation/rejection tank.

In the preparation/rejection tank, the waste papers are mixed and diluted (pulped) with a large amount of process water, and then agitated which is provided by a propeller mixer located on the bottom, or a whirlpool mechanism of the process water.

While in agitating process, lightweight impurities are floated up and toward outside of the tank while

heavy weight impurities, such as dirt and earths, are sunk on the bottom of the tank. Those heavy impurities must be removed from the tank periodically.

(5) De-inking/Bleaching process

Deinking or bleaching process is a necessary step to recycle printed papers. At present, most of the collected waste papers are mixture of heavily printed and/or colored papers. This process consequently is essential procedure to manufacture high quality (non-colored) recycled paper. However, bleaching agents used in the process can contaminate the effluent so that the wastewater must be treated before discharge.

(6) Paper manufacturing process

Paper manufacturing process from waste papers after de-inking or bleaching processes are basically same as the process utilized in paper manufacturing from virgin pulp.

(7) Wastewater treatment process

All the wastewater generated from the thickening processes is named as white waters, which are contaminated with high COD. When the white water contains low contamination of alkaline/acid, it can be utilized as recycled process water after removing small solids by screening process.

Most white waters are required to treat by neutralization and solids separation process such as aerations, filtrations, sludge-separations and skimming, which are similar processes as the general wastewater treatment.

(8) Energy saving

Generally paper manufacturing utilizes lots of process waters and energies, including electricity for driving paper mills and steams for drying process. To generate the steam, oils are the most commonly used fuels. The generated heat energy should be recovered to as a pre-heat energy to optimize energy efficiency.

3.2.2 Technology Requirements in Recycling Steel Scraps

(1) Recycling of Steel Scraps

1) Advantageous of utilizing steel scraps

Waste steels like metal scraps can be recycled through melting down with iron ore and limestone. The molten metal is poured into a mould and then cooled down. Waste steels scraps generated as a by-product in metal manufacturing process can be fed into an electric furnace to melt and re-use as a raw material.

2) Regeneration of steel scraps

Application of recycled steel varies considerably so that the possible area of utilizing regenerated steel spread in wide fields. Same of applications are shown as follows.

- Bicycle frames
- Pipes
- Train tracks
- Ship hulls

3) Necessary technologies for pre-treatment of mixed steel scraps

Wide varieties of waste steels are discharged into a market as scraped steels, which are from industries of iron mill, foundry, casting, metal machining, automobile, etc. However those steel scraps are commonly bulky, mixed with other metals, or strips, and grinded. In order to effectively utilize the scraps, those are separated segregated, consolidated as well as bundled in prior to smelt at the plant. The following are pre-treatment process for steel scarp recycling.

a Bushy, stringy metal scraps (machined scraps)

Must be crushed or shredded into smaller chips to satisfy with following requirements:

- Effective extraction and reclamation of cutting fluids from machined scraps
- Reduce particle size (i.e.: max 75mm)

b Bulky steel scraps

Should be crushed or shredded in shoveling sized chip to satisfy handling and transportation.

c Briquette metal chips

Briquette metal chips should be shredded and solidify so that handling and transporting can easily be made.

- Reduced scrap handling and transportation costs
- Obtain premium price for scrap value
- Reclamation of cutting fluids
- Avoidance of environmental contamination issues

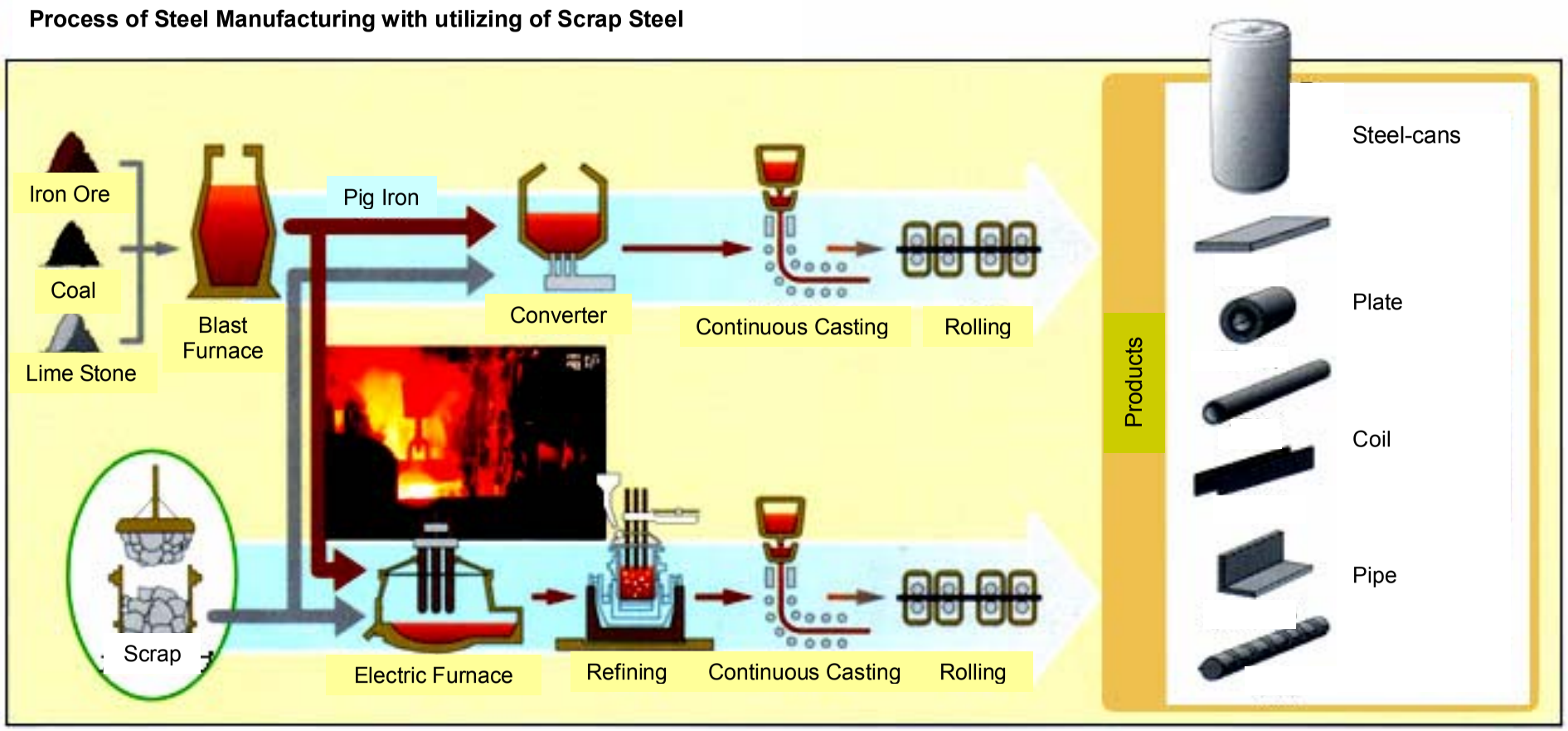
d Segregation of steel alloy scraps

By adding different kinds of metals or elements such as chromium or carbon during the manufacturing process, different types of steel alloys can be produced. These other types of steel include stainless steel, which resists corrosion, and certain alloy steels are high tensile strengthen or thermal resistance. Those steel alloys must be segregated in prior to smelting and can be recovered from products and recycled.

e Magnetic separation

Scrapped steels can be easily separated and sorted out from the other waste stream by magnetic. In order to obtain high quality steel scraps, steel scraps should be composed of single type of steel.

The following figure shows the typical steel manufacturing process from iron ore to steel products



Source: Japan Steel can recycle association 2006

Figure 3.2.2 Typical Steel Manufacturing Process

(2) Recycling Waste Steel-cans

Since the invention of steel-cans about 100 years ago, they have been widely utilized as containers for fruits, vegetables, soups, meats, condiments, juices, pet foods, cleaning agents, paints, adhesive bandages, shoe polishes, coffees, cookies, and etc. In addition to those steel cans, used (scrap) steel products from construction, automobile, machinery, and etc. are commonly recycled and turned into raw metals by smelting with virgin metals.

Current there are 2 methods for steel manufacturing process, i.e. using blast furnace and electric furnace. Use of scrap steels in smelting process can save up to 75% of thermal energy consumption comparing to the same process using original iron ore.

1) Technologies in steel-cans recycling

- Waste steel-cans are turned into same steel-cans as reusing as raw materials
- Steel-cans can be separates by magnet
- Sorted and segregated in different types, then pressed in a common size
- In a steel mill, the bales are fed into the furnace with other recyclable steels

2) Steel can recycling network

Waste steel-cans are recycled as shown in following network.

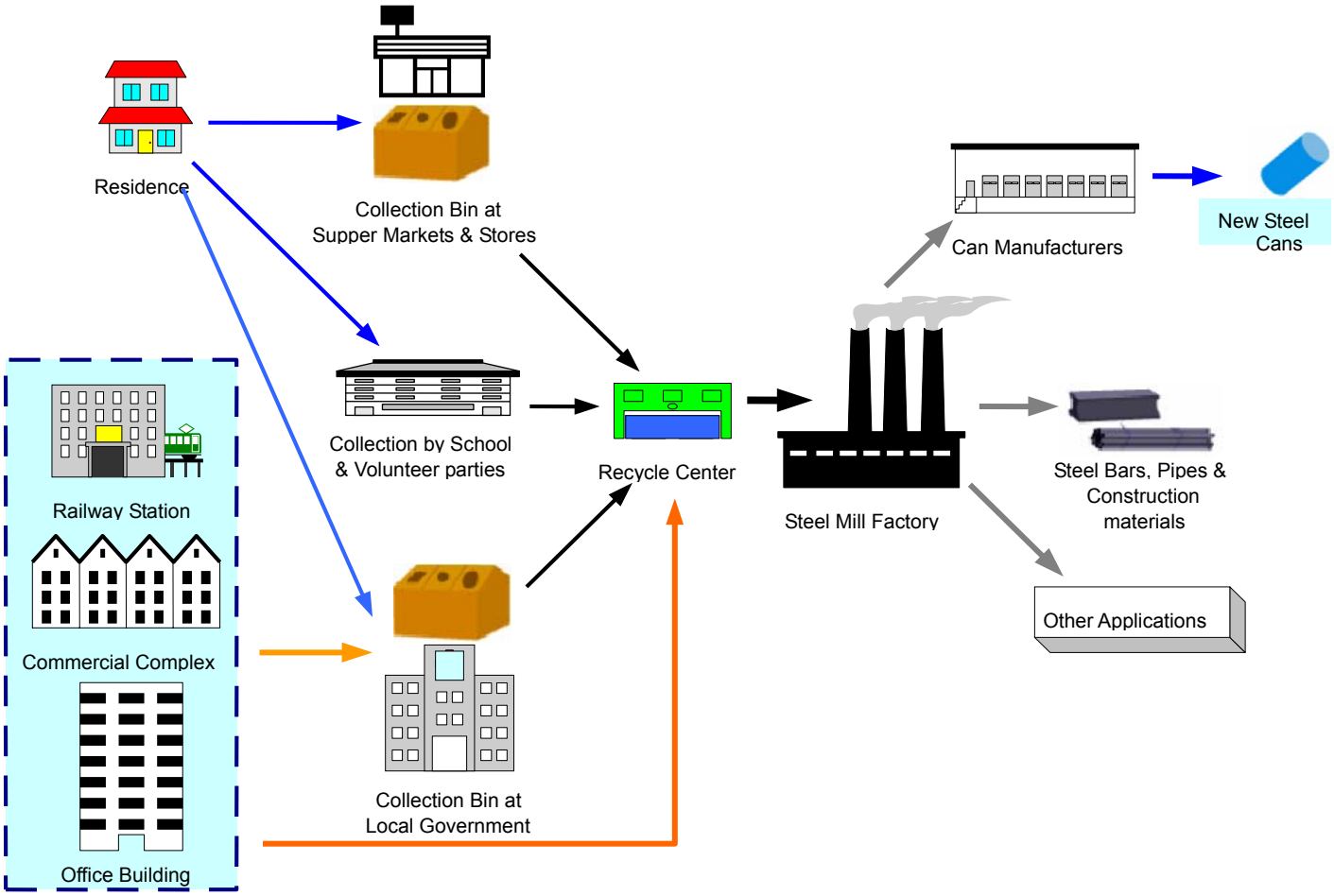


Figure 3.2.3 Recycle Flow of Steel Cans

3.2.3 Recycling Wastes Aluminum-Cans

(1) Advantages in recycling aluminum-cans

Recycling aluminums requires only 3% of the thermal energy required for refining from the ore (bauxite). Consequently, recycling of waste aluminum-cans enable to reduce material resources but also the total energy in can manufacturing process. The following figure shows a typical collection network for the aluminum-cans recycle system.

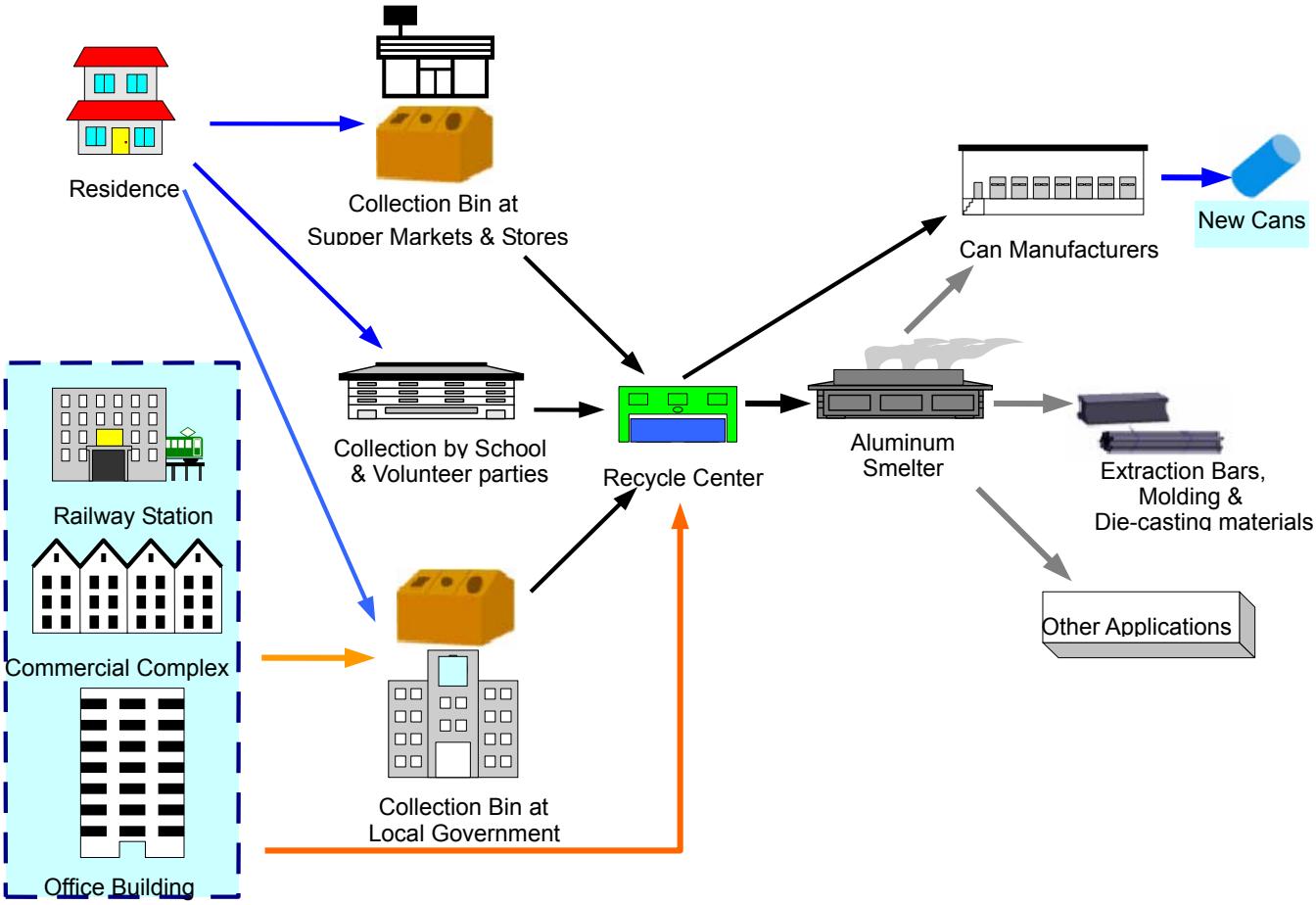


Figure 3.2.4 Recycle Flow of Aluminum Cans

(2) Receiving, weight measuring and recording

When the recycled cans are delivered to a recycler plant, weight measurement and recording are required.

(3) Removing impurities including steel-cans (metals) and plastics

Collected aluminum-cans are often mixed with steel-cans and/or other type of plastic materials such as strings, packages and films. The steel-cans (metals) must be removed by magnetic separators which is relatively inexpensive method for steel separation. If those waste cans are delivered in compressed style, steel-cans may be mixed within pressed cans so that mechanical separation is impossible, but only the metallurgical process.

No plastic impurities should be allowed in the aluminum can manufacturing as they directly interfere with the manufacturing process. The plastics are incinerated in molting process or removed as slugs.

(4) Compressing the waste cans

In general, waste aluminum-cans are pressed to 60 x 60 x 60 cm cubic or suitable size for transportation after removing of the steel metals.

(5) Quality of Aluminum

The body and cap uses completely different types of materials as follows.

- Body : Aluminum-Manganese Alloy (Approx.1-1.5%)
- Cap : Aluminum-Magnesium Alloy (Approx. 4-5%)

A body material requires rather flexible and strengthen due to its characteristics of manufacturing process while a cap material requires easy shearing force to open by the pull-top mechanism. The following table shows a typical comparison of those material compositions.

	Cu	**Si**	**Mg**	**Zn**	**Fe**	**Mn**	**Ti**	**Cr**
Body %	0.15	0.37	1.39	0.15	0.36	0.79	0.01	0.01
Cap%	0.05	0.07	3.80	0.01	0.21	0.36	0.00	0.02

(6) Body coating/painting

The outer/inner surface of can-body is normally coated and/or painted; those materials contain pigments, which are titanium for the white and cadmium for the yellow color. However those colorants materials show similar melting temperature as the aluminum, so that these are melted together in the molten metal. Therefore, the colorants are re-crystallized through cooling down process; as this result, the re-crystalline are never separated and remained as impurities in the aluminum base metal.

(7) Removing impurities

In order to purify the recycled aluminum metal, it is necessary to completely remove those impurities in prior to smelting process. However, it is difficult to remove the colorants completely by mechanical process because of that the inks/paints are thermally baked on the surface. One of effective methods to remove these inks/paints is the thermal treatment process, which requires high investment and not favorable method in recycling business.

(8) Utilize of high quality cap materials

The cap material, on the other hand, contains least impurities in the aluminum material, and therefore it can recover high quality aluminum when re-melted. As a result, selling value is higher than a body part aluminum; nonetheless, the separation of caps from bodies is not economical as it requires a lot of energies. Thus caps and bodies are melted together in a same process, reducing the purity value along with slightly lower monetary value. Consequently it is not practical to have Can-to-Can" recycling system by utilizing 100% recycled aluminum.

(9) Current situation on use of recycled aluminum for cans

As the result, if the recycled aluminum metals are mixed with a virgin aluminum metal, it can utilize only for manufacturing the body process, which is named as a partially “Can-to-Can” System. But for cap manufacturing, 100% virgin aluminum (Aluminum/Magnesium) alloy must be used.

(10) Can-to-Can System

By developing an effective recycling process for manufacturing aluminum cans from waste aluminum-cans, it is possible to realize the recycling-based society. Energy needed in aluminum smelting can be saved up to maximum of 97% by utilizing scrap aluminum in this system. In other words, recycling aluminum can could contribute to reduce environmental burden as a whole.

The following figure shows one of the examples of aluminum “Can-to-Can” system.

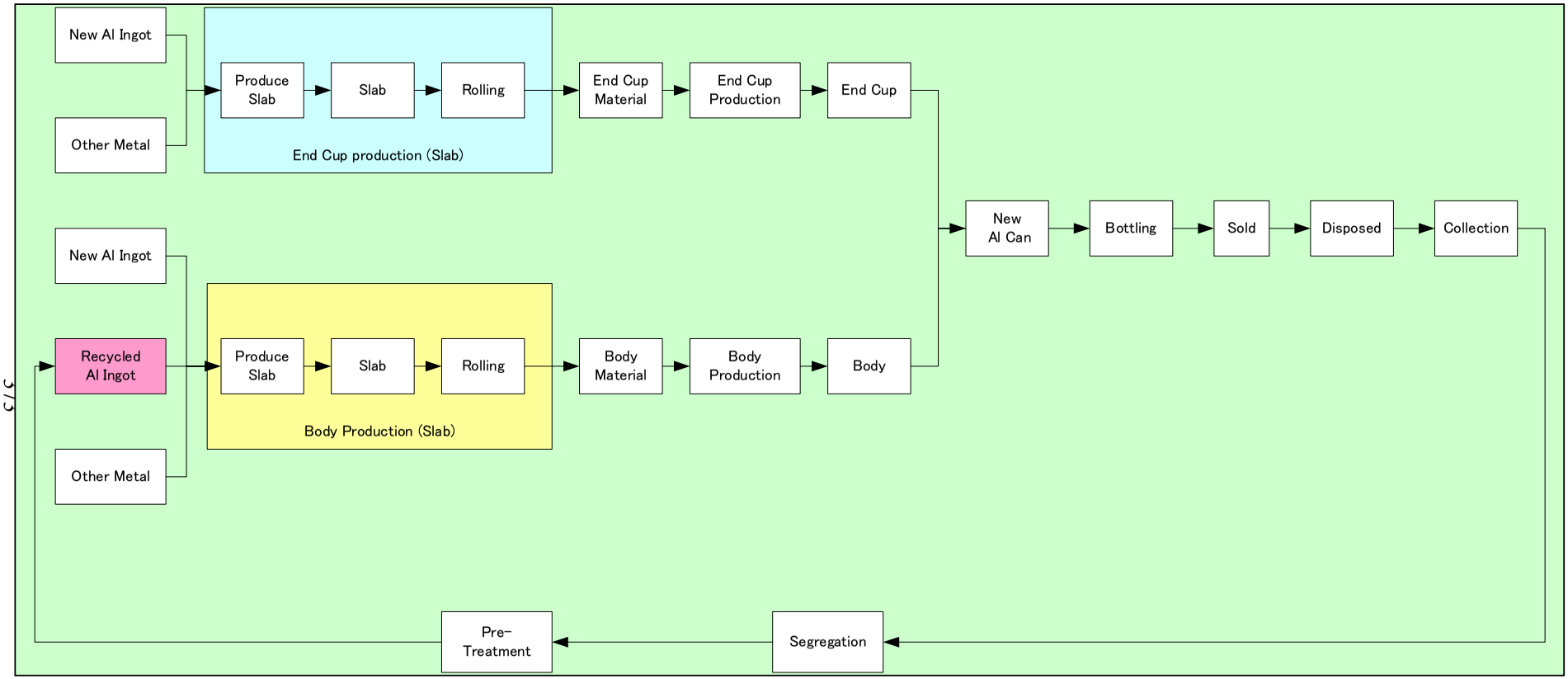


Figure 3.2.5 Flow of Aluminum Can Recycling Process

(11) Aluminum-cans recycling process

Following table shows the typical recycling process from collection of wastes aluminum-cans to manufacturing new cans.

Table 3.2.1 Recycle Process of Aluminum Cans

Process	Operation	
Collection	By local communities, volunteers, and recyclers	
Removal of irons and other impurities	Irons are separated with magnet separator	
Shredding	Shredded in certain sizes	
Paint removal	Incineration by Kiln after shredding	
Smelting	Constant feeding into furnace	
Casting of slug	Melted aluminum metal is cast for a certain size for rolling process	
Hot rolling	Aluminum is rolled until a specified thickness	

Process	Operation
Cold rolling	Remove the oxidized film on the surface, and cold rolled
Trimmed for body size (Stamping)	Adjusted with size of cans
Can manufacturing	Body drawing 
Washing and inspection	Remove lubricants and oils, solvents, and cracks, lines, deforms, pinholes, etc. 
Paint (Print)	Done at Bottling company

Photo: Catalog of Mitsubishi Materials

3.2.4 Technology Requirements in Recycling Glass Bottles

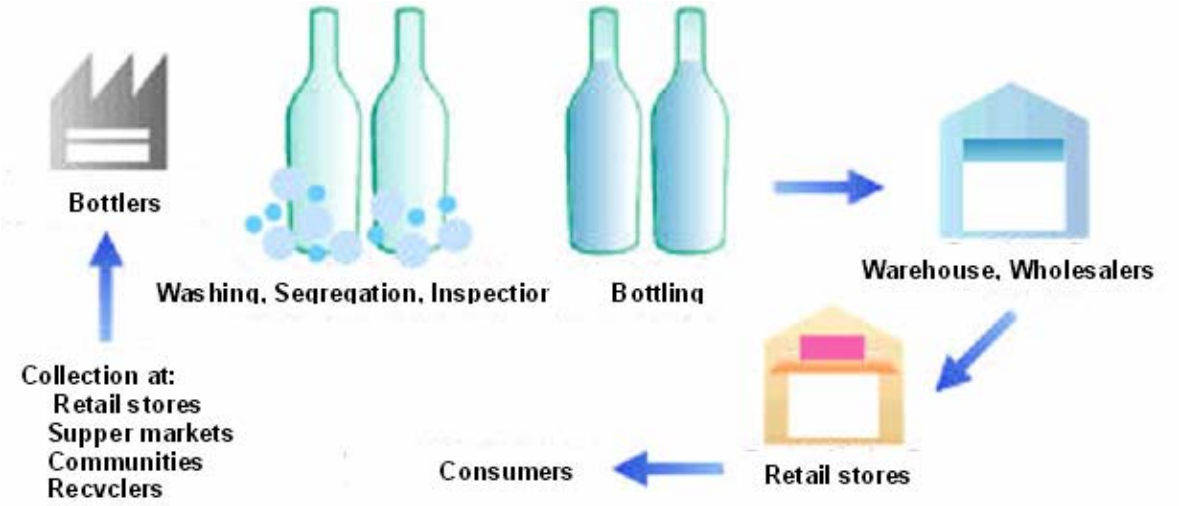
Since the glass bottle manufacturing began in Phoenicia era, or around 3000 years ago, glass containers have been widely used for various uses, for example, for liquids, grain powders and others materials, such as water, wine, oil, medicine, and other products. The glass bottles have being re-used as returnable containers.

In current market, there are many types of glass bottle in terms of shapes, sizes, and colors etc., which are used to contain liquors/beers, beverages, medical supplies and/or supplements. Some types of beverage bottles like beers and juices are already in the recycled/re-used system called "bottle-to-bottle" recycling. There are 2 types of bottles in glass bottle recycling system, "returnable" and "one-way" bottles.

(1) Recycling flow of returnable glass bottle

The returnable bottles, which are collected by "treater" or other "contractors" at recycle centers are segregated by types, size and colors. bottles are then delivered back to bottlers and/or beverage manufactures.

The following figure describes a typical recycling flow for the returnable glass bottles.



Japan Glass Bottle Recycling Association

Figure 3.2.6 Typical Recycle Flow for Returnable Glass Bottles

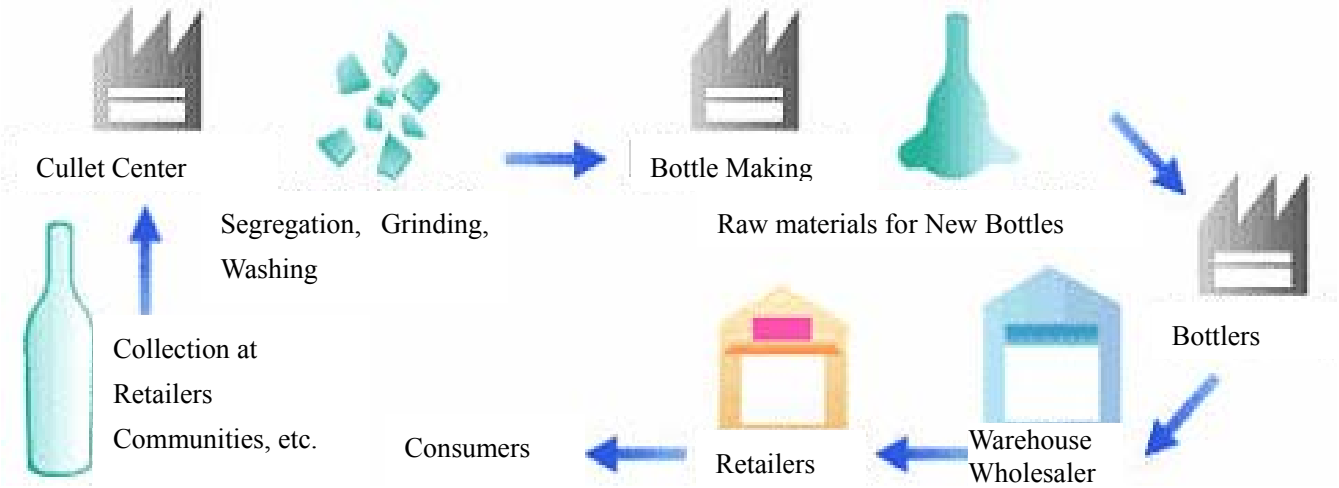
(2) Necessary treatments for recycling glass bottles

First of all, bottling facilities preliminary diagnose breakages/cracks, scratches/chips and any other unacceptable defects on the delivered bottles prior refilling. The defect bottles are segregated through an inspection process, and then only qualified bottles are transferred to washing/rinsing process. The qualified bottles are checked again whether any impurities are existed in bottles; finally sanitized, and only cleaned bottles are transferred to bottling process lines. The rejected bottles are re-used as raw materials for molding of new bottles same as "One-way" system.

(3) Recycling flow of one-way glass bottles

One-way glass bottles are used at one time only. After bottling, the glass bottles are distributed in a market and delivered to consumers. In order to carry out effective recycling on the wastes glass bottles, these one-way bottles must be segregated by colors and types at collection points. The collected colored/segregated bottles are grinded into flinders as cullet, which can be utilized as raw materials to mold new bottles. Same types of colored bottles can be molded with original colors by using the same colored cullet so that it is possible to develop "Bottle-to-Bottle" mechanism.

The following figure shows a typical flow for the "Bottle-to-Bottle" system.



Japan Glass Bottle Recycling Association

Figure 3.2.7 Typical Recycle Flow for One-Way Glass Bottles

(4) Treatment technology for waste glass bottles

Beer bottles can be seen as a typical glass bottles that have been widely recycled. However, "One-way Bottle" has been gaining its popularity in market share instead of "Returnable Bottles." As the result, the cullet production is in expanding trend.

1) Segregation by colors and types

In the cullet production, it is extremely important to segregate all bottles by colors and types in prior to shredding process. A new technology has been developed that variety of glass bottles can be automatically segregated, but such facility requires high invest costs. Therefore, manual segregation process is still favorable process in majority of Asian nations including Philippines.

2) Utilization for pavement materials and new glass products

Current technology can utilize the mixed culets (variety of colors) for pavement materials, materials for aggregates and concrete boards. The technologies can also use the mixed culets to mold color-mixed glass bottles as new products.

(5) Other concerns in producing quality recycled glass products

- Colored plate glass should be segregated from the non-colored glass bottle because the colored glass bottles are tinted with some metals. The tint metal has extremely high temperature resistance metal like titanium. In addition, the high temperature glass is hardened by other additive metals, which become impurities in recycling glass.
- A general glass wear is also made with the high temperature resistance materials, as not same nature of the glass bottles. Therefore, it cannot melt at same temperature of glass

bottle materials.

3.2.5 Technology requirements in recycling waste plastics

Most waste plastics collected from the market are mixed with different type of materials. Those can be mechanically recycled for utilizing as raw materials. In general, these plastics should be segregated at source or recycling centers as much as possible before shredded at recyclers for plastic recycling process.

With recent technology, shredded plastic with variety of plastic types can be segregated by "mutual classifying technology" in which plastics are automatically segregated by types. Nonetheless, this technology requires considerable investment it does practical to employ in developing nations.

When the recycled PET is mixed with other type of plastics, such as polypropylenes and/or polyethylene, the plastics can be turned into new forms like urethane foams. These can be transferred into new products, like insulations, floor materials, inertia materials for automobiles, and sound acoustic insulations.

In addition, a new technology to decompose FRP (Reinforced Resin Plastics) materials, which are very difficult to recycle, into resin solutions, glass fibers and fillers. This new technology has been studied and will be able to manufacture a new FRP by using discarded FRP materials in a near future.

Many different types of technologies involved in recycling and segregating waste plastic materials are being developed, though those technologies are still very premature and/or require high investment at this moment.

(1) Type of plastic materials and their uses

Following table shows type of plastics materials and usages.

Table 3.2.2 Types of Plastics and Their Uses

	Shape		Use/Contents	Type of resin	
Bottles & Tubes	Beverage bottles	Soft drinks	Juice, Cola, mineral water, tea, alcohol beverages	PET	
		Lactic acid & beverages	Yogurt	Polystyrene	
	Food & condiment bottles		Cooking oil, salad oil, soy-source, and others condiment	PET, Polystyrene, Polypropylene	
	Condiment tubes		Mayonnaise, ketchup, dressing, mustard, etc.	Polystyrene, Polypropylene	
	Bottles & Tubes for daily products		Toiletry, gardening supplies, car care products, liquid detergent, fabric softener, toothpaste, cosmetics, shampoos, hair conditioner, bleach, and body shampoo	PET, Composite plastics, Polystyrene, Polypropylene	
s &	Food packages		Margarine, fruits, vegetables,	EPS	Polystyrene

	Shape	Use/Contents	Type of resin	
	(EPS & Non-EPS)	process foods, prepared foods, packed snacks & lunches	Non-EPS	PET, Polystyrene, Polypropylene
	Food cups (ESP & Non-ESP	Soup, yogurt, noodles, jelly, custard pudding, desserts	EPS	Polystyrene
			Non-EPS	PET, Polystyrene, Polypropylene, Polyethylene
	Cup & Pack lids		PET, Polystyrene, Polypropylene, Polyethylene	
Trays & Blisters packs	ESP & Non-ESP tray	Meat, fish, sliced ham, vegetables,	EPS	Polystyrene
			Non-EPS	PET, Polystyrene, Polypropylene
	Blister pack	Drugs (tablets), processed meat & fish products, roast ham, bacon, curry roux, household tools, toothbrushes, cosmetics	PET, Polystyrene, Polypropylene, Polyethylene, PVC	
	Egg boxes		PET, Polystyrene	
Bags	Large, Medium & Plain bags	Rice, gardening bags, fishes, fruits confectionery, frozen foods, noodles, vacuum-packed foods, pickles, cooked/boiled foods, bread, dry fishes, cleaning bags	Polypropylene, Polyethylene	
	Carrier bags		Polyethylene	
	Rubbish bags		Polyethylene	
	Small bags	Quail's eggs, ginger, pickles, condiments, noodles, stock, cakes, candy, wafers, chocolate	Polypropylene, Polyethylene, Composite plastics	
Caps & Stoppers		Beverages, foods, daily supplies, other bottles	Polypropylene, Polyethylene	
Cellophane & Films			Polyvinylidene chloride resin, PVC, Polyethylene	
	Films	Foods, curry roux, plastic food decorations, cakes, cheese, frozen foods, cod roe, sausages, frozen noodles	Polypropylene, Polyethylene, Composite plastics	
	Labels	Bottles, caps	PET, Polystyrene, Polypropylene, Polyethylene	
Boxes & Cases		Detergent boxes & lids, foods, underwear, power compacts, lotion cases, dehumidifier, deodorizers	Polypropylene, Polystyrene, Polyethylene, PVC	
Protection & Fixing		Urethane sponge, foam products, nets, air caps	Polystyrene, Polyethylene	

	Shape	Use/Contents	Type of resin
Others		Baskets, handles, multi-packs, sieves, replanting pots	Polypropylene, PET, Polystyrene, Polyethylene, PVC

Source: Plastic Waste Management Institute

(2) Basic Process of Plastic Recycling

Plastic wastes have great potential in terms of recycling for raw materials, oil recovery, and energy recovery. Many technologies have been developed which are mainly categorized into 3 types shown in the following table.

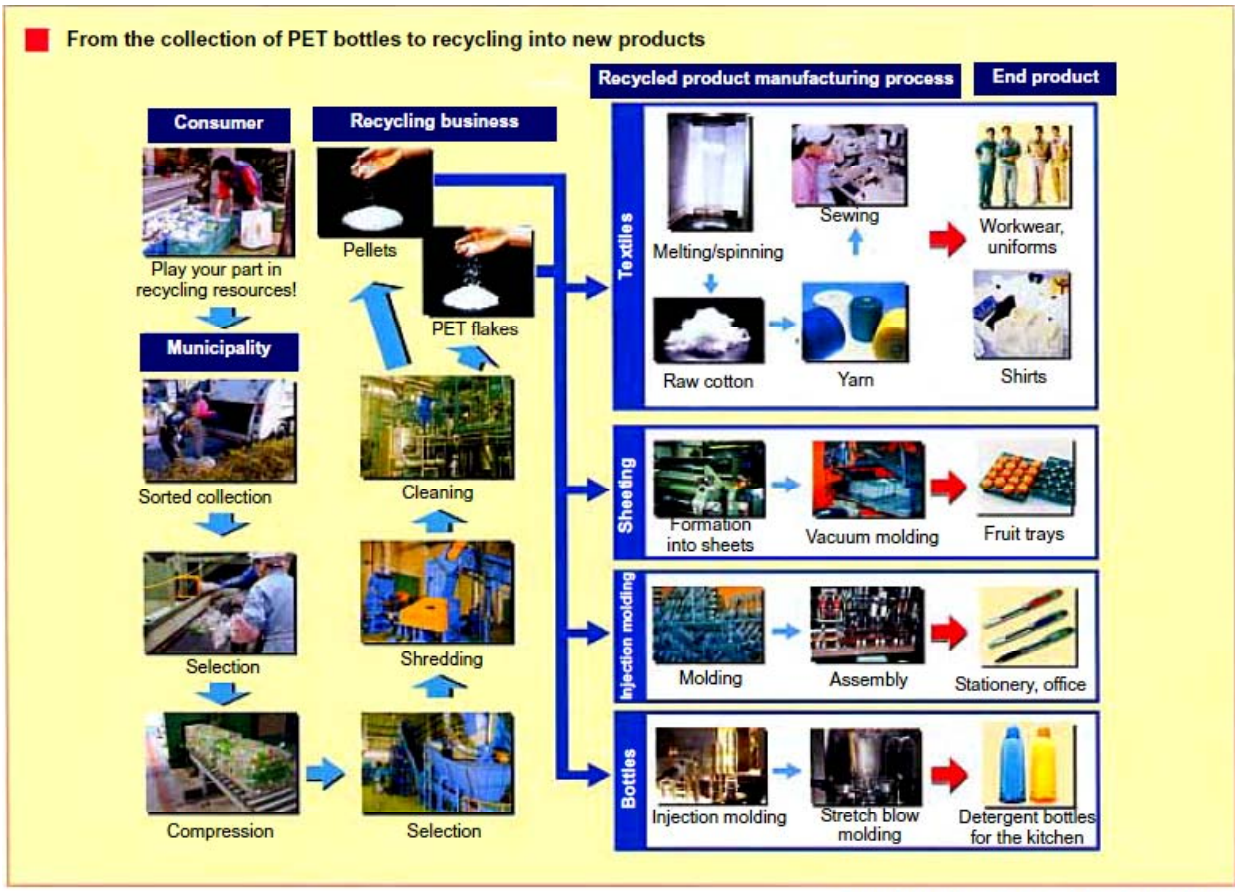
Table 3.2.3 Recycling Methods for Waste Plastics

Categories	Recycling Methods		Recycling Process
Mechanical recycling	• Convert into raw materials • Make a products		Material recycling
Feedstock recycling	• Monomerization • Blast furnace reducing agent • Coke oven chemical feedstock recycling		Chemical recycling
	• Gasification • Liquefaction	Chemical feedstock	
Energy recovery		Fuel	Thermal recycling
	• Cement kiln • Waste power generation • RDF		

An important element in the waste plastic recycling is separation technologies. This permit to use less virgin materials – oils, when manufacturing and put less burden on the environment from waste discharge.

(3) Recycling of PET materials and use as resources

The following figure shows an example of PET recycling mechanism from a collection to finished products.



Source: Council for PET Bottle Recycling in Japan

Figure 3.2.8 PET Bottle Recycle Flow

(4) Mechanical Recycling Process (Material recycling)

Waste plastics are normally compressed and transferred to recycling facilities. At recycling facilities, non-plastics materials such as papers and metals are removed. The plastic materials are then segregated by colors and types in prior to feeding into shredding process. The shredded plastics materials are washed and further purified to remove any impurities remains, such as irons, aluminums, dirt/earths, and other materials. After completion of purifying process, the plastic materials are made into flakes and/or pellets (flakes are granulated after heated) and then turned into reusing. Those raw materials are normally melted and utilized at textile and/or sheet manufacturing factories as well as fabricated products.

1) Typical Plastics Molding Processes:

The following are typical molding process widely applied in molding industries.

Table 3.2.4 Molding Process for Plastics

Type of Molding	Process	Main Products
Extraction Molding	Resin is melted and continually extracted into a molded product by molder.	Pipes, sheets, films, cable capsulation
Injection Molding	Heated melted resin is injected into a mold to solidify a product.	Small product: washing basin, bucket, plastic models Large products: Bumper, Pallets
Blow Molding	An extracted or injected parison is clamped into a mold, and inflated by air making a bottle.	PET Bottles, shampoo bottles
Vacuum Molding	A heated-softened sheet is sandwiched in a mold, and the air is vacuumed between a sheet and a mold.	Cups, trays
Inflation Molding	A melted resin is inflated into a cylinder to foam a film. It is a type of extraction molding.	Shopping bags

(5) Feedstock Recycling

1) Monomerization

Monomerization process can be applied for chemically decomposing PET materials into the monomers states (depolymerization process) for reusing as raw resins to make new PET bottles. Following figure shows the decomposition process of combining the Ethylene Glycol (EG) and Methanol to break the wastes PET materials and turn down into the Dimethyle Terephtalate (DMT), developed by Teijin Ltd in Japan. Applying this technology, the wastes PET bottles can be broken further into Purified Telephthalic Acid (PTA) from DMT, and then able to make PET resins.

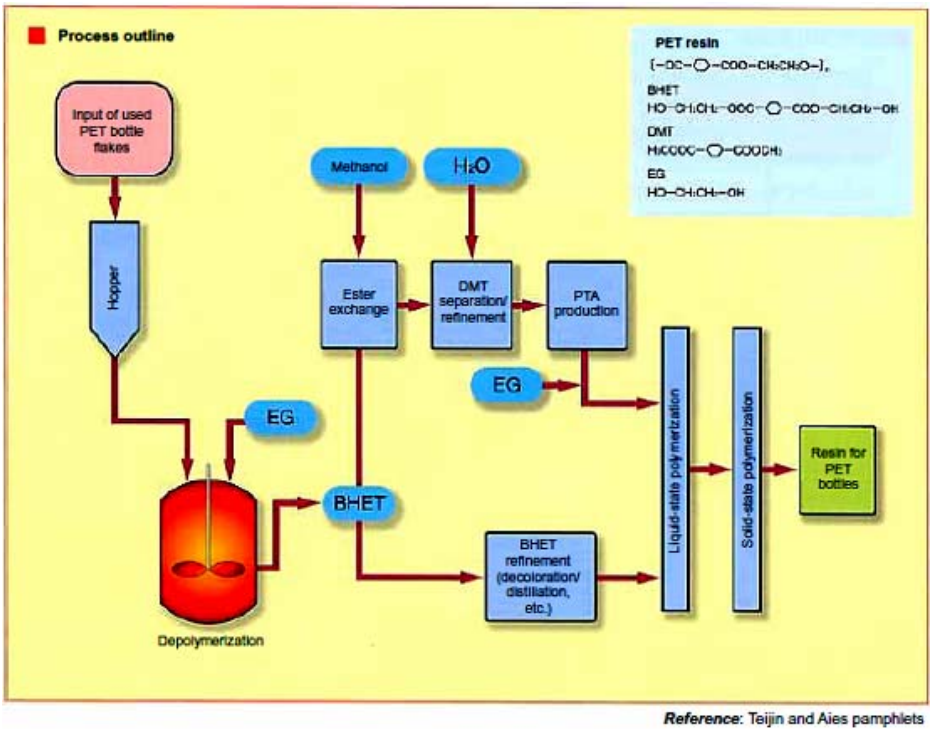


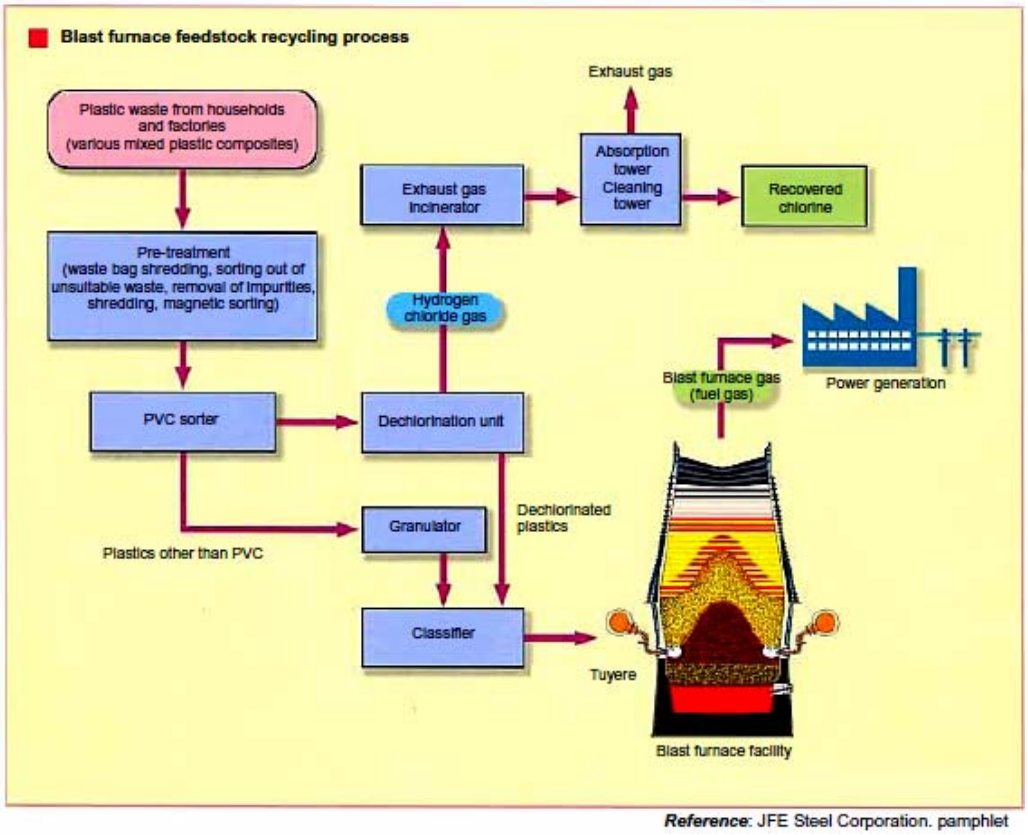
Figure 3.2.9 Feedstock Recycling Process for PET Bottles

2) Blast Furnace Feedstock Recycling Process

At a steel mill factory, the iron is produced together with iron ore, cokes and other auxiliary raw materials in a blast furnace. The iron ore is then melted and produce pig irons. While in melting process, the coke is combusted as fuels to increase the process temperature in the blast furnace. And also the coke acts as reducing agent by removing the oxygen from the iron oxides, which are main constituents of the iron ore.

Main composition of plastics is the carbon and hydrogen elements; therefore, the waste plastics can be utilized as a reducing agent in a blast furnace. A process of using the waste plastics as a reducing agent is as following processes.

The waste plastics collected from residence and industries must be removed impurities such as metals and non-combustible materials. Then those are shredded in small sizes and compacted to reduce the total volume. PVCs are further removed form the plastics and are granulated, then fed into the blast furnace. PVC removed because it can damage the furnace from hydrogen chlorides gases it produces. Alternatively, plastic wastes with PVC can be fed into a blast furnace at the approximately 350℃ in the absence of the oxigen, by which the hydrogen chlorides are removed. The hydogen crolide can be recoverd and comosed as the hydroclrlc for acid treatment process in a steel finishing line of the hot mill process.



Reference: JFE Steel Corporation. pamphlet

Figure 3.2.10 Recycling Process for Waste Plastics used as Reducing Agent

3) Coke oven chemical feedstock recycling process

When the coal is baked to make cokes, the hydrocarbon and coke oven gas are generated from the volatile components. In similar reaction process occurred when the waste plastics is bake to produce cokes and hydrocarbon oils. The waste plastics collected from household and industries are shredded into small sizes. Then impurities like iron metals and PVCs are removed. Remained plastics are fed into the coke oven with coals in which temperature is heated to 100 degree C. Since the chamber of the furnace is indirect heating mechanism by sandwitch construction, the waste plastic materials are decomposed at high temperature in absens of oxygen and turned into cokes which can be used as reducing agen in blast faurnace, into hydrocarbon oils that can be used as raw materials, and into coke oven gases for generating electricity.

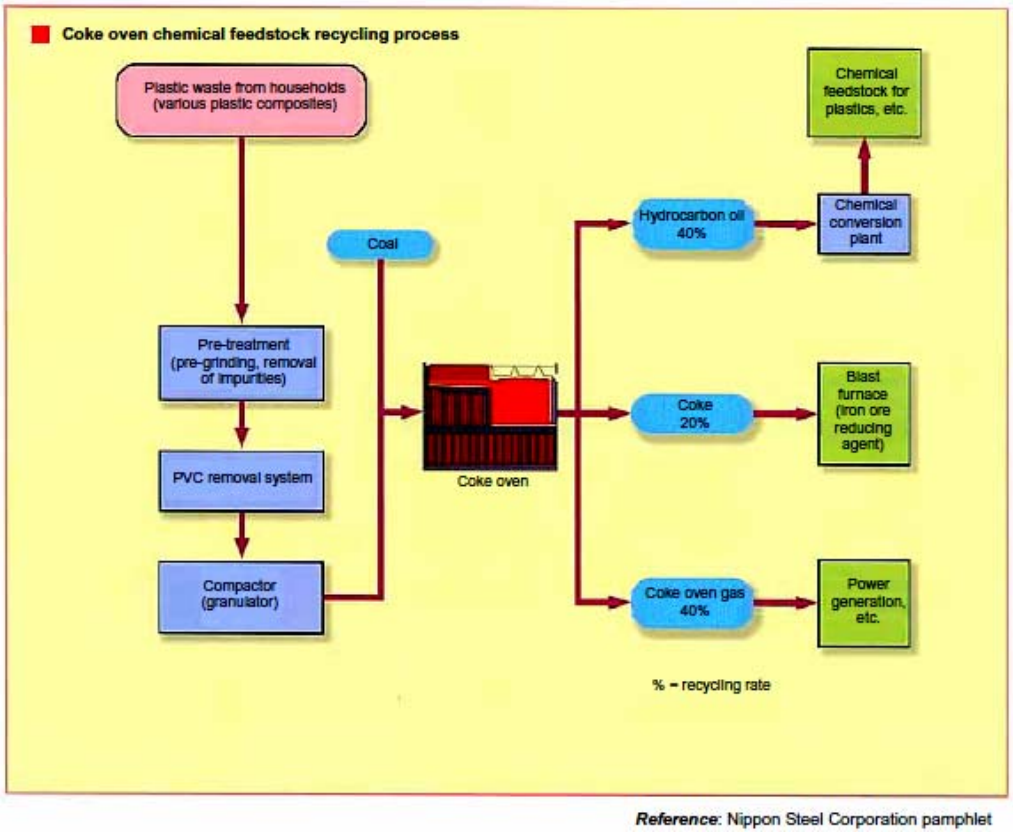


Figure 3.2.11 Use of Waste Plastics in Coke Oven

(6) Energy Recovery

1) Gasification Process

Because main components of plastics are the carbon and hydrogen, the carbon dioxides (CO_2) and water are normally produced when combusted. The gasification process is realized when the waste plastics are heated, under controlling of the oxygen and water so that the plastics are

decomposed into hydrocarbon, carbon monoxide (CO) and water.

At the first stage in a lower temperature gasification furnace, feeding plastic materials are contacted with high temperature sands that are circulated at approximately 600 – 800 degree C which result decomposision of hydrocarbon, the carbon monoxides (CO), hydrogen, char and etc. If chlorine-contaminated plastics are present, hydrogen chloride gas is also generated. In case metals and glass are contained, they are melted and solidified to be collected as impurities.

At the second stage in high temperature gasification furnace, which is heated up to approximately 1300 to 1500 degree C, the gasses that are taken from the lower temperature gasification furnace are decomposed with mainly the carbon monoxides (CO) and hydrogen. The flue gasses at the exit of furnace are chilled down to lower than at 200 degree C by cooling water to prevent forming dioxins. Produced granulated slugs can be utilized in civil engineering and construction materials. The produced hydrogen chloride gasses are neutralized by alkaline and removed. As a result, the generated gasses can be utilized to produce such materials as hydrogen, methanol, ammonia, and acetic acid in chemical industries.

2) Liquefaction Process

Because the plastics are made from petroleum, it is possible to produce petroleum through reversing manufacturing processes. Naturally, the liquefaction process has been studied since 1970 although proven technologies with cost effective, applicable and practical processes have not yet developed. At present, technologies may be applied for relatively easier wastes plastic only, which are collected from industries, but no development for residential waste plastics is progressed for waste plastic materials discharge from household. This area has urgent development need, especially for process for PVC contaminated plastics.

(7) Energy Recovering Process

Energy recovery is one of the basic treatment processes in which plastics are cycled. However, the energy recovering should be seen as the second option similar mechanical recycling.

The waste power generation is generally carried out in stoker oven, gasification and melting furnace, as well as gasification reformer. Rotary kiln type furnace, which is employed with typical gasification and melting process, can gasify wastes at high temperature. Then the pyrolysis gas and char formed produce steams to drive a steam turbine and generate the electricity while incinerated ashes are melted and solidified. As a result, the gasification process reforms the pyrolysis wastes with adding gasses containing some oxygen and steams (vaporized water) to the combustible gases as fuels. This process is the typical operation for shaft furnace and rotary kiln.

The following figure shows an example of gasification and melting furnace with power generation system as applying for rotary kiln furnace.

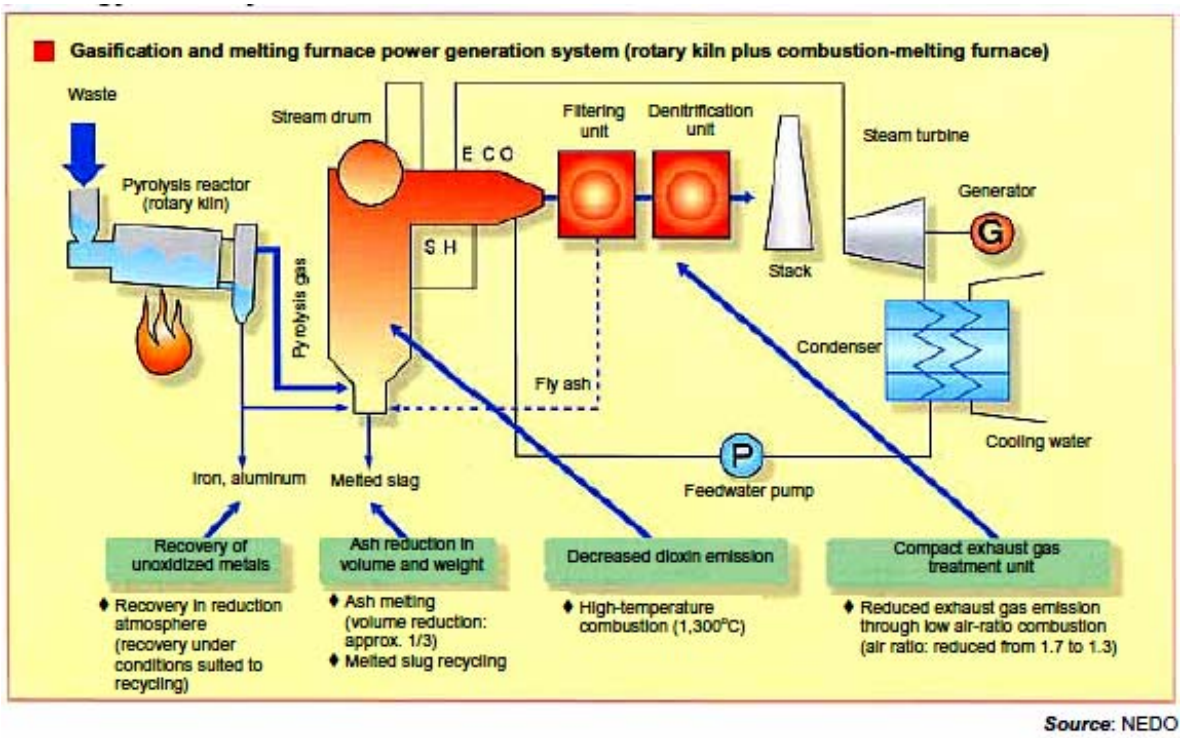


Figure 3.2.12 Flow of Rotary Kiln using Waste Plastics

3.2.6 Technology Requirement for PET Recycling

Recently the PET production has being increased sharply while the recycling rate is also gradually increasing in the recycling industries. Main areas of applications are developed in fibers, textiles and packages for eggs (Egg-Pak) and etc. On the other hand, "PET to PET" technology has being developed for applying in some beverage industries, but it is not yet completely proven technology as feasible and practical at this moment. The "monomerization process" is being studied, so that the "supercritical methanol process", which can reuse disposed PET materials to manufacture new PET bottles without contaminations of impurities as same quality as virgin PET, could apply. It is becoming a real "PET to PET" process. Requiring technologies in recycling of PET materials are shown bellow.

(1) Segregation process

Beside, a segregation technology, use of the "near-infrared ray guidance system" has been developed to recognize PET materials. This technology can be applied effectively to separate the PET materials from other mixed plastics.

(2) Shredding/Separation process

In order to precisely separate PET from the mixed plastic materials, the "Selective Shredding Technology" should be developed, which can shred only materials that need to shred. Therefore this process is more effective and practical as well as cost effective method. However the current process is still the "Premixed Shredding Method" that all plastic materials have been mixed in prior shredding.

(3) Pellet and Flake process

Already shredded-PET, if non-contaminated, can turn into pellets and/or flakes, or granules that are made of flakes thermally processed by granulator.

3.2.7 Requirement Technologies for E-Waste Recycling

(1) Basic technology required in cell phone recycling

1) Typical recycling process

A cell phone is consisted of a handset, which are integrated with electrical circuit boards and a push-pad and plastic case body (cover), battery pack and its charger. The weight for old models are around 100 to 300gr per a handset, whereas the latest modes weigh less than 100 grams because of employing smaller sized lithium-ion battery. In addition, use of the precious metals is also declining. The following figure shows the typical recycling procedure, currently applied.

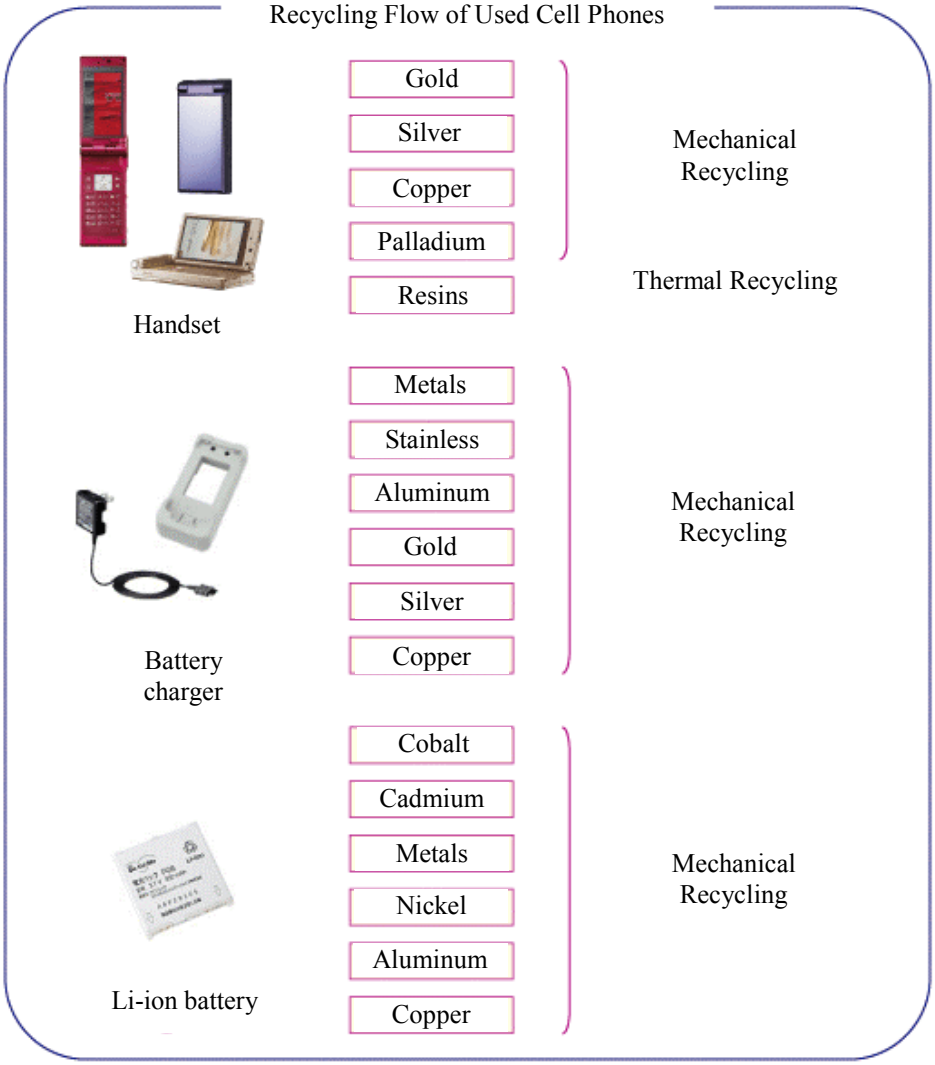


Figure 3.2.13 Component of Cell Phone and its Recycling Methods

2) Structure of Lithium-ion battery

Structure of lithium-ion battery is shown below. Japan Battery Recycling Association

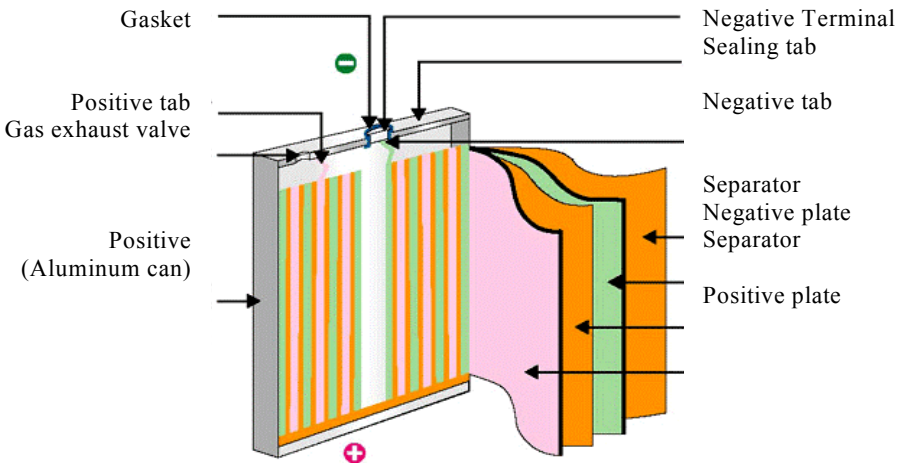


Figure 3.2.14 Typical Structure of Lithium-ion Battery

3) Characteristics of Lithium Metal

Lithium metal is extracted from only limited countries on earth. The following are some typical characteristics and applications.

- Main components of the lithium mineral are (Li2O, Al2O3, SiO2)
- Produced at very limited area as Chili reserves more than half on the earth.
- Alkaline, silver-white metallic color. Oxidized by the atmosphere and turn to black color
- Density is 534kg/m^3, lightest in metals
- Melting point: 453.5K, boiling point: 1,620K, which are relatively low among metals
- React with water and generate hydrogen gas to form the lithium hydride (LiH)
- Easy bonded with halogen family and form salts
- Lithium metal and its compounds are used for the Lithium battery and terminal parts for the Lithium-Ion battery, as well as additive for glass absorbing heating/cooling agent for the gas absorption heating/cooling unit, and construction materials for aircraft structure.
- Catalytic for synthetic rubber, fluorescent materials, surface acoustic devices (SAW) made by fine ceramics as wide applications

4) Lithium Cobalt Acid recovering technologies

In general, recycling rechargeable batteries should be considered after careful review of following conditions.

- Impact on the environmental loads

- Possibility on effective use of materials
- Consumption of energy
- Economical efficiency

Since an effective recycling technology/process has not been developed in recovering the lithium metal from waste batteries, no large amount of discharged batteries are recyclable at once, and cost for recovering are rather expensive than that of the normal battery, collected Li-ion batteries has often be discarded. However, use of the lithium battery in mobile phones, digital cameras, and other applications has being increased, and as a result, the volume of waste lithium batteries have also been in increase. Under these circumstances, the technology to recycle lithium metal has under development to recover the lithium metal. To date, no effective/practical process has been developed yet, however the following processes are experimentally studied in a market.

A. Incineration (baking) process

Waste lithium battery is fed into the incinerator, and then baked. After baking process, the cobalt and lithium metals are separated by magnet separator and/or leaching method after cooling down.

B Floatation separation process

Waste lithium battery is shredded as fine powder. Cobalt Acid Lithium and Graphite (carbon) are recovered as the mixed power (black color). The recovered black powder is heated up to approximately 500 degree C to burn the binders. After removing of the binder, the mixed powder of Cobalt Acid Lithium has become the hydrophilic so that it is possible to precipitate by using of the coagulator and/or foaming agents. This process can recover the Cobalt Acid Lithium more than 92% with over 93% purity.

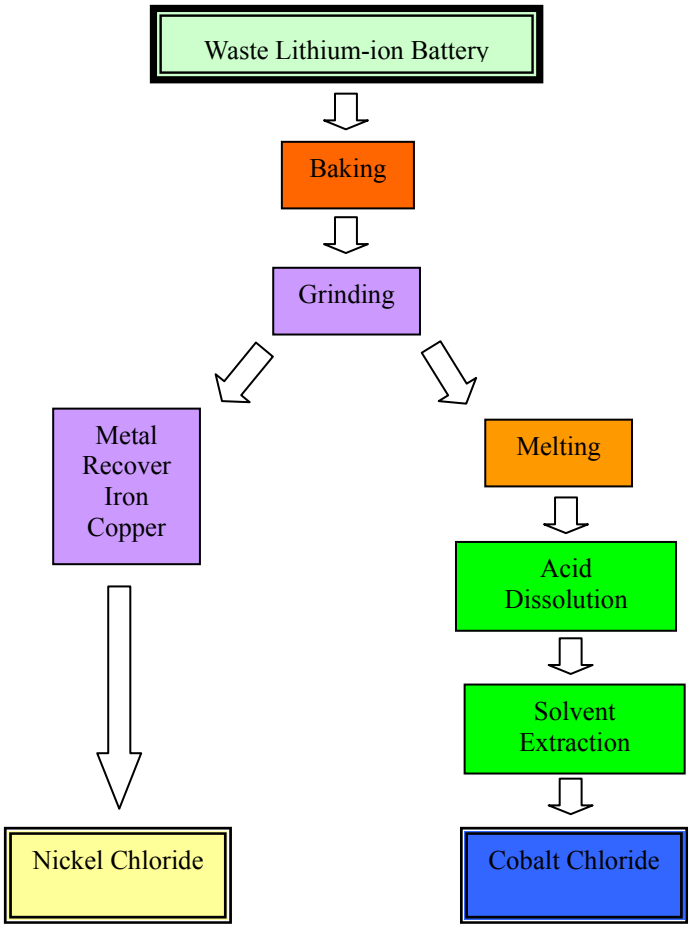


Figure 3.2.15 Recovering Flow of Rare Metals from Used Cell Phones

(2) Technologies in E-waste Recycling

E-wastes such as PCs, TV and refrigerators are similar construction, which can be dismantled manually. The dismantled E-wastes are recycled to obtain some valuable materials by the physical and/or chemical separation processes.

Basic technologies required in E-waste recycling can apply with the following 3 processes.

1) Low temperature shredding/separation process

Plastics materials are segregated with “brittle temperature” characteristics of the target materials. This process utilized the characteristics that each material has different “embrittle” depending on the temperature. The plastic materials are shredded and then segregated into “embrittlement” and “non-embrittlement” materials.

2) Eddy current (EC) Separation Process

By providing of rotational magnetic field (the eddy current) onto mixed metal materials, ferrous and

non-ferrous materials can be separated into two kinds of the metals by repelling force.

3) Anti-dissolution Process

Shredder dusts, incinerated ashes, fly ashes and dust particles, which might be contaminated with heavy metals, are kneaded with water and some chemicals. Then, these heavy metals can be converted into non-soluble compounds in the alkaline solutions.

It should be noted that for recycling refrigerators, recovering CFC prior to dismantling compressor is necessary.

In general, necessary technologies in recycling of the E-wastes are basically same as technologies used in its production. However such technologies are becoming more complex because employing more chemical materials, especially for various types of plastics materials. Consequently, advanced technologies are needed to recycle E-wastes for segregation, dismantle, shredding, separation, refining, extraction, material resource, re-productions and etc.

4) Decomposing of the electronics components

Since the electronic circuit boards are compounded with plastics and metals like the copper, such circuit boards should not be shredded in prior to removing the electrical component parts. All electrical parts and plastic materials should be carefully removed without breakage by hands. Plastics materials, which are basically thin films or sheets, should be peeled off from the circuit boards so that the plated copper materials are remained with a bit of solders on the boards. The copper with solder can be separated by gravity sorting process after grinded. Shredding process is one of the most energy intensive process in the recycling.

Hence new experimental process is being studied that the plastics and metals can economically be separated into two parts. This process can minimize the cost and energy consumption, if realized

5) Utilizing of recycled materials

Following figure indicates how recycled and/or recovered parts and materials are utilized.

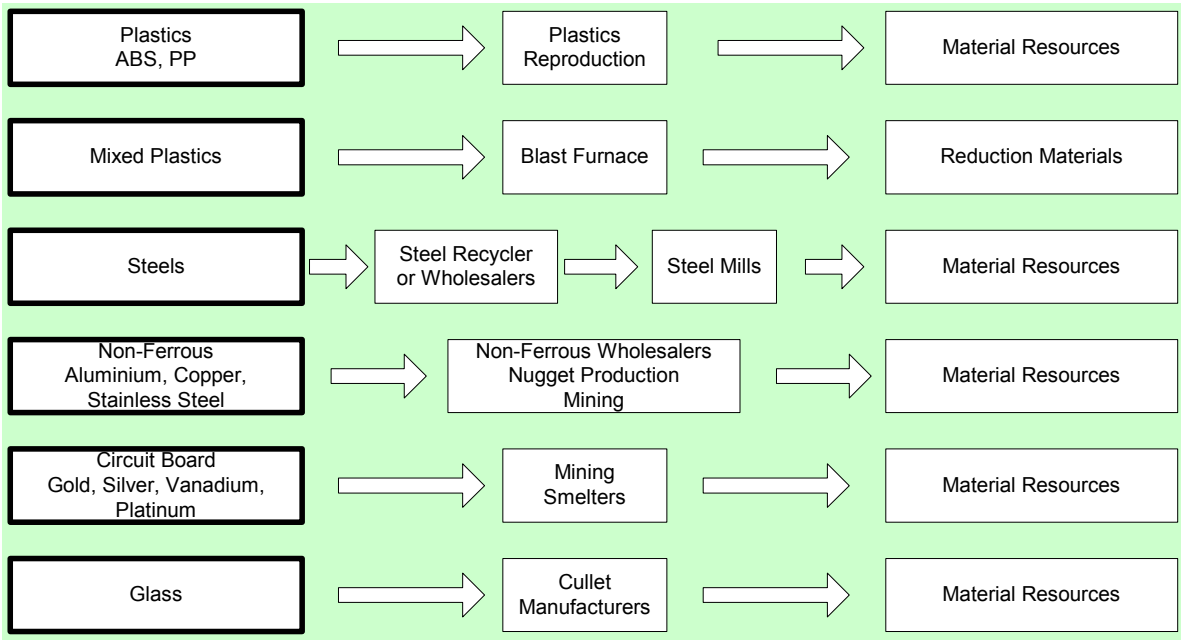


Figure 3.2.16 Utilization of Recycled/Recovered Materials

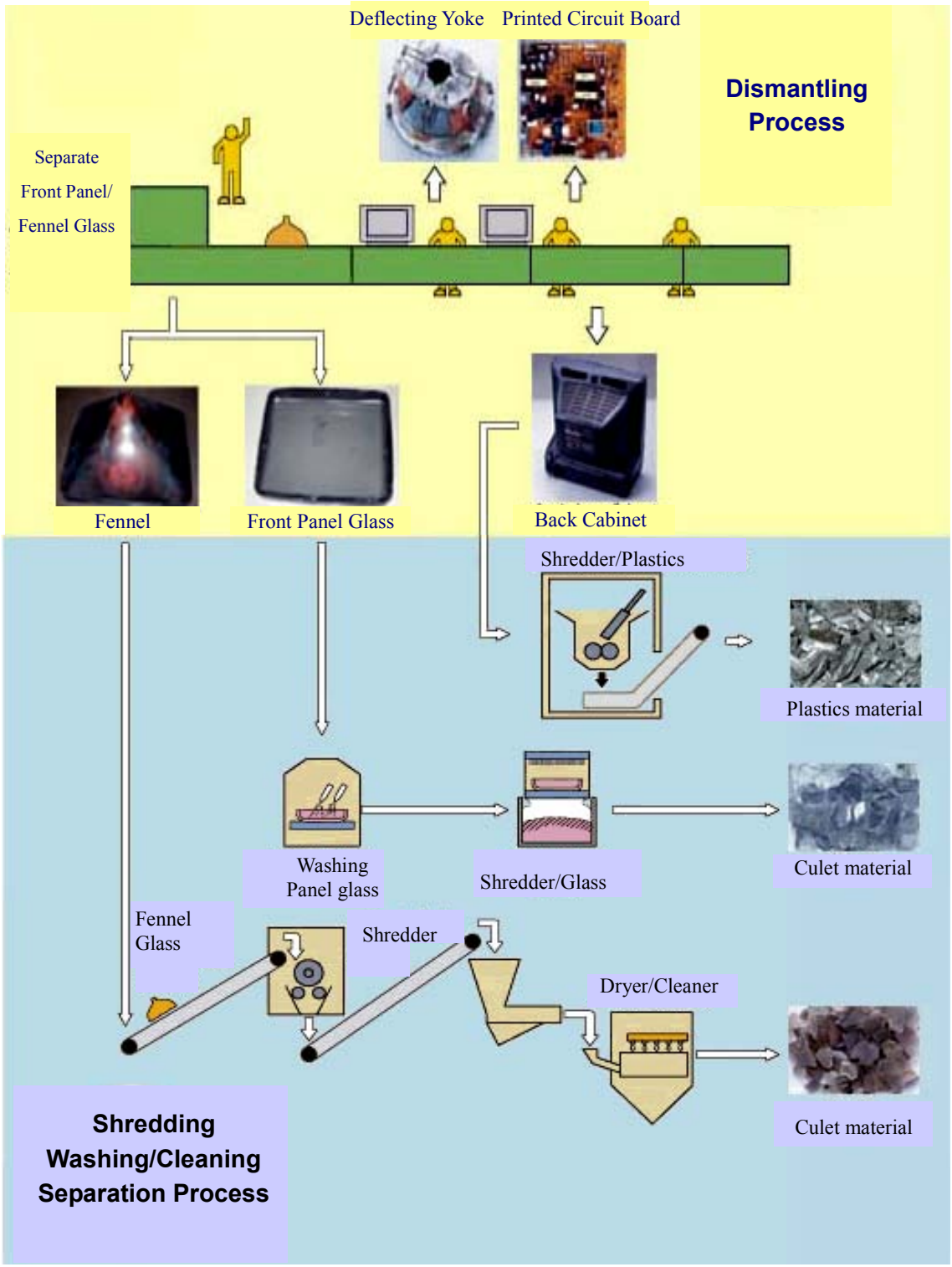
(3) TV recycling flow

TV is consisted of 3 major components as shown in the table below. Recyclable materials are iron, normal glass, lead glass and plastics.

Table 3.2.5 Major Components of TV set

Conponents	Major recycled meterials
TV Tuve (CRT) • Shadow mask • Electric gun • Anti-maget band	Iron, Normal glass, lead glass
Electric parts • Circuit board • Cable	Copper, Silver, Plastics
Cabinet	Plastic materials

Used TV requires manual dismantling to separate into several main components. The separated components go though shredding and washing process before recovering valuable materials. The following diagram shows typical dismantlling and recovering materials.

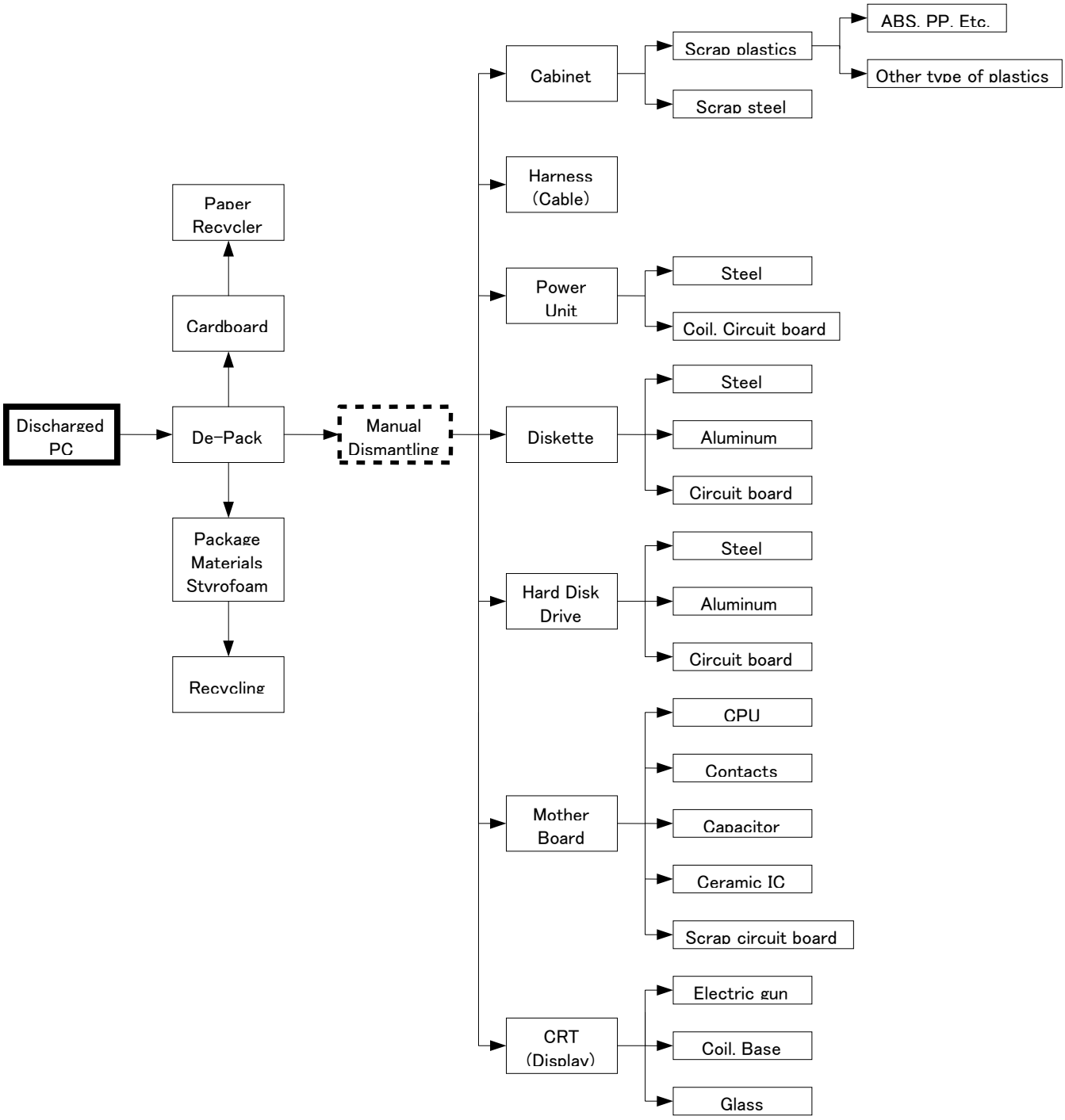


Source: Electric appearances recycling association

Table 3.2.6 Recycle Process and Materials Recovered from Used TV Set

(4) PC Recycling

The following figure shows PC dismantling process and its recovered waste.



Source: Japan Electronics Appliances Recycling Association

Figure 3.2.17 Dismantling Procedures and Recovered Material for PC

(5) Refrigerator Recycling Flow

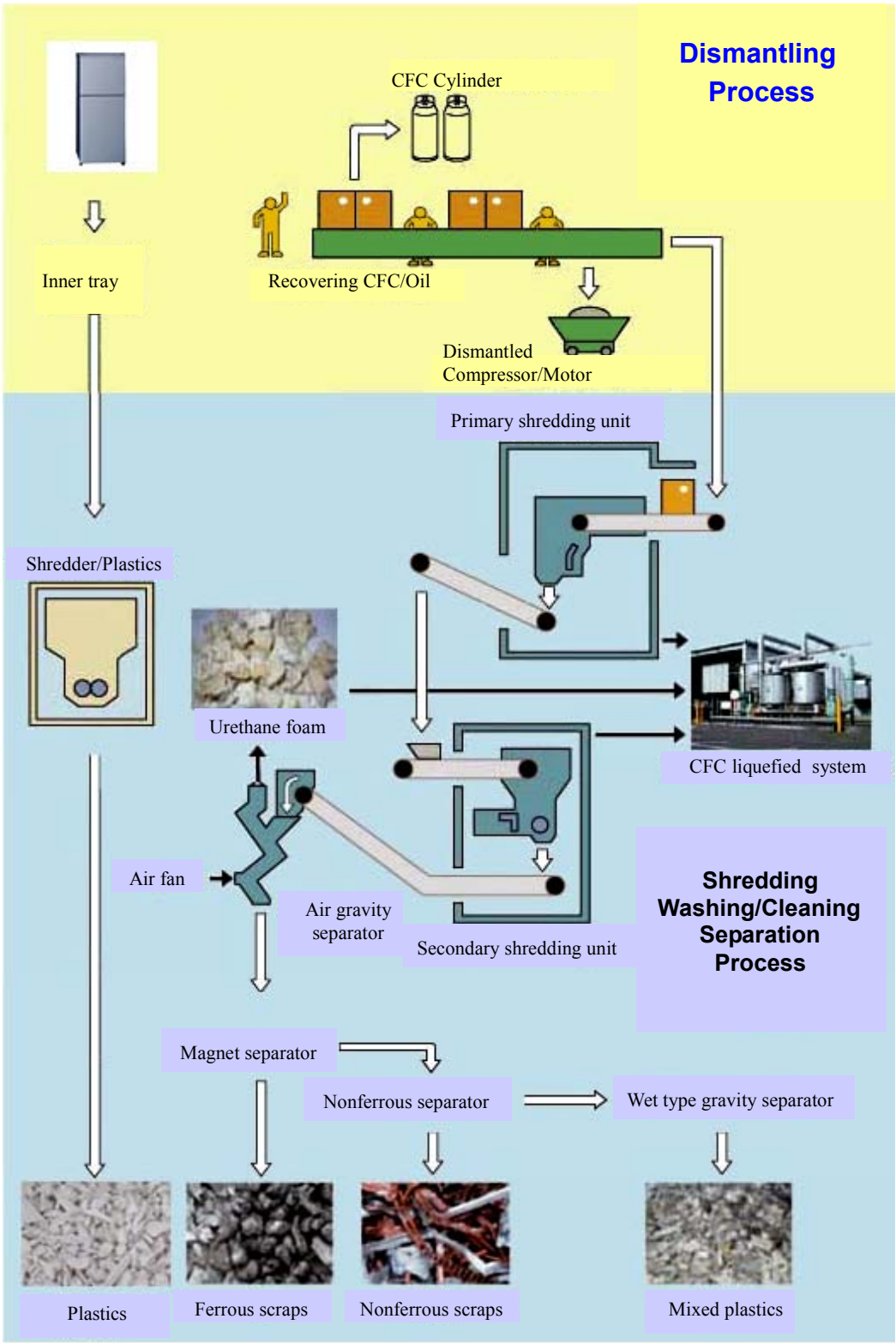
Refrigerators are generally consisted with following 4 major components as described in the teble below. Recycled materials are iron, copper, aluminum and plastics.

Table 3.2.7 Major Components of Refrigerator

Components	Major recycled materials
Cabinet	Iron, Plastics
Compressor	Iron, Copper, Plastics
Electric parts	Copper, Silver, Plastics
Inner parts	Plastics, Alminum

Discharged waste referigerator is manually dismantled to remove the above componens. After this process, separated component parts are shredded and washed, and then valuable materials are recovered. In additon, CFC must be properly recovered in prior dismantlling since old types of refrigerators employ CFC for cooling media as well as forming material are inflated by CFC gas.

The following figure shows typical dismantlling and recovering materials.



Source: Electric appearances recycling association

Figure 3.2.18 Recycle Flow and Material Recovered from Used Refrigerator

(6) E - Waste Management by Manifest System

In order to properly manage E-waste, implementing manifest system is an essential process that can track the movement of the E-waste among discharger, recycler, and treatment facility. Following figure shows an example of manifest system. (Source from Japan Electronic Appliances Association)

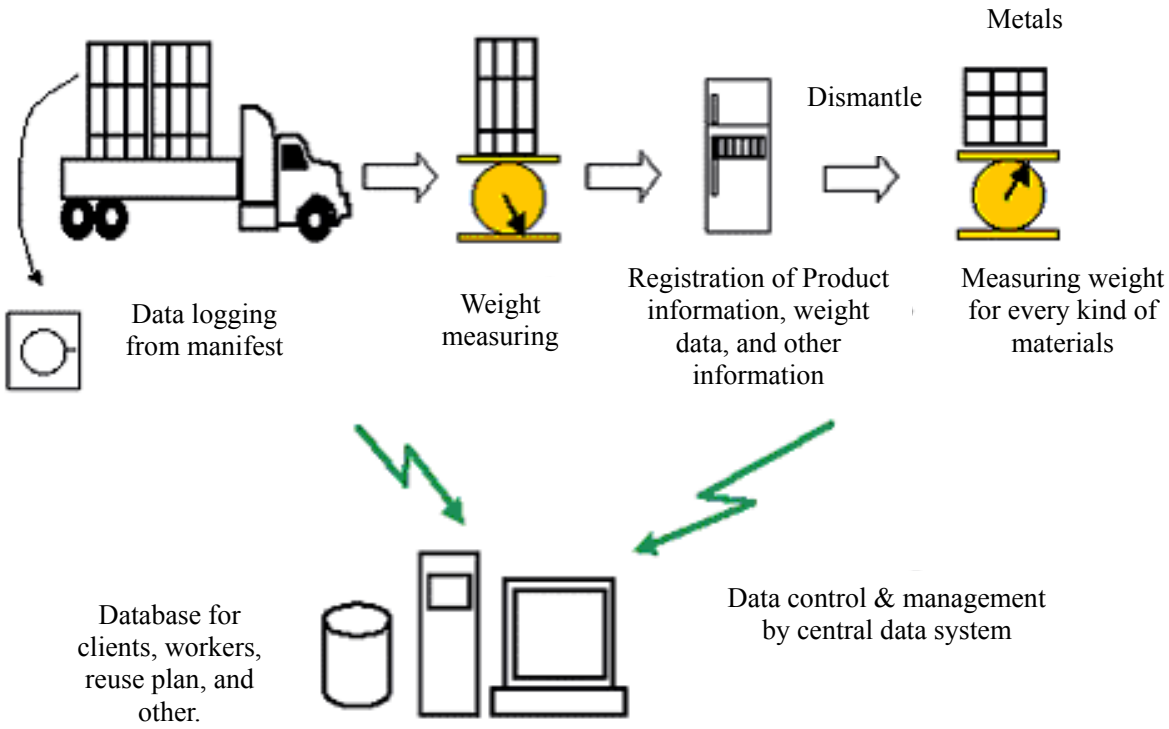
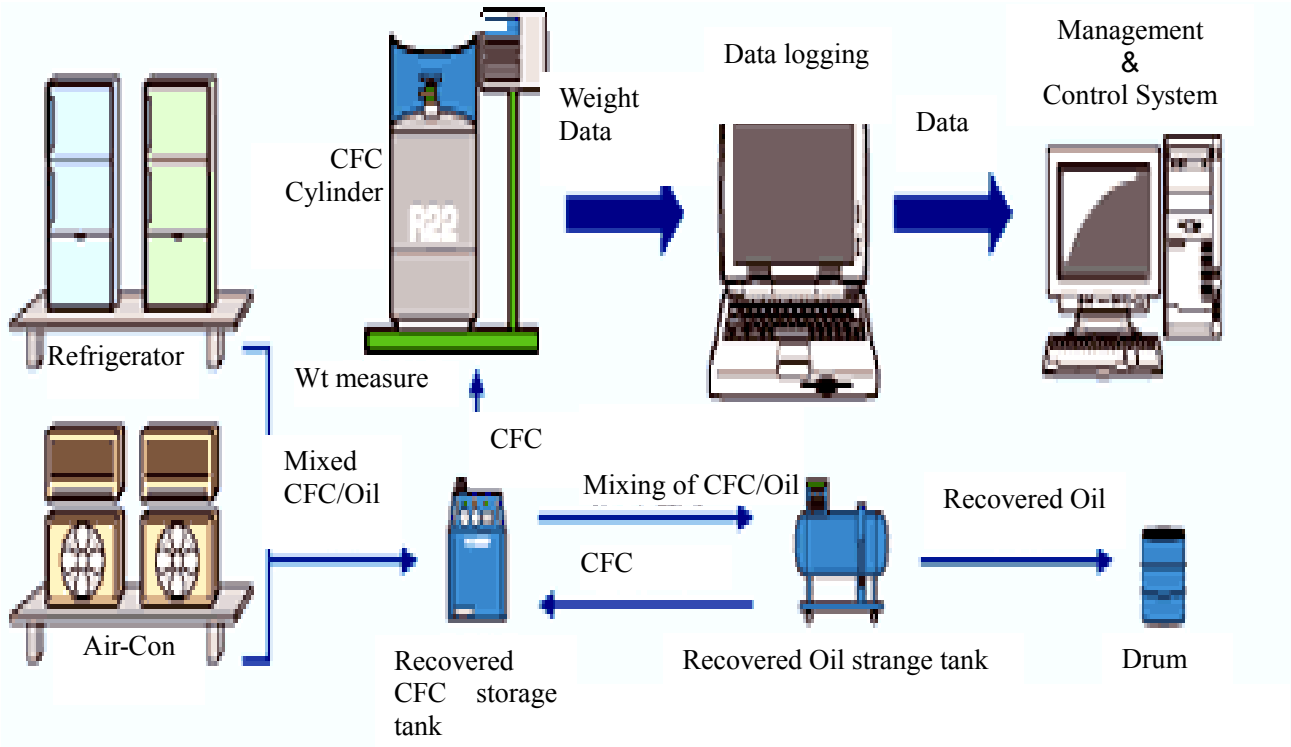


Figure 3.2.19 E-waste Management by Manifest System

(7) CFC Recovering System

Following figure shows an example of recovering CFC from refrigerators and air-conditioning units. The system is consisted with CFC weight measurement, CFC/Oil separation and data logging & control by PC system. The CFC cylinders are strictly control and stored in the CFC storeroom.



Source from Japan Electronic Appliances Association

Figure 3.2.20 Recovering CFC from Used Refrigerators and Air-Conditioning Unit