Light Weight Packaging
Sorting Plants
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Este libro se ha impreso en papel 100% libre de cloro y parcialmente reciclado
From the start of our activity, Ecoembes has collaborated closely with the parties involved in the recycling chain with a view to caring for the environment while following criteria of efficiency and sustainability. The first issue of the Sorting Plants Manual, which you are now holding, is an example of this collaborative spirit that has always guided our steps.

On this occasion the Manual results from Ecoembes’ alliance with ASPLARSEM, a collaboration in very different fields but nevertheless with a clear goal: to understand innovation as the cross-cutting theme that must guide all of our actions.

One of the goals that Ecoembes set for itself when preparing this document was to expand and improve the dissemination of the knowledge it has acquired on design, treatment and production control of light packaging waste treatment facilities. After all, if there is one thing we believe in is the pursuit of continuous improvement and knowledge transfer as a tool which provides competitiveness.

One of the pillars of this shared knowledge is based on the close collaboration with companies in charge of operating the facilities, suppliers, engineering firms, recyclers/recoverers, public administrations and materials institutions. The collaboration with ASPLARSEM is an outstanding example of this approach. These alliances provide global and tested knowledge of the various actions covered by our activities. In this sense, the Sorting Plants Manual aims to become a useful tool for waste technicians from public agencies, operating companies and treatment process engineering firms. We hope that this document will provide the necessary means to improve your processes and increase the efficiency of your facilities, and therefore of the system of which we all form part.

With this Manual, Ecoembes wishes to contribute to the dissemination of innovation-based knowledge to help protect the environment, so that we can all work together, pushing in the same direction towards a more sustainable world and indeed a better world.
This Manual represents an advance in showing the processes involved in solid urban waste management in a descriptive and graphic manner. The Manual supplies information of great interest thanks to the experience of its authors, with clearly-presented information ranging from the packaging sorting processes to the sizing criteria at the treatment facilities.

At the Association of Solid Urban Waste Packaging Recovery and Sorting Plants (ASPLARSEM, Asociación de Plantas de Recuperación y Selección de Envases de Residuos Municipales) we have shared experience and knowledge that contributes towards improving the operation of the packaging recovery plants, currently having nearly 80 associated packaging recovery plants which account for over 65% of the packaging obtained from selective recovery. At our plants we are capable of sorting light packaging with high standards of effectiveness and quality, attaining the highest European standards due to the investments we have made in the latest technology and innovation in the sorting process, which have made important contributions to improving plant efficiency.

One of the main challenges we face is that of contributing progressively in order to make Spain a European leader in packaging sorting, a direction in which we are already moving. Proof of this comes from the following figures: in 2003, 43% of packages in the market were recycled; currently, over 70% are recycled. As the European Commissioner for Climate Change and Energy, Mr. Miguel Arias Cañete, noted in his participation in our latest event commemorating the 10th Anniversary of ASPLARSEM, we face “the shared challenge of becoming a recycling society”.

I would like to emphasise the importance of urban waste recovery, which has a direct impact on the economy, given that the sector contributes to creating thousands of jobs all over Spain, as well as on the need for a continued effort by all the parties involved: the general public, companies, and local, regional and national administrations. Awareness and consciousness-raising within society continues to represent an essential element for continued progress and improvement in recycling and packaging waste recovery, whether for separation at source or for collection, transport, waste management and innovation by plants. This Manual therefore represents an essential pillar in this effort.

Moving towards a recycling society

Joan Griñó
President of ASPLARSEM
One of the principles of Ecoembes is to see waste as a resource, so that it can have a new life as part of a circular economy approach. This vision allows the raw materials used in the production of packaging to be reused for other purposes at the end of their service life, thereby reintegrating these materials in the productive cycle and reducing the demand pressure on new raw materials.

In this respect, as an organisation caring for the environment through recycling and the eco-design of domestic packaging in Spain, the function of Ecoembes is to enable the recovery and recycling of plastic, metal and cardboard containers for drink and food, as well as wood, paper and cardboard packages, in the most efficient way possible. To this end, Ecoembes coordinates the efforts of all the players involved in the selective collection and recycling of packages: companies, the general public, public administrations and recyclers.

Ecoembes is committed to promoting innovation throughout the entire life cycle of the package and to maximising efficiency in all the processes that make up its direct activity and that of its collaborators, among which the sorting plants deserve special emphasis as they generate a shared value based on sustainability and quality. It is worth noting the constant collaboration of Ecoembes and ASPLARSEM, which began several years ago in works such as capacity, performance and quality studies, in the measures adopted for energy savings (due to studies conducted jointly by the two entities), training programmes and numerous technical workshops, to name just a few examples of this alliance which promotes knowledge exchange as the basis for innovation.

Currently the 95 sorting plants installed in Spain are models of effectiveness (the percentage has grown continuously in recent years), modernisation and efficiency, among other reasons because more than half of them have automated their processes, leading to improved performance: about 80% of selected packages come from automated plants. This has been aided by the continuous collaboration between all the players in the packaging recovery and recycling sector and Ecoembes in the field of efficiency and R&D and innovation. It has thereby been possible to conduct production performance studies at sorting plants in order to fine-tune the need for investment and the operational costs. Similarly, this collaboration allows the improvement of the packages themselves by improving their design, detecting problems in the sorting process or taking the appropriate measures following the arrival of new materials that could affect the work in the sorting plants. It should be recalled that this constant effort towards innovation and improvement results in environmental, social and economic benefits, since among other advantages it creates thousands of jobs in what is termed the green economy.

In short, the collaboration between Ecoembes and the sector as a whole allows the anticipation of the new scenarios imposed by technological changes and increasingly demanding environmental regulations.
A light weight packaging sorting plant is a facility specialising in the classification, either manually and/or mechanically, of the different types of light weight packaging obtained from selective collection performed by the general public in yellow street containers, based on their composition.

Objectives

- Satisfy the hierarchy of actions on waste (Directive 2008/98)
  a. Prevention
  b. Preparation for reuse
  c. Recycling
d. Other type of recovery, including energy recovery
e. Elimination

- Compliance with current Spanish Regulations on Waste (Ley de Envases y Residuos de Envases 11/1997 and Ley de Residuos 12/2012).

- Recovery of selected waste (light weight packaging).

- Reintroduce selected materials into the consumer cycle, with the ensuing savings in raw materials. Create an industrial and commercial production infrastructure that generates jobs.

- Generate environmental improvement from suitable management of the treatment of the selected waste.

Light weight packaging sorting plants (2014)

ANDALUCÍA: Alcalá, Alcalá de Guadaíra, Alcalá del Río, Alhendín, Almería, Antequera, Casares, Córdoba, El Puerto de Santa María, Estepe, El Ejido, Elvas, Elvas, Jerez de la Frontera, Los Barrios, Málaga, Marbella, Menton and San Juan de Pinto.

ARAGÓN: Huesca and Zaragoza.

ASTURIAS: Serín.

BALEARES: Mallorca and Menorca.


CANTABRIA: El Mazo and Santander.


CASTILLA-LEÓN: Badajoz, Badajoz de San Juan, Amejuz, Cuauca, Guadix and Talavera.

CATALUÑA: Berga, Celrà, Constantí, Gala-Valdecas, Hostoles de Piamonte, Llagostera, Malgrat de Meiú, Montbui, Montblanc, Muntanyes de Pals, Olot, Vilafranca.

COMUNIDAD VALENCIANA: Alicante, Aitona, Elche and Alicante.

COMUNIDAD DE MADRID: Colmenar Viejo, Fuenlabrada, La Palma, Los Alcoraz, Nava Rendija and Pinto.

NAVARRA: Castejón, Castejón, Pircas and Tudela.

PAÍS VASCO: Azpeitia, Jarrés, Legazpi and Urnieta.

REGION DE MURCIA: Alhama de Murcia, Alhama de Murcia, and Valencia.

Number of plants

Automated plants

Total 95

Total 54

ON AUTOMATION Progress in automation

ON EFFECTIVENESS Progress in effectiveness

Manual

Automatic

Manual

Automatic

Effectiveness

% Tonnes selected by type of plant

% Effectiveness
Waste to treatment

Companies that connect their packages to the Ecoembes IMS identify them with the “Green Dot”. This forms part of their legal obligations. Waste generated in light weight packaging sorting plants is obtained from the selective collection of yellow containers, where members of the public deposit domestic light packages. These are plastic, metal and food and drink carton packages or beverage carton. The containers contain impurities or unsolicited material which must be separated from the requested materials during the sorting process.

Requested materials: HDPE (high density polyethylene), PET (polyethylene terephthalate), LDPE (low density polyethylene, generally in film form) and the mixed plastic fraction composed of materials made of PS (polystyrene), PP (polypropylene) and other plastics; also included are aluminium and steel packages, as well as beverage carton (hereinafter BC).

Unsolicited materials: Cardboard, cellulosics, P/C, low and high density film plastics and other impurities such as glass, textile wood, non-packaging plastic, organic matter, other metals, etc.

It is essential to perform quality control on the collected waste arriving at sorting plants in order to ascertain the quality of the selective collection, obtain the necessary data to calculate effectiveness, as an indicator of proper function of the sorting plants, and ascertain the stream of materials in the sorting processes and the potential for packaging recovery through selective collection. For this purpose a statistically representative analysis is performed of the waste known as characterisation (Point 3).

Sorting process

The treatment process in a light weight packaging sorting plant is divided into four main groups of operations:

1. Reception and storage.
4. Quality controls: adaptation of selected material and rejected waste management.

These operations will vary depending on the automation level of the sorting plants. Facilities are classified as automated (fig. 2) or manual (fig. 3) depending on how the material sorting operation is performed. This section discusses how to perform the light weight packaging sorting process at a plant and the equipment used for this purpose.
LIGHT WEIGHT PACKAGING
SORTING PLANTS

Diagram of the manual sorting process
Figure 2

Diagram of the automated sorting process
Figure 3
Scales for monitoring and weighing of collection vehicles

Vehicles with packaging waste collected from streets arrive at the sorting facility passing through access control and weighing (scales). In order to transport the collected material more efficiently, when the street collection vehicles need to travel distances greater than 40km from the place of collection to the destination plant, it is convenient to unload the material at intermediate locations (transfer stations) for compacting and subsequent transport in larger containers. In this case the material arriving at the plant has a greater density, which must be considered when sizing the treatment capacity of the facility.

Unloading area for transported waste

After weighing the vehicles and identifying their origin and schedule, they are led to the covered reception area where the transported waste is unloaded in the area or location indicated by the discharge and feeding operator.

Positioning and stacking of unloaded waste

The loading shovel stacks the unloaded waste vertically, optimising the surface available for storage prior to treatment. This process can include several components of bulky waste with sizes or shapes (as in mattresses, large packages, bicycles, etc.) that hinder the work and could affect the sorting equipment to be used. Using the loading shovel the operator must place these in a specific container located on this or another surface.
Reception and storage

1. Scales for monitoring and weighing collection vehicles
   - At the inlet and outlet points, the origin/destination of the trucks, their license plate, load type and material weight are recorded.

2. Unloading area for transported waste: yard
   - The waste is unloaded in the unloading yard for standardisation and subsequent feeding with the loading shovel.

3. Unloading area for transported waste: pit
   - In large volume plants, the material is stored in pits for subsequent feeding with grapple hooks.

4. Positioning and stacking of unloaded waste
   - The loading shovel or grapple hook removes bulky materials, homogenises and stacks the material based on its origin and schedule.

LIGHT WEIGHT PACKAGING SORTING PLANTS
Pre-treatment Operations

Primary feeding-dosing
The waste deposited in the reception area are collected with the loading shovel (unload yard) or grapple hook (pit), transferred and unloaded in the dosing feeder with variable speed and flow limiter, used to control the treatment flow rate.

Bulk waste sorting
Waste regularly supplied by the feeder is unloaded in a bulky waste sorting conveyor belt, where sorting operators select the materials which due to their size or shape are detrimental to subsequent treatments, such as film sheets, cardboard, EED waste, etc.

Bag opener
Non-sorted waste is downloaded by the same sorting belt in a bag opening unit designed to extract the materials from the bags when they are ready for the remaining sorting operations.

Classification in trommel
The components of the bags are subjected to a sieving process using a trommel or revolving sieve, which classifies the materials into three sizes:

- Fine components with a high content in organic and inert material.
- Intermediate components with a high content in recyclable packages.
- Large components or sieving rejects.

Classification in ballistic separator
The stream of intermediate size materials is subsequently subjected to ballistic classification according to size, shape and density, and again separated into three new material streams:

- Stream of heavy-rolling material formed by the majority of the heavy and/or rolling material, mainly packaging for liquids, metal packaging and beverage-carton. This falls down the inclined slope of the ballistic separator.
- Stream of light flat materials, mainly formed by cardboard, paper and other film plastics with a flat or flattened shape that rise up the inclined plane of the separator.
- Stream of fine materials made up of fine material that could not be sieved in the trommel because it was attached to or blocked by other material, which falls through the mesh of the separator.

The amount of material reaching each of the three fractions will depend on the quality of the material introduced in the equipment. For examples, in facilities with 75-85% of requested material at the inlet, the classification performed by a ballistic separator is about 80% rolling material, 15% light flat material, and 5% fine material. At facilities where the sorting operations are performed manually, the ballistic separator is not used. The material arriving from the trommel is taken directly to the sorting cabin, where the operators sort the requested materials.
Feeding and dosing

The material is unloaded by the shovel or grapple hook to the primary feeder, charged with suspending and dosing the treatment line.

Bulky waste sorting

Materials likely to cause jams in the rest of the line (film sheets, cardboard, EED waste, etc.) must be removed.

Classification in trommel

Classification by size to separate light weight packaging (underflow) from organic matter (fine waste underflow) and bulky waste (overflow).

Opening, ripping and emptying of bags, standardising the stream while breaking bottles to empty them.

Classification using the ballistic separator

Classification based on density in segregating light flat material (film and P/C) from heavy rolling material (packages).

Materials likely to cause jams in the rest of the line (film sheets, cardboard, EED waste, etc.) must be removed.
Pneumatic separation
The main objective of pneumatic separation is to clean film and paper from the rolling and light flat material streams, since these hinder the segregation of the remaining materials. The selected material is subjected to a manual quality control to separate impurities. It is subsequently stored to prepare it for dispatch (compaction).

Magnetic separation
The rolling material stream obtained from ballistic segregation is subjected to segregation of magnetic materials (steel) using over-band separators. Similarly, the fine material fraction from the trommel and ballistic separator are subjected to magnetic material sorting before being sent to the rejected waste fraction.

Optical separation
The rolling material stream that has not been selected by pneumatic aspiration on this line nor by the magnetic separator is subjected to optical segregation by infra-red or colorimetry detectors to segregate the following requested materials:

- PET packaging
- HDPE packaging
- Beverage carton packaging
- Mixed plastic packaging

To improve the performance and quality in the sorting of these materials, the magnetic and pneumatic sorting must take place prior to the optical separation.

Induction separation
The stream of materials not sorted by the optical separation is subjected to a sorting of non-magnetic metals (aluminum) by an eddy current separator.

Manual separation
Materials not selected in the rolling and light flat material streams converge on a belt in which they are subjected to manual sorting. The remaining unselected material is sent to the rejected waste fraction. In facilities where sorting operations are performed manually, the material obtained from the trommel is sent directly to the sorting cabin, where operators sort the requested materials.
Sorting of materials

1. Pneumatic separation
   In the light flat and rolling material streams the film material must be sucked out first to facilitate the sorting of the remaining materials.

2. Magnetic separation
   Steel is selected using a magnetic separator placed above the stream of rolling material.

3. Optical separation
   Optical separators are used to segregate PET, HDPE, beverage carton and mixed plastic materials.

4. Induction separation
   The induction separator removes aluminium material using its behaviour in eddy currents.

5. Manual separation
   Materials not selected in the rolling and light flat material streams converge in a current where a positive sort is performed.
Quality control
Due to errors occurring in the different types of equipment, the selected packaging material contain impurities that reduce the purity of the final product. These impurities are removed through manual sorting.

This operation is usually performed after the sorting of each of the recovered materials (PET, HDPE, beverage cartons and mixed plastics) before storing in silos for compaction. In other facilities the quality control is performed before compaction, so that a single operator can perform the operation.

The sorted impurities are sent to the rejected waste stream at the facility or, if they are requested materials, recirculated to previous points of the process for sorting.

Temporary storage of selected materials
The selected materials are deposited in specific confined spaces for each one (intermediate storage silos) awaiting compaction operations. Storage silos are compartments sized according to the following parameters:
- Apparent density of each material
- Production of each selected material per shift
- Hourly capacity of the compacting press.

The extraction of the materials stored in the silos is performed using moving bases, conveyor belts or directly with a loading shovel, which evacuate them to the feeder of the baling press placed downstream.

If the selected amount of any material is small (e.g. aluminum) the production is stored in auxiliary containers for subsequent compaction.

Compaction of selected materials
Materials stored temporarily in the containers are subsequently subjected to density increasing operations using baling presses, which produce bales with a density suitable for final storage and subsequent transport in order to comply with the requirements of the Technical Specifications for Recovered Materials (TSRM) of Ecoembes.

A single properly sized press can bale the output of all selected materials (PET, HDPE, FILM, beverage cartons and mixed plastics) except metals, and particularly steel, which require different bale sizes and features as well as specific presses.

Rejected waste management at the facility
All sorting facility rejects are typically concentrated on a single output conveyor belt that discharges them at the evacuation point. Occasionally the fine materials current is discharged at different points from other rejected waste.

Due to the low density of the rejected waste material, its volume needs to be adapted for an efficient disposal to the landfill. This can involve several alternative systems:
- Self-compacters.
- Static compacters.
- Rejected waste press.
- Containers (for low-volume facilities).

Transport of containers with rejects is performed using container vehicles to take them to processing sites (dumping or energy recovery).

Quality control, material adaptation and rejected waste management
Operations
Quality control, material adaptation and rejected waste management

1. Quality control of selected materials
   The selected materials are automatically subjected to quality control through negative manual sort in order to remove non-targeted material.

2. Rejected waste management at the facility
   The rejected waste material at the facility is compacted or stored in containers for delivery to the landfill.

3. Temporary storage of selected materials
   Before they are pressed, the materials are stored until they reach the amount needed for a bale of material.

4. Supply to press
   Selected materials in silos are transported by a feeder to the multimaterial press for baling.

5. Material compaction
   Plastics and beverage cartons are compacted in the multimaterial press. Metals are pressed separately in a specific press.
Light weight packaging sorting plants control

To ascertain the efficiency of the processes, several control operations must be performed at the packaging sorting plants regarding performance, quality of sorted materials and operator performance. Ecoembes carries out several controls at the sorting plants to analyse their performance, quality of sorted materials and operator performance.

Input material characterisation

As mentioned in section 2.2, quality controls performed for the quality of selected waste arriving at the sorting plants in order to determine the quality of the selective collection, supply data needed to calculate effectiveness in the sorting plant, obtain information about material streams in the sorting processes and determine the potential for package recovery in selective collection. To this end, an analysis of the waste is performed known as characterisation.

Waste characterisation consists in determining the composition of waste by a standardised test, controlling the error in the estimation of non-targeted material percentage with a 5% margin of error.

The procedure followed to characterise the collected waste is described below. The aim is to obtain a sample that is as homogeneous as possible on which to perform the sorting of material:

1. Depending on the point where the material to be analysed is obtained, the sample is taken as follows:
   • From the unload yard or reception pit at the sorting plant.
   • Depending on the point where the material to be analysed is obtained, the sample is taken as follows:
     • When the material is obtained from a collection vehicle, its entire contents must be unloaded on a clean and paved surface. It is then homogenised by mechanical means and an amount of approximately 1,000 kg is taken.
     • When the material is obtained from the unload yard or reception pit, after homogenisation an amount of about 1,000 kg is taken.

2. The samples obtained from the collection vehicle and the reception pit or unload yard are deposited on a clean, paved surface, in order to proceed to spread and homogenise them by mechanical means.

3. After this homogenisation a first quartering is performed taking the material from two randomly selected opposing quarters. This material must be extended separately and the closed bags opened.

4. This fraction of material, about 500 kg, is homogenised and quartered again. Then any bags that remain closed are opened. Finally, taking 50 kg from each quarter and another 25 kg from two randomly selected opposing quarters. This provides a 250 kg sample for which material sorting is performed.

5. Material sorting for characterisation is performed manually, weighing each fraction with a suitable calibrated/verified scale.

6. Material sorting for characterisation is performed manually, weighing each fraction with a suitable calibrated/verified scale.

Table 1

<table>
<thead>
<tr>
<th>Material</th>
<th>Quantity (kg)</th>
<th>% Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rejected waste from Plant</td>
<td>56,01</td>
<td>21,65</td>
</tr>
<tr>
<td>Unsolicited materials (*)</td>
<td>202,66</td>
<td>78,35</td>
</tr>
<tr>
<td>Commercial packaging without Green Dot</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Commercial packaging with Green Dot</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Domestic packaging without Green Dot</td>
<td>1,12</td>
<td>0,43</td>
</tr>
<tr>
<td>Domestic packaging with Green Dot</td>
<td>1,47</td>
<td>0,57</td>
</tr>
<tr>
<td>Printed paper</td>
<td>3,78</td>
<td>1,46</td>
</tr>
<tr>
<td>Paper/Cardboard</td>
<td>6,37</td>
<td>2,46</td>
</tr>
<tr>
<td>Other (specify significant)</td>
<td>10,82</td>
<td>4,18</td>
</tr>
<tr>
<td>Aluminium commercial/industrial packaging</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Aluminium non-packaging</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Steel non-packaging</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Debris from small works</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Commercial/industrial film</td>
<td>6,14</td>
<td>2,37</td>
</tr>
<tr>
<td>Garbage bag film</td>
<td>0,37</td>
<td>0,14</td>
</tr>
<tr>
<td>Plastic commercial/industrial packaging (except commercial/industrial film)</td>
<td>3,58</td>
<td>1,38</td>
</tr>
<tr>
<td>Beverage carton</td>
<td>36,69</td>
<td>14,18</td>
</tr>
<tr>
<td>Plastic non-packaging (except garbage bag film)</td>
<td>3,86</td>
<td>1,49</td>
</tr>
<tr>
<td>Garden and pruning remains</td>
<td>0,08</td>
<td>0,03</td>
</tr>
<tr>
<td>Wood</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Organic matter</td>
<td>10,12</td>
<td>3,91</td>
</tr>
<tr>
<td>Garbage and pruning remains</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Glass (containers)</td>
<td>3,14</td>
<td>1,21</td>
</tr>
<tr>
<td>Wood commercial/industrial packaging</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Plastics commercial/industrial packaging (except commercial/industrial film)</td>
<td>1,36</td>
<td>0,51</td>
</tr>
<tr>
<td>Glass non-packaging</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Steel non-packaging</td>
<td>30,00</td>
<td>11,60</td>
</tr>
<tr>
<td>Aluminium</td>
<td>2,85</td>
<td>1,10</td>
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<td>-</td>
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<tr>
<td>Glass</td>
<td>3,14</td>
<td>1,21</td>
</tr>
</tbody>
</table>

(*) All materials that do not apply to household packaging of metal, plastic, wood or cardboard for drinks.

Type of Characterisation: Entry to Plant - Rejected waste from Plant

Date: 34-35

Ecoembes carries out several controls at the sorting plants to analyse their performance. As mentioned in section 2.2, quality controls performed for the quality of selected waste arriving at the sorting plants in order to determine the quality of the selective collection, supply data needed to calculate effectiveness in the sorting plant, obtain information about material streams in the sorting processes and determine the potential for package recovery in selective collection. To this end, an analysis of the waste is performed known as characterisation.

Waste characterisation consists in determining the composition of waste by a standardised test, controlling the error in the estimation of non-targeted material percentage with a 5% margin of error.

The procedure followed to characterise the collected waste is described below. The aim is to obtain a sample that is as homogeneous as possible on which to perform the sorting of material:

1. Depending on the point where the material to be analysed is obtained, the sample is taken as follows:
   - From the unload yard or reception pit at the sorting plant.
   - Depending on the point where the material to be analysed is obtained, the sample is taken as follows:
     - When the material is obtained from a collection vehicle, its entire contents must be unloaded on a clean and paved surface. It is then homogenised by mechanical means and an amount of approximately 1,000 kg is taken.
     - When the material is obtained from the unload yard or reception pit, after homogenisation an amount of about 1,000 kg is taken.

2. The samples obtained from the collection vehicle and the reception pit or unload yard are deposited on a clean, paved surface, in order to proceed to spread and homogenise them by mechanical means.

3. After this homogenisation a first quartering is performed taking the material from two randomly selected opposing quarters. This material must be extended separately and the closed bags opened.

4. This fraction of material, about 500 kg, is homogenised and quartered again. Then any bags that remain closed are opened. Finally, taking 50 kg from each quarter and another 25 kg from two randomly selected opposing quarters. This provides a 250 kg sample for which material sorting is performed.

5. Material sorting for characterisation is performed manually, weighing each fraction with a suitable calibrated/verified scale.

6. Material sorting for characterisation is performed manually, weighing each fraction with a suitable calibrated/verified scale.

Table 1

<table>
<thead>
<tr>
<th>Material</th>
<th>Quantity (kg)</th>
<th>% Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rejected waste from Plant</td>
<td>56,01</td>
<td>21,65</td>
</tr>
<tr>
<td>Unsolicited materials (*)</td>
<td>202,66</td>
<td>78,35</td>
</tr>
<tr>
<td>Commercial packaging without Green Dot</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Commercial packaging with Green Dot</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Domestic packaging without Green Dot</td>
<td>1,12</td>
<td>0,43</td>
</tr>
<tr>
<td>Domestic packaging with Green Dot</td>
<td>1,47</td>
<td>0,57</td>
</tr>
<tr>
<td>Printed paper</td>
<td>3,78</td>
<td>1,46</td>
</tr>
<tr>
<td>Paper/Cardboard</td>
<td>6,37</td>
<td>2,46</td>
</tr>
<tr>
<td>Other (specify significant)</td>
<td>10,82</td>
<td>4,18</td>
</tr>
<tr>
<td>Aluminium commercial/industrial packaging</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Aluminium non-packaging</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Steel non-packaging</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Debris from small works</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Commercial/industrial film</td>
<td>6,14</td>
<td>2,37</td>
</tr>
<tr>
<td>Garbage bag film</td>
<td>0,37</td>
<td>0,14</td>
</tr>
<tr>
<td>Plastic commercial/industrial packaging (except commercial/industrial film)</td>
<td>3,58</td>
<td>1,38</td>
</tr>
<tr>
<td>Beverage carton</td>
<td>36,69</td>
<td>14,18</td>
</tr>
<tr>
<td>Plastic non-packaging (except garbage bag film)</td>
<td>3,86</td>
<td>1,49</td>
</tr>
<tr>
<td>Garden and pruning remains</td>
<td>0,08</td>
<td>0,03</td>
</tr>
<tr>
<td>Wood</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Organic matter</td>
<td>10,12</td>
<td>3,91</td>
</tr>
<tr>
<td>Garbage and pruning remains</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Glass (containers)</td>
<td>3,14</td>
<td>1,21</td>
</tr>
<tr>
<td>Wood commercial/industrial packaging</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Plastics commercial/industrial packaging (except commercial/industrial film)</td>
<td>1,36</td>
<td>0,51</td>
</tr>
<tr>
<td>Glass non-packaging</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Steel non-packaging</td>
<td>30,00</td>
<td>11,60</td>
</tr>
<tr>
<td>Aluminium</td>
<td>2,85</td>
<td>1,10</td>
</tr>
<tr>
<td>Plastics non-packaging (except garbage bag film)</td>
<td>3,86</td>
<td>1,49</td>
</tr>
<tr>
<td>Glass</td>
<td>3,14</td>
<td>1,21</td>
</tr>
</tbody>
</table>

(*) All materials that do not apply to household packaging of metal, plastic, wood or cardboard for drinks.

RAEE: 2.11 kg, unclassifiable material that has been totally separated from the packaging fraction: 2.71 kg

Breakdowns in kg: (1) Other: Liquid contained in the packaging: 2.13 kg, Multimaterial: 1.86 kg, Remains of medicines: 0.01 kg.

Observations:

- RAEE: 2.11 kg, unclassifiable material that has been totally separated from the packaging fraction: 2.71 kg
- Breakdowns in kg: (1) Other: Liquid contained in the packaging: 2.13 kg, Multimaterial: 1.86 kg, Remains of medicines: 0.01 kg.
- Observations:
It must be verified that the materials are correctly selected, recording the result for each sampling in a characterisation sheet. The results obtained in the characterisation sheet are shown classified into requested and non-requested materials (Table 1). The requested materials are domestic light packaging, and all other materials are those not requested.

**Quality control for selected material**

The objective is to analyse the quality of the various fractions of materials recovered in the sorting plants, controlling the error in the estimation of non-targeted material percentage with an error margin of 10%.

Quality control can be performed on the bulk material or the material pressed in bales.

The reasons for performing quality control on the materials recovered in the plants are the following:

1. Controls derived from annual scheduling (follow-up control).
   For materials pressed into bales these controls will be limited to opening the number of bales indicated in the corresponding column of the Acceptable Quality Level in Table 2.
2. Control due to non-conformity.
3. Control due to first designation as recoverer/recycler.

Bale quality control is performed using an AQL sampling system. This follows the sampling table method from MIL-STD-105D “Quality Control Manual” by J. M. Juran and Frank M. Gryna. This control methodology is based on the following basic steps:

- Obtaining the sample size according to the number of bales in the batch or in stock for each material,
- Obtaining the number of accepted or rejected bales for the acceptable quality level selected as per Table 2,
- Accepting or rejecting the batch or initial stock according to the number of rejected bales, referenced with the corresponding TSRM if the number of rejected bales specified for the sample is reached; the batch or stock is considered to be non-conforming and identified accordingly.

### Selection of sample size in the quality controls, Table 2

<table>
<thead>
<tr>
<th>Batch size</th>
<th>Sample size</th>
<th>Acceptable quality level (1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 to 8</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>9 to 15</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>16 to 25</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>26 to 50</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>51 to 90</td>
<td>13</td>
<td>4</td>
</tr>
<tr>
<td>91 to 150</td>
<td>20</td>
<td>6</td>
</tr>
</tbody>
</table>

(1) Number of bales not conforming to TSRM for rejecting the batch or stock.

For sample sizes larger than those shown in the table above, the inspection level and acceptable quality must be studied.

### Technical Specifications for Recovered Materials (TSRM) for Pet Plastic Packaging Waste in Light Weight Packaging Sorting Plants, Table 3

<table>
<thead>
<tr>
<th>Requested material</th>
<th>PET packaging (all colours admitted) obtained from selective collection &lt;95%, 50% (including labels and caps that form part of the packaging after compaction).</th>
</tr>
</thead>
</table>
| Non-targeted materials | Non-targeted materials <4.50% with maximum limits for the various fractions as follows:  
  • PVC (complete bottles and fragments) <0.25%
  • Metals <0.25%
  • Sum of other plastic materials and other impurities <4.00% |
| Delivery conditions | The packaging must have been punctured  
  In bales of length: 1.00 ≤ L ≤ 1.50 m and density ≥190.00 kg/m³  
  Bale strapping: steel |

The bale integrity must be preserved throughout the loading, transport, unloading and storage processes.

Delivery: full truck (minimum 10.00 tonnes)

Percentages weight values:
The percentages for both the total limit of non-targeted materials and partial limits for each fraction are given with respect to wet material.
The sum of other plastic materials and impurities does not include PVC or Metals.
### TECHNICAL SPECIFICATIONS FOR RECOVERED MATERIALS (TSRM) FOR NATURAL HDPE PLASTIC PACKAGING WASTE IN LIGHT WEIGHT PACKAGING SORTING PLANTS, Table 3

<table>
<thead>
<tr>
<th>Requested material</th>
<th>Bottles and jugs of NATURAL HDPE obtained from selective collection ≥90.00% (including labels and caps that form part of the package after compaction). This percentage includes moisture.</th>
</tr>
</thead>
</table>
| Non-targeted materials | Non-targeted materials <10.00% with maximum limits for the various fractions as follows:  
  • rubber, silicone, polystyrene and polyurethane foam <0.05%  
  • packages of other polyolefins and other plastic materials (except rubbers, silicones, polystyrene foams and polyurethane) <7.00%  
  • metals <0.50%  
  • paper/cardboard, beverage cartons and other impurities <2.00% |
| Delivery conditions | In bales of length: 1.00≤ L ≤1.50 m with density ≥210.00 kg/m³  
  Bale strapping: steel  
  The bale integrity must be preserved throughout the loading, transport, unloading and storage processes.  
  Delivery: full truck (minimum 10.00 tonnes) |

Percentage by weight values.  
*Rubber, silicone, polystyrene foams and polyurethane foam* relates to packaging made from rubber, silicones, polystyrene foams and polyurethane or packaging which has previously contained any of these substances.  
The percentages for both the total limit of non-targeted materials and partial limits for each fraction are given with respect to wet material.  
The sum of other plastic materials and impurities does not include PVC or metals.

---

### TECHNICAL SPECIFICATIONS FOR RECOVERED MATERIALS (TSRM) FOR HDPE PLASTIC PACKAGING WASTE IN LIGHT WEIGHT PACKAGING SORTING PLANTS, Table 3

<table>
<thead>
<tr>
<th>Requested material</th>
<th>HDPE bottles and jugs obtained from selective collection ≥90.00% (including labels and caps that form part of the package after compaction). This percentage includes moisture.</th>
</tr>
</thead>
</table>
| Non-targeted materials | Non-targeted materials <10.00% with maximum limits for the various fractions as follows:  
  • rubber, silicone, polystyrene and polyurethane foam <0.05%  
  • packages of other polyolefins and other plastic materials (except rubbers, silicones, polystyrene foams and polyurethane) <7.00%  
  • metals <0.50%  
  • paper/cardboard, beverage cartons and other impurities <2.00% |
| Delivery conditions | In bales of length: 1.00≤ L ≤1.50 m with density ≥210.00 kg/m³  
  Bale strapping: steel  
  The bale integrity must be preserved throughout the loading, transport, unloading and storage processes.  
  Delivery: full truck (minimum 10.00 tonnes) |

Percentage by weight values.  
*Rubber, silicone, polystyrene foams and polyurethane foam* relates to packaging made from rubber, silicones, polystyrene foams and polyurethane or packaging which has previously contained any of these substances.  
The percentages for both the total limit of non-targeted materials and partial limits for each fraction are given with respect to wet material.  
The sum of other plastic materials and impurities does not include PVC or metals.
### TECHNICAL SPECIFICATIONS FOR RECOVERED MATERIALS (TSRM) FOR FILM PLASTIC PACKAGING WASTE IN LIGHT WEIGHT PACKAGING SORTING PLANTS. Table 3

<table>
<thead>
<tr>
<th>Requested material</th>
<th>Flexible film packaging (bags and packaging film, including stretchable film and shrinkable film) from selective collection ≥82.00% (including labels that are part of the packaging after compaction).</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Non-targeted materials</strong></td>
<td>Improper materials ≥18.00% with maximum limits for the various fractions as follows:</td>
</tr>
<tr>
<td></td>
<td>• PET &lt;1.00%</td>
</tr>
<tr>
<td></td>
<td>• Silicone rubbers, polystyrene foams and polyurethane &lt;0.05%</td>
</tr>
<tr>
<td></td>
<td>• Metals &lt;1.50%</td>
</tr>
<tr>
<td></td>
<td>• Paper/cardboard, beverage cartons &lt;2.50%</td>
</tr>
<tr>
<td></td>
<td>• Other impurities &lt;9.00%</td>
</tr>
<tr>
<td></td>
<td>• Moisture &lt;5.00%</td>
</tr>
</tbody>
</table>
| **Delivery conditions**                                                             | In bales of length: 1.00 ≤ L ≤ 1.50 m with density ≥ 250.00 kg/m³ /
|                                                                                     | Bale strapping: steel                                                                                                                               |
|                                                                                     | The bale integrity must be preserved throughout the loading, transport, unloading and storage processes.                                           |
|                                                                                     | Delivery: full truck (minimum 15.00 tonnes)                                                                                                         |

**Percentage by weight values.**

1. Rubber, silicones, polyethylene foams and polyurethane relates to packaging made from rubber, silicones, polyethylene foams and polyurethane which has been used or contained in different packaging materials.
2. The percentage for both the total limit of non-targeted materials and the partial limits for each fraction refer to wet material, except for the moisture fraction limit which relates to dry material.
3. Other impurities are not included in the package and the total impurities of the package and the impurities of the package that are not part of it.

---

### TECHNICAL SPECIFICATIONS FOR RECOVERED MATERIALS (TSRM) FOR MIXED PLASTIC PACKAGING WASTE IN LIGHT WEIGHT PACKAGING SORTING PLANTS. Table 3

<table>
<thead>
<tr>
<th>Requested material</th>
<th>Plastic containers obtained from selective collection, not claimed in other fractions ≥80.00% (including attached labels and caps that are still part of the package after compaction).</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Non-targeted materials</strong></td>
<td>Non-targeted materials &lt;20.00% with maximum limits for the various fractions as follows:</td>
</tr>
<tr>
<td></td>
<td>• Plastic containers that must be included in the corresponding fractions (PET, HDPE and Film) &lt;10.00%</td>
</tr>
<tr>
<td></td>
<td>• Other non-packaging plastic material &lt;10.00%</td>
</tr>
<tr>
<td></td>
<td>• Metals, paper/cardboard, beverage cartons and other impurities &lt;4.00%</td>
</tr>
</tbody>
</table>
| **Delivery conditions**                                                             | In bales of length: 1.00 ≤ L ≤ 1.50 m with density ≥ 210.00 kg/m³ /
|                                                                                     | Bale strapping: steel                                                                                                                               |
|                                                                                     | The bale integrity must be preserved throughout the loading, transport, unloading and storage processes.                                           |
|                                                                                     | Delivery: full truck (minimum 10.00 tonnes)                                                                                                          |

**Percentage by weight values.**

1. Other non-packaging plastic material includes injected HDPE boxes.
2. Other impurities do not include plastic packages that must be included in the corresponding fractions (PET, HDPE and Film) or other non-packaging plastic material.
Table 3

**Requested material**
- Cartons for drink/liquid food from selective collection ≥95.00% (including labels and caps that form part of the packaging after compacting).
  - This percentage includes moisture.

**Non-targeted materials**
- Non-targeted materials <5.00% with maximum limits for the various fractions as follows:
  - other packaging <3.00%
  - other non-targeted materials <2.00%

**Moisture**
- Moisture <10.00%

**Delivery conditions**
- In bales of length: 1.00 ≤ L ≤ 1.50 m with density ≥400.00 kg/m³
- Bale strapping: steel
- The bale integrity must be preserved throughout the loading, transport, unloading and storage processes.
- Delivery: full truck (minimum 20.00 tonnes)

---

**TECHNICAL SPECIFICATIONS FOR RECOVERED MATERIALS (TSRM) FOR BEVERAGE CARTON PACKAGING WASTE IN LIGHT WEIGHT PACKAGING SORTING PLANTS.**

**Characteristics of the material**
- Material in bales with different paper and cardboard grades. Minimum GRADE 5.01 as per Standard UNE-EN 643 “European List of Standard Grades of Paper and Board for Recycling”.

**Origin**
- Multi-material collection of light weight packaging

**Dimensions of the bales and delivery conditions**
- Presentation in bales with dimensions depending on the press in each plant.
- Delivery: full truck

**Identification of bales**
- Bales shall be identified with at least the following information: material, baling date, plant of origin and approximate weight.

**Maximum moisture**
- 10.00 %

**Non-targeted materials**
- strapping, sand, metals, plastics, and, in general, any material that is not paper-cardboard
- Maximum 3.00% of total weight (this percentage does not consider unusable substances that are part of the packaging).

---

**TECHNICAL SPECIFICATIONS FOR RECOVERED MATERIALS (TSRM) FOR OUTPUT OF PAPER AND CARDBOARD PACKAGES FROM SORTING PLANTS OBTAINED FROM MULTIMATERIAL COLLECTION.**

**Characteristics of the material**
- Material in bales with different paper and cardboard grades.

**Origin**
- Multi-material collection of light weight packaging

**Dimensions of the bales and delivery conditions**
- Presentation in bales with dimensions depending on the press in each plant.
- Delivery: full truck

**Identification of bales**
- Bales shall be identified with at least the following information: material, baling date, plant of origin and approximate weight.

**Maximum moisture**
- 10.00 %

**Non-targeted materials**
- strapping, sand, metals, plastics, and, in general, any material that is not paper-cardboard
- Maximum 3.00% of total weight (this percentage does not consider unusable substances that are part of the packaging).
### TECHNICAL SPECIFICATIONS FOR RECOVERED MATERIALS (TSRM) FOR ALUMINIUM METAL PACKAGING WASTE IN LIGHT WEIGHT PACKAGING SORTING PLANTS. Table 3

<table>
<thead>
<tr>
<th>Requested material</th>
<th>Aluminium packaging from selective collection ≥90.00% (including moisture and anything forming part of the packaging itself).</th>
<th>Single material laminar aluminium packaging content ≤ 5.00%.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-targeted materials</td>
<td>Total non-targeted materials ≤10.00% with a maximum limit for the following fractions:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Free ferrous metals ≤ 0.00%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Non-ferrous metals ≤ 3.00%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Plastics, paper/cardboard, beverage cartons and complex laminates ≤ 4.00% (under no circumstances can these fractions exceed 2% separately)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Fine materials and others ≤ 3.00% percentages with respect to wet material</td>
<td></td>
</tr>
<tr>
<td>Delivery conditions</td>
<td>Compacted into packages or bales. Preferable packages/bales of 50.00 kg to 500.00 kg. The packages/bales must be able to withstand industrial handling.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Apparent density ≥ 500.00 kg/m³.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Minimum delivery: full truck.</td>
<td></td>
</tr>
</tbody>
</table>

### TECHNICAL SPECIFICATIONS FOR RECOVERED MATERIALS (TSRM) FOR STEEL METAL PACKAGING WASTE IN LIGHT WEIGHT PACKAGING SORTING PLANTS. Table 3

<table>
<thead>
<tr>
<th>Requested material</th>
<th>Magnetic ferrous content ≥ 90.00% (includes moisture and anything that is part of the packaging).</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-targeted materials</td>
<td>Non-targeted materials ≤ 5.00%</td>
<td></td>
</tr>
<tr>
<td>Delivery conditions</td>
<td>Compacted into packages or bales. Preferable packages/bales of 50.00 kg to 500.00 kg. The packages/bales must be able to withstand industrial handling.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Apparent density ≥ 800.00 kg/m³.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Minimum delivery: full truck.</td>
<td></td>
</tr>
</tbody>
</table>

**Percentage by weight values.**

*The percentages for both the total limit of non-targeted materials and partial limits for each fraction are given with respect to wet material.*

*Other impurities do not include free ferrous metals, non-ferrous metals, plastics, paper and cardboard, food/drink cartons and complex laminates.*
Quality control operations

Summary of quality control operations for bales:

1. Check the number of bales of each material being held by counting the number of bales in stock.
2. Determine the sample size (number of bales to control as per Table 2).
3. Select the first bale at random.
4. Measure the dimensions of the bale (in order to obtain the density).
5. Open the bales and perform control: materials must be selected manually. The total weight of the bale is obtained by adding up the weights of the selected materials. To weigh the materials, a suitably calibrated and/or verified precision scale is provided.
6. Check that the materials have been correctly selected.
7. Record the results on a sheet prepared for this purpose (Quality Control Sheet).
8. Controls resulting from annual programming: obtain average amount for total percentage of non-targeted materials found in each bale analysed. This average value will be compared to the limit of total non-targeted materials specified in the corresponding TSRM. If this value is exceeded the material will not comply with the specifications.

First designation controls as recoverer/recycler: the process described above (steps 1 to 7) is repeated until reaching the number of reject bales suggested by the MIL-STD-105D method for each material or the batch or stock is accepted.

Controls resulting from non-conformities: in this case, follow the indications for first designation controls as recoverer/recycler, but when assessing compliance with the TSRM only consider the non-conforming parameters.

Controls resulting from annual programming: after analysing the material, compare the total percentage of non-targeted materials obtained in the analysis with the total non-targeted materials limit set in the corresponding TSRM. If this value is exceeded the material will not comply with the specifications.

Production control

Apart from the production control performed by ECOEMBES at each of the light weight packaging sorting plants, each plant must perform a production control using the monthly data on input, output and stock. The balances obtained from these data and the input compositions obtained from the characterisation processes allow very useful parameters to be obtained for determining whether the plant is operating correctly. The performance index is calculated as follows:

\[
\text{Performance} = \frac{\text{Light weight packaging sorting (kg)}}{\text{Total input (kg)}}
\]
Effectiveness (%) = \( \frac{\text{Light weight packaging sorting (kg)}}{\text{Light weight packaging input (kg)}} \)

The effectiveness is calculated globally and for each material.

The performance parameter does not eliminate the effect of the input material quality (total input includes non-requested or non-targeted materials collected in containers and arriving at the plant), while the effectiveness parameter does (as it considers only the requested or targeted material). This means that a plant with a low level of performance can have a high level of effectiveness in its process.

In manual plants, 80% is considered an adequate global effectiveness value, while for automatic plants values of 85% or higher should be reached.

Performance control for sorting operators

An extensive database is currently available due to the continuous performance of performance improvement studies at sorting plants, which includes studies performed from 2003 to the present day. Specifically, in the studies performed at sorting plants the measurements made on activity by material and production by material have been analysed. These measurements are described below along with their importance in the analysis of the production at the sorting plants. The values obtained in these studies act as a reference point for controlling and analysing the performance of the sorting operators.

- **Average activity by operator (movements/operator and hour)**
  
  Measurements have been made of the movements performed in two minutes by each sorting operator at the positive sorting stations. Extrapolating this to the movements performed by an operator in one hour allows calculation of the mean value of the activity by operator. In these calculations, primary and secondary sorting stations have been differentiated (Table 4). Due to the variety of qualities of the selected materials, no reference value is supplied for the quality control stations.
  
  **Activity values (movements/operator and hour) for sorting operators. Table 4**

  | Reference value | Primary sorting | 1,400 |
  | Secondary sorting | 2,000 |

- **Activity level for the selected material (movements/operator and hour)**
  
  The mean of the maximum value of fraction-related movements performed in one hour by a sorting operator has been calculated. The values found using an atypical value determination analysis have been eliminated. As it is well known that a single operator segregates several materials simultaneously, the partial activity for each material does not indicate a reference value for the sorting of a single fraction, while the maximum number of movements for a given material can do so. After analysing the results for this parameter, it has been found that all selected fractions can be assigned the same reference activity level (2,000 movements/operator and hour).
  
  **Mean performance per operator (kg/operator and hour)**

  The mean of the values obtained has been calculated by dividing them into the total kg selected manually and the operators engaged in segregating them, and by the effective sorting hour (Table 5). Due to the variety in the quality of the input material, no reference value is provided for the bulky materials sorting stations.
  
  **Performance by secondary sorting operator. Table 6**

<table>
<thead>
<tr>
<th>PET</th>
<th>HDPE</th>
<th>NATURAL</th>
<th>COLOUR</th>
<th>HDPE FILM</th>
<th>MP</th>
<th>CB</th>
<th>CO</th>
<th>PC</th>
</tr>
</thead>
<tbody>
<tr>
<td>kg/operator and hour</td>
<td>90</td>
<td>122</td>
<td>192</td>
<td>126</td>
<td>58</td>
<td>54</td>
<td>78</td>
<td>306</td>
</tr>
</tbody>
</table>

- **Mean performance per operator (kg/operator and hour)**

  The values found using an atypical value determination analysis have been eliminated. The remaining values have been used to calculate the mean value for each manually selected material. In automated sorting plants where manual sorting of materials of the light flat fraction is performed, the parameter measured in manual sorting plants are applied (Table 6). It should be noted that steel and aluminium materials are not subjected to manual sorting, as the machinery that segregates these materials is installed in both manual and automated plants.

Sorting line availability

This is the percentage of effective operation hours of the line with respect to the plant working hours:

\[
\text{Line availability} (%) = \frac{h_{\text{actual line operation}}}{h_{\text{shift}} - h_{\text{stops}}} \times 100
\]

A line availability under 85% for a plant is considered to be a very low value. To calculate a reference value, the data on plants which on the day of the study obtained a value under 85% have been eliminated. After analysing the results of the data obtained, it is determined that for both manual and automated plants the line availability must be greater than 95% of the time employed, since values lower than this lead to a reduction in the annual capacity of the facility.
The parameter that identifies a light weight packaging sorting plant is the treatment capacity, expressed as t/h of input material. It is considered that automated plants can be classified into standard capacities of 3, 4, 5, 6, 7 and 8 t/h. This classification includes the various types of automated plants currently in operation, while for manual plants a single type is considered with 2 t/h treatment capacity.

To specify in greater detail the main equipment needed in each of these stages, the standard processes corresponding to the various capacities are described below, comparing each group of operations according to the various standards. The last point shows a full block diagram of each of the standards.

Reception and storage of packaging waste input in the plant

At the main access to the plant the vehicles that bring in waste and those leaving the plant with by-products are subjected to weighing and control in scales in the reception area. After the transport vehicles are weighed they enter the reception area. The standard storage system for packaging waste is the unload yard. The unload yard must have a minimum capacity equivalent to that needed to store the amount of material collected in two days.

Considering that the input material stored in the unload yard must not exceed 3m in height and 15% of the surface must remain free to allow the loading shovel to manoeuvre, the surfaces calculated for each standard are shown in Table 7:

<table>
<thead>
<tr>
<th>Design regime (t/h)</th>
<th>Yard surface (m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>262</td>
</tr>
<tr>
<td>3</td>
<td>410</td>
</tr>
<tr>
<td>4</td>
<td>536</td>
</tr>
<tr>
<td>5</td>
<td>660</td>
</tr>
<tr>
<td>6</td>
<td>784</td>
</tr>
<tr>
<td>7</td>
<td>907</td>
</tr>
<tr>
<td>8</td>
<td>1,030</td>
</tr>
</tbody>
</table>

Pre-treatment

The waste storage and conditioning stage must have the necessary means for achieving its goals, as indicated below:

- Waste feeder / doser
- Primary sorting cabin
- Bag opening system
- Trommel (except in 3 t/h sorting plants)
- Ballistic separator

The arrangement of these means depends on the capacity of the facility. For manual plants this stage does not include the ballistic separation equipment, as manual sorting is performed using trommel overflow and underflow collected in sorting belts.

The standard block diagrams according to the design capacity of the facilities are shown below:
Pre-treatment in 2 t/h plants (manual plant)

For manual plants, this stage does not include the ballistic separation equipment, as manual sorting is performed using trommel bottle underflow (<200 mm) and overflow (>150x200 mm) collected in sorting belts.

Pre-treatment in 3 t/h plants

Since the capacities of the ballistic separators are greater than those needed for this type of facility, all fine material (<40mm), mostly non-targeted, present in the plant input material is eliminated. For this reason, it is not necessary to use a trommel for this purpose.

Pre-treatment in 4, 5 and 6 t/h plants

It is necessary to install a trommel that divides the streams and separates fine material (<50 mm) from more bulky materials (>350x120 mm) that can affect the automated sorting of the requested material (50 < Ø < 120x350).

The equipment comprising this stage will be sized according to the supply regime of the facility (4, 5 and 6 t/h).
Pre-treatment in 7 and 8 t/h plants.

The trommel must be fitted with a third mesh to divide the stream into four fractions: fines (Ø < 50 mm), 120x250 mm underflow mainly consisting of bottles (Ø < 250 mm), 250x300 mm underflow mainly consisting of closed bags (Ø < 300 mm) and overflow (Ø > 300 mm). In this way the bag opened is placed in the closed bags underflow stream, thereby reducing the load received by this equipment. To avoid jams in the bag openers it is advisable to include a sorting cabin (jam prevention cabin) in which to perform sorting of materials that can be detrimental to the equipment. The equipment comprising this stage will be sized according to the supply regime of the facility (7 and 8 t/h).

Package sorting

In automated plants in this stage of the process the main stream is divided into three fractions: fine, rolling and light flat. The equipment needed to segregate the requested materials contained in each of these fractions is available.

Rolling fraction
- Film suction equipment.
- Magnetic separator.
- Optical separators.
- Eddy current separator.

Light flat fraction
- Film suction equipment.
- Manual sorting belt. Provided in the stations and bins needed for manual sorting of requested material present in this stream.

Fine fraction
- Magnetic separator.

In manual plants this stage is performed by operators in charge of manual sorting of plastic materials. Metals are selected at the end of the line using a magnetic separator (steel) and an eddy current separator (aluminium).

Package sorting in 2 t/h plants.

Only the requested metal material (steel and aluminium) is selected automatically. The remaining requested materials are selected manually in the two remaining streams of the trommel, in the secondary sorting cabin.

To reach 80% effectiveness (efficient value in manual plants) 12 sorting operators are required to sort an average of 79 kg/h*operator, assuming that the input material contains 75% requested material.
Package sorting in 3 t/h plants.
in this type of facility it is not necessary to use an optical separator to segregate each of the materials requested at this stage of the process (PET, HDPE, beverage cartons and mixed plastics). Two very wide optical separators are used divided such that each one forms two channels. This means four channels are formed for segregating the four materials, as shown in the diagram.

Package sorting in 4 t/h plants.
One optical separator must be provided for each of the materials constituting the majority of those present at the input of the process (PET and HDPE). The purpose is to ensure efficient sorting values, thereby preventing the need for a subsequent sorting of these materials manually in the secondary sorting cabin.
Packaging sorting in 5, 6, 7 and 8 t/h plants.

One optical separator is necessary for each of the materials selected by this type of equipment, as the capacities required for these supply regimes do not allow the installation of two input channels.

The equipment comprising this stage will be sized according to the supply regime of the facility (5, 6, 7 and 8 t/h).

Packaging sorting in 6, 7 and 8 t/h plants.

Adaptation of selected material and rejected waste management

For both automated and manual sorting plants, the materials must be adapted to the needs of the technical specifications for recovered materials (TSRM) such that part of the products can be placed in containers for bulk transport, or compacted in continuous baling presses provided at the facility for the various materials.

To improve the recycling processes for the selected materials and rejected waste management, the following processes and machinery are required:

- Quality controls for the selected materials.
- Storage silos prior to material compaction.
- Multimaterial press.
- Metal press.
- Film press.
- Containers.
- Rejected waste material management system.
- Storage of selected materials.
Adaptation of selected material and rejected waste management at 2 t/h plants.

- Quality controls for selected materials. In manual sorting plants it is not necessary to perform quality controls on materials that are manually sorted.
- Storage silos prior to material compaction. Selected material silos do not need to be automated, as the transport of the material to the press feeder can be performed by hand truck or loading shovel. There must be as many silos as there are selected materials to be compacted in the multimaterial press (PET, HDPE, FILM, beverage cartons and mixed plastics).
- Multimaterial press. Used to compact material stored in the automated silos. Depending on the amount of material stored, a forklift or loading shovel will dump its contents on a feeder/doser placed transversely to transport the selected material to the press.
- Metal press. As most of the metal present is steel, this is pressed in a continuous arrangement. Aluminium is stored in containers or in a buffer conveyor for separate compaction at the end of the shift.

- Film press. In plants with capacity under 3 t/h there is no specific press for this material, the multimaterial press is used.
- Containers. Containers from 1 to 5 m³ are needed to store aluminium and empty it into the metal press bin. In addition, open containers from 25 to 30 m³ are needed to store bulky material and bales of compacted metal.
- Rejected waste material management system. For capacities under 2 t/h it is considered ideal to install an autocompactor to manage and transport the rejected waste.
- Storage of selected materials. For manual plants it is considered that selected and compacted material must be stored in a minimum surface area calculated for two and a half deliveries of each material, approximately 180 m².

[Diagram of sorting plant process]

Standard for a 2 t/h manual sorting plant
Adaptation of selected material and rejected waste management in 3 and 4 t/h plants

• Quality controls for selected materials. At least two shared quality control stations are necessary for PET/beverage cartons and HDPE/mixed plastics, as well as one for film material. This task may or may not be necessary depending on the quality obtained for the metallic materials.

• Storage silos prior to material compaction. At least 5 automated silos must be installed for PET, HDPE, FILM, beverage cartons and mixed plastics. This number can be greater if Natural HDPE is selected.

• Multimaterial press. Used to compact material stored in the automated silos. Depending on the amount of material stored, the silos dump their contents onto a feeder/doser placed transversely to it in order to transport the selected material to the press.

• Metal press. As most of the metal present is steel, this is pressed in a continuous arrangement. Aluminium is stored in containers or in a buffer conveyor for separate compaction at the end of the shift.

• Film press. In plants with capacity under 7 t/h there is no specific press for this material: the multimaterial press is used.

• Containers. Containers from 3 to 5 m³ are considered necessary, depending on plant capacity, to store aluminium (if it is not collected in a buffer conveyor) and empty it in a metal press bin. In addition, open containers from 25 to 30 m³ are needed to store bulky material and bales of aluminium and steel.

• Rejected waste material management system. For capacities under 5 t/h it is considered optimum to install two autocompactors to manage and transport the rejected waste.

• Storage of selected materials. For manual plants it is considered that selected and compacted material must be stored in a building with a minimum surface area calculated for two and a half deliveries of each material, approximately 180 m².
Adaptation of selected material and rejected waste management in 5 and 6 t/h plants

- Quality controls for selected materials. At least one shared quality control station is considered necessary for PET/beverage cartons, as well as one station for each of the HDPE, mixed plastics and film materials.

- Storage silos prior to material compaction. At least 5 automated silos must be installed for PET, HDPE, FILM, beverage cartons and mixed plastics. This number can be greater if Natural HDPE is selected.

- Multimaterial press. Used to compact material stored in the automated silos. Depending on the amount of material stored, the silos dump their contents onto a feeder/doser placed transversely to it in order to transport the selected material to the press.

- Metal press. As most of the metal present is steel, this is pressed in a continuous arrangement. Aluminium is stored in containers or in a buffer conveyor for separate compaction at the end of the shift. However, it may be convenient for greater capacities to install a second press for aluminium.

- Film press. In plants with capacity under 7 t/h there is no specific press for this material; the multimaterial press is used.

- Containers. Containers from 3 to 5 m³ are considered necessary, depending on plant capacity, to store aluminium (if it is not collected in a buffer conveyor) and empty it in a metal press bin. In addition, open containers from 25 to 30 m³ are needed to store bulky material and bales of aluminium and steel.

- Rejected waste material management system. Ideally a compacting system with container transport should be installed to manage and transport rejected waste.

- Storage of selected materials. It is considered that selected and compacted material should be stored in a building with a minimum surface calculated to store 3 deliveries (5 t/h plants) and 4 deliveries (6 t/h plants) for each material. It is considered that this surface must be 225 m² (5 t/h plants) and 300 m² (6 t/h plants).
Adaptation of selected material and rejected waste management in 7 and 8 t/h plants

- Quality controls for selected materials. At least one control station is necessary for each of the automatically selected materials.
- Storage silos prior to material compaction. At least 4 automated silos must be installed for PET, HDPE, beverage cartons and mixed plastics. This number can be greater if Natural HDPE is selected.
- Multimaterial press. Used to compact material stored in the automated silos. Depending on the amount of material stored, the silos dump their contents onto a feeder/doser placed transversely to it in order to transport the selected material to the press.
- Metal press. Two presses must be installed, one for each metal fraction.
- Film press. In plants with this capacity a specific press is required for this material. The selected film is pressed continuously after the quality control, so that no storage silos is necessary for this material.
- Containers. Containers from 3 to 5 m³ are considered necessary, depending on plant capacity, to store aluminium (if it is not collected in a buffer conveyor) and empty it in a metal press bin. In addition, open containers from 25 to 30 m³ are needed to store bulky material and bales of aluminium and steel.
- Rejected waste material management system. Ideally a compacting system with container transport should be installed to manage and transport rejected waste.
- Storage of selected materials. It is considered that selected and compacted material should be stored in a building with a minimum surface calculated to store 5 deliveries (7 t/h plants) and 6 deliveries (8 t/h plants).
Basic sizing criteria for sorting plants

The capacity of the sorting plants must be properly sized to maximise recovery and technical and economic efficiency. Oversized facilities can lead to financial loss due to the amortisation of unnecessary investment. Similarly, undersized facilities can lead to high operational costs as more work shifts will be needed to reach the treatment goals.

The following must be considered when calculating the capacity of the facilities:

- Nominal capacity (t/h): tonnes per treatment hour processed in one line in normal operation conditions.
- Design capacity (t/h): maximum tonnes per treatment hour processed in one line maintaining the guaranteed quality and recovery amounts.

Sizing of light weight packaging sorting lines

Expected input

In order to size a sorting plant, the expected input throughout its service life must be considered. As a rule, a light weight packaging sorting plant is considered to have a service life of 25,000 hours. For sizing purposes it is considered that these 25,000 h will be reached in 10 years of operation.

Work plan

Light weight packaging sorting plants in general have a maximum of 2 shifts/day at the end of their lifetime. However, either due to insufficient capacity or seasonal increases in waste generation, some facilities may process 3 shifts/day. It is recommended not to exceed 3 shifts/day due to the advantages of not having to run this third daily shift:

- Flexibility of the facility in case of seasonal increases in plant input material and possible stoppages due to breakdowns, as the time dedicated to the third shift will be used to deal with said problems.
- Lower operational costs by avoiding paying night shift bonuses to workers as per collective bargaining agreements. In addition, personnel cost increases due to working on holidays are also avoided, since the third shift requires performing maintenance work on weekends.

In addition, personnel cost increases due to working on holidays are also avoided, since the third shift requires performing maintenance work on weekends.

Standard work shifts are considered to comprise 1,800 h/year, although due to breaks, cleaning time and line availability, the useful working hours per shift are 1,729:

- Operation days/year: 247
- Hours/shift: 8
- Break time/shift: 0.5
- Cleaning time/shift: 0.13
- Line availability: 95%
- Useful hours/shift/year: 1,729
- Useful hours/2 shifts/year: 3,458

Standard for annual useful working hours at light weight packaging sorting plants, Table 8

Sizing

In order to optimise operational costs it is necessary to have two work shifts at the end of the facility's service life. Therefore, the nominal capacity of a sorting plant must be such that allows processing of all inputs at the end of the facility's service life in two daily work shifts. In this way, the nominal capacity of the facility can be calculated as:

Nominal capacity = inputs at the end of the useful lifetime (t/year) / 2 shifts * 1,729 h/year

Seasonal input increases must also be considered. For example, it is common in coastal areas for inputs to increase in the summer months. Therefore, the design capacity of a sorting plant must be such that it allows processing of the seasonal input increases at the end of the facility's service life in two daily work shifts. In addition, to ensure that all waste is treated the design capacity must be oversized by 10%. The design capacity of the facility can be calculated as:

Design capacity = 1.1 * (mean monthly input and end of lifetime (t/month) * Input increase in one month (%) / (2 shifts * 144 h/month)).
Example 1: Sizing of a light weight packaging sorting plant

<table>
<thead>
<tr>
<th>Year</th>
<th>t/year</th>
<th>Annual growth estimate %</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>8,400</td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td>8,667</td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td>9,274</td>
<td></td>
</tr>
<tr>
<td>2016</td>
<td>9,923</td>
<td></td>
</tr>
<tr>
<td>2017</td>
<td>10,617</td>
<td></td>
</tr>
<tr>
<td>2018</td>
<td>11,361</td>
<td></td>
</tr>
<tr>
<td>2019</td>
<td>12,156</td>
<td></td>
</tr>
<tr>
<td>2020</td>
<td>13,007</td>
<td></td>
</tr>
<tr>
<td>2021</td>
<td>13,917</td>
<td></td>
</tr>
<tr>
<td>2022</td>
<td>14,892</td>
<td></td>
</tr>
</tbody>
</table>

Standard work plan 1,729 useful hours shift/year

Expected input Table 9

<table>
<thead>
<tr>
<th>Month</th>
<th>Increase compared to average month %</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>-4%</td>
</tr>
<tr>
<td>February</td>
<td>-3%</td>
</tr>
<tr>
<td>March</td>
<td>-2%</td>
</tr>
<tr>
<td>April</td>
<td>-1%</td>
</tr>
<tr>
<td>May</td>
<td>1%</td>
</tr>
<tr>
<td>June</td>
<td>2%</td>
</tr>
<tr>
<td>July</td>
<td>3%</td>
</tr>
<tr>
<td>August</td>
<td>5%</td>
</tr>
<tr>
<td>September</td>
<td>3%</td>
</tr>
<tr>
<td>October</td>
<td>0%</td>
</tr>
<tr>
<td>November</td>
<td>-1%</td>
</tr>
<tr>
<td>December</td>
<td>-3%</td>
</tr>
<tr>
<td>Average</td>
<td>0%</td>
</tr>
</tbody>
</table>

Annual seasonality of inputs. Table 10

Nominal capacity

Nominal capacity \( (t/h) = \text{inputs at the end of the service life (t/year)}/(2 \text{ shifts} \times 1,729 \text{ h/year}) \)

\( 14,892 \text{ t/year}/(2 \text{ shifts} \times 1,729 \text{ h/year}) = 4.31 \text{ t/h} \).

The sorting plant must have a nominal capacity of 4.5 t/h.

Design capacity

Inputs year 10 = 14,892 t/year.

Average monthly input = 14,892 t/year / 12 months = 1,241 t/month.

Most unfavourable month input (August) = 1,241 t/month \times 1.05 = 1,303 t/month.

Useful hours/month = 1,729 h / 12 months = 144 h/month.

Design capacity = 1.1 \times (mean monthly input at end of lifetime (t/month)/2 shifts \times 144 h/month)).

\( 1.1 \times (1,303 \text{ t/month}/(2 \text{ shifts} \times 144 \text{ h/month})) = 4.97 \text{ t/h} = 5 \text{ t/h} \).

A design capacity of 5 t/h for the facility allows us to ensure treatment of the input throughout the lifetime.
### Sizing shared solid urban waste and light weight packaging treatment lines

In order to plan/design efficient plants in geographical areas where the supply is less than 3,000 t/year, the alternative to manual facilities is automation of the sorting process for shared use of remainder fraction treatment and material obtained from selective collection. This provides the lines with sufficient nominal capacity to process the fraction from selective collection in the fewest possible processing hours, dedicating the remaining annual hours to treating the remained fraction. The increased nominal capacity means improved efficiency, which is increased even more by the increased performance compared to that obtained in manual sorting plants. In addition, a greater design capacity is an advantage for adapting the process work plan to seasonal changes in input.

It should be noted that sharing the processing line also allows sharing of the fixed costs by the two processes. In light weight packaging sorting lines these costs represent 40-50% of the unit sorting cost. In this way the cost of amortisation and financing, insurance and management and administration personnel can be allocated according to the dedication of the line to each process.

For shared line plants the nominal capacity is designed according to the solid urban waste fraction input. The nominal capacity must be such that it allows processing in a single work shift all solid urban waste input at the end of the facility’s service life.

The design capacity must allow processing in a single work shift the seasonal input peaks in the last year of the facility’s service life. In addition, to ensure that all waste is treated at all times the design capacity must be oversized by 10%. The design capacity of the facility can be calculated as:

\[
\text{Design capacity} = 1.1 \times (\text{mean monthly input} \times \text{end of lifetime (t/month)} + \text{Input increase in one month (%)} / (1 \text{ shifts} \times 144 \text{ h/month})).
\]

The equipment needed to reach this capacity will depend on the nominal line capacity when processing the light weight packaging fraction, and must fulfill the condition that the light weight packaging fraction is processed in a single work shift in the last year of the facility’s service life. This allows the use of the third shift for maintenance operations.

### Light Weight Packaging Sorting Plants

![MANUAL AND AUTOMATIC COST CURVE](image_url)

**Unit cost**

<table>
<thead>
<tr>
<th>Kg outgoing Lightweight Packaging</th>
<th>0</th>
<th>2,000,000</th>
<th>4,000,000</th>
<th>6,000,000</th>
<th>8,000,000</th>
<th>10,000,000</th>
<th>12,000,000</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MANUAL SORTING PLANTS Cost Curve</strong></td>
<td>Manual Sorting Plants Cost Curve</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>AUTOMATIC SORTING PLANTS Cost Curve</strong></td>
<td>Automatic Sorting Plants Cost Curve</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

> 3,000 t treated

Automation of light weight packaging sorting manual lines

The decision to automate a light weight packaging sorting facility is conditioned by the annual amounts to be processed. From the point of view of unit sorting costs, automated sorting installations have better efficiency compared to manual facilities beyond 3,000 t/year input or 2,000 t/year of sorted materials. Automated processes have higher treatment capacity, resulting in fewer processing hours and sorting efficiencies above 85%, reducing unit sorting costs.
Example 2: Sizing of a shared line sorting plant

### Table 11

<table>
<thead>
<tr>
<th>Year</th>
<th>Expected input of light weight packaging</th>
<th>Expected input of solid urban waste</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>1,950 t/year</td>
<td>46,500 t/year</td>
</tr>
<tr>
<td>2014</td>
<td>2,087 t/year</td>
<td>46,965 t/year</td>
</tr>
<tr>
<td>2015</td>
<td>2,233 t/year</td>
<td>47,435 t/year</td>
</tr>
<tr>
<td>2016</td>
<td>2,556 t/year</td>
<td>48,388 t/year</td>
</tr>
<tr>
<td>2017</td>
<td>2,775 t/year</td>
<td>48,873 t/year</td>
</tr>
<tr>
<td>2018</td>
<td>2,926 t/year</td>
<td>49,361 t/year</td>
</tr>
<tr>
<td>2019</td>
<td>3,131 t/year</td>
<td>50,133 t/year</td>
</tr>
<tr>
<td>2020</td>
<td>3,585 t/year</td>
<td>50,856 t/year</td>
</tr>
</tbody>
</table>

### Table 12

<table>
<thead>
<tr>
<th>Month</th>
<th>Increase compared to average month (light weight packaging)</th>
<th>Month</th>
<th>Increase compared to average month (solid urban waste)</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>-1.27%</td>
<td>January</td>
<td>-3.7%</td>
</tr>
<tr>
<td>February</td>
<td>-1.98%</td>
<td>February</td>
<td>-6.6%</td>
</tr>
<tr>
<td>March</td>
<td>-2.10%</td>
<td>March</td>
<td>-3.8%</td>
</tr>
<tr>
<td>April</td>
<td>-2.90%</td>
<td>April</td>
<td>0.0%</td>
</tr>
<tr>
<td>May</td>
<td>3.48%</td>
<td>May</td>
<td>0.1%</td>
</tr>
<tr>
<td>June</td>
<td>-0.71%</td>
<td>June</td>
<td>5.20%</td>
</tr>
<tr>
<td>July</td>
<td>8.56%</td>
<td>July</td>
<td>5.64%</td>
</tr>
<tr>
<td>August</td>
<td>12.71%</td>
<td>August</td>
<td>7.53%</td>
</tr>
<tr>
<td>September</td>
<td>-4.00%</td>
<td>September</td>
<td>5.13%</td>
</tr>
<tr>
<td>October</td>
<td>5.68%</td>
<td>October</td>
<td>-0.76%</td>
</tr>
<tr>
<td>November</td>
<td>0.03%</td>
<td>November</td>
<td>2.45%</td>
</tr>
<tr>
<td>December</td>
<td>3.15%</td>
<td>December</td>
<td>-6.91%</td>
</tr>
<tr>
<td>Average</td>
<td>0.00%</td>
<td>Average</td>
<td>0.00%</td>
</tr>
</tbody>
</table>

Design capacity solid urban waste

Inputs per year = 50,856 t/year
Average monthly input = 50,856 t/year / 12 months = 4,238 t/month.
Most unfavourable month input (August) = 4,318 t/month * (100% + 7.51%) = 4,558 t/month.
Useful hours/month = 1,729 h / 12 months = 144 h/month.
Design capacity = 1.1 * [mean monthly input and end of service life (t/month) * Input increase in one month (%) / (1 shift * 144 h/month)].
3,585 t/year / (1 shift * 129 h) = 2.1 t/h.
A design capacity of 2.1 t/h for the facility allows us to ensure treatment of solid urban waste throughout its service life.

Nominal capacity light weight packaging

Nominal capacity (t/h) = inputs at the end of the service life (t/year) / (1 shift * 1,729 h/year)
3,585 t/year / (1 shifts * 1,729 h) = 2.1 t/h.
The sorting plant must have a nominal capacity of 2.1 t/h.

Design capacity light weight packaging

Inputs per year = 3,585 t/year
Average monthly input = 3,585 t/year / 12 months = 298.7 t/month.
Most unfavourable month input (August) = 398.7 t/month * (100% + 12.71%) = 436.7 t/month.
Useful hours/month = 1,729 h / 12 months = 144 h/month.
Design capacity = 1.1 * [mean monthly input and end of service life (t/month) * Input increase in one month (%) / (1 shift * 144 h/month)].
3,951 t/year / (1 shift * 129 h) = 2.6 t/h.
With a design capacity of 2.6 t/h the facility can ensure treatment of light weight packaging input throughout its service life.

The design capacity of the facility must be 35 t/h when processing the solid urban waste fraction and at least 3 t/h when processing the light weight packaging fraction.
Having described the various processes for package sorting according to their capacity, this chapter provides a technical description of the equipment and operations used in these processes.

The following aspects are analysed for each equipment and process:

- **FUNCTION**
- **DESCRIPTION**
- **TYPES**
- **CHARACTERISTICS**

### Glossary of equipment and processes

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**LIGHT WEIGHT PACKAGING SORTING PLANTS**
Reception and storage

FUNCTION
Area where the waste transported by collection vehicles to the sorting plants is unloaded and stored.

DESCRIPTION
These are large covered and closed spaces, with the exception of the access gates. They are connected with the treatment building where the sorting equipment is housed through the first equipment, the primary feeder.

TYPES
These areas are classified into two types:

- Reception pits provided with gantry crane and grapple hook.
- Reception yards for handling with loading shovel.

For package sorting plants with standard characteristics and capacity, the unload yard or area is considered. If the treatment capacity of the facility is high (6,7 and 8 t/h) or if it is combined with "remainder fraction" treatment plants, the reception and storage type is generally an unload pit for packaging adjoining the conventional pits of the remainder fraction treatment plant.

Depending on the primary feeder position, various alternatives to these two types can be obtained.

CHARACTERISTICS
- The design of the unload yard or storage pit is such that the average storage volume is two days of production, in order to solve potential stoppages in case of jams, breakdown, power outages etc.
- To avoid undesired collisions of the trucks and feeding shovel, the unload area must be free of any intermediate supporting columns. The shovel and truck manoeuvres and construction costs recommend an optimum minimum width of 25 to 30 metres without columns.
- The unload area must have access gates that can open for the collection vehicles.
• The surface area of the unload area and manoeuvre area of the unload pit must be made of reinforced concrete (with pozzolana cement to prevent physico-chemical degradation thereof) and must withstand transport and unloading and turning manoeuvres of the transport vehicles and loading shovel used to feed the waste.

• To prevent collisions between the roof and the container trucks in the unload position or with the rear doors of of conventional collection trucks open, the height of the unload yard ceiling and the doors have a minimum clearance of 7 metres.

• In unload yards the natural slope formed by the stored packaging waste shall be 45º, with a height up to 3 metres (empirically obtained data).

• In the unload yard, a storage height of three metres will be established, approximately matching the free unload height of a loading shovel of small-medium size typically used for these treatment capacities. This prevents the unload shovel used for feeding and stacking input amounts from squashing and deforming them, with the resulting detriment to the sorting operations.

• In unload pits, the unload stations shall be provided on the bottom with a strong lip made of reinforced concrete with an approximate height of 25 cm. Thus, if the unload vehicle wheels approach the pit they will stop against this lip. In addition, the width of the lip must not exceed the recommended width of 25 cm, preventing part of the waste unloaded by the vehicle from spilling on the platform.

• To collect the liquids that can appear in selective collection, the unload area must have a 2% slope towards the sides of the building other than the sides of the access doors or feeding. Similarly, the floor of the unload pits will be designed with a minimum slope of 2% towards one of the corners of the base of the pit, provided with a grille of about 0.5 x 0.5 m, located at the bottom of one of the walls defining said corner.

• Both the unload areas and storage pits must be provided with illumination and ventilation allowing the performance of unloading, storage and feeding of the waste to be treated.
The main function of the primary feeders is to regulate and dose, in a continuous regime, the flow of waste to be treated in the sorting plant. The feeders have a centring and tensioning system for the conveyor chains. Some feeder models resemble sturdy conveyor belts with a belt that moves on metal rollers or sliding planes. Waste feeding with the unloading shovel or grapple hook is essential for ensuring correct dosing. Unloading of waste on the feeder guide hopper must be performed gradually in order to facilitate dosing. The waste must fall from the lowest possible height on the feeder area when emptied of waste and should cause distribution of the unloaded volume along the feeder area. In this way the feeder slope performs the backward flipping dosing effect and the longitudinal distribution in an even layer. Erroneous operations in which unloading takes place on top of the waste being dosed by the feeder in most cases results in irregular feeding and potential jams.

**FUNCTION**

The main function of the primary feeders is to regulate and dose, in a continuous regime, the flow of waste to be treated in the sorting plant.

**DESCRIPTION**

They are mechanical transport systems, generally metallic, located at the base of large guiding hoppers. In this way the waste fed to said hopper is transported to the pre-treatment of the process in the form of conveyor belts using pulling means equipped with transverse ribs. The transport system consists of two shafts (a drive shaft and a return shaft) provided with toothed wheels on the end of each shaft that drag worm gear chains to which are connected to the transport elements provided with rolling or sliding system (rollers or sliding plates). The assembly rests on a sturdy metal trellis frame on which the rolling or sliding paths are installed. The feeders have a centring and tensioning system for the conveyor chains. Some feeder models resemble sturdy conveyor belts with a belt that moves on metal rollers or sliding planes. Waste feeding with the unloading shovel or grapple hook is essential for ensuring correct dosing. Unloading of waste on the feeder guide hopper must be performed gradually in order to facilitate dosing. The waste must fall from the lowest possible height on the feeder area when emptied of waste and should cause distribution of the unloaded volume along the feeder area. In this way the feeder slope performs the backward flipping dosing effect and the longitudinal distribution in an even layer. Erroneous operations in which unloading takes place on top of the waste being dosed by the feeder in most cases results in irregular feeding and potential jams.

**TYPES**

There are several types of feeders used in segregation plants:
- Metal plates or conveyor belts with ribs or blades.
- Moving base with drive strips.

**CHARACTERISTICS**

- 40° inclination to adjust feeding in case of metal plate or conveyor belt feeders. In this way the waste unloaded in the chute flips over itself naturally moving towards the bottom of the feeder, being distributed evenly and obtaining a proper dosage of the process. If the inclination is less than 40°, the dosing feeder becomes a conventional conveyor. If it is greater, the waste will slide to the bottom of the feeder, causing flow gaps and irregular feeding.
- The feeder chute must be large enough to hold two crane or shovel loads.
• The chute sides must have an inclination of 70° at the edges. For slighter slopes there can be waste retention, jamming and irregular feeding. It has been found that the 70° wall slope in the chute at the area closest to the feeder must become vertical at a height of approximately 0.5 metres to prevent the formation of domes and jams.

• In the unloading operation, the guide chute must be large enough at the top to prevent waste from spilling out.

• The feeder rate is determined by the flow volume to be supplied. In any case, the feeder rate can be controlled by the operator depending on the calculated flow.

• The conveyor system (boards, plates or belt) must be provided along its entire length with blades or ribs acting as lifters to facilitate the advance of the materials. They must have a height of 5 to 10 cm and be removable in order to use the most suitable one in each case. The length of each blade must cover 60% to 80% of the feeder width to prevent materials from not being carried.

• Feeders must have an adjustable vein limiter in the form of vertical rods placed raised above the inclined area and near the highest end of the
Primary feeders

• Inclined blade feeder (plan view).
• Feeder embedded in unload area.

Feeder, to stop access of larger materials or accumulations of smaller materials. Its main mission is therefore to help regulate the flow volume.

- Feeder length. As necessary depending on the general implementation of the other equipment.
- Feeder width. The minimum size will be determined by the average size of the waste bags. The orders of magnitude will depend on the plant capacity. For small capacity plants the width of the primary feeder is generally 1,000 mm. For large capacity plants the width is 2,000 mm.
FUNCTION

The bag opener releases the material stored in the bags for their subsequent classification and separation processes of the sorting plant.

DESCRIPTION

It is a sturdy steel box. There is an upper inlet and a lower outlet. Inside are one or two revolving shafts or rotors provided with strong cutting or ripping elements. Between the cutting elements is a space of adjustable size between which the bags with the waste are made to pass.

The rotation of the rotors caused by the actuation of a gear motor installed outside makes the bags introduced in the inlet to be ripped by the pressure exerted between the rotor blades or between the rotor blades and the fixed counter-blade installed in the equipment frame, releasing the material contained in the bags on the inner walls of the equipment.

Crushers, in which the bags are slightly crushed due to the pressure exerted by the teeth of the rotor against the fixed counter-blades fitted in the equipment or against the teeth of the second rotor. The technical features defining a bag opener in a package sorting plant are:

• An inlet with dimensions greater than the maximum size of the packages and bags containing the waste.

• Equipment capacity. The capacity of the equipment depends on the inlet dimensions, installed power, length of the opening rotor and the density of the waste. The bag openers have a capacity of 3 t/h to 45 t/h depending on the density of the material to be supplied.

• Opening effectiveness. The opening effectiveness is defined as the number of bags opened after passing through the bag opener divided by the total number of bags fed into the unit. The

TYPES

The bag openers are classified according to the following criteria:

• Number of rotors. There can be two rotors with cutting elements between which the opening pressure is exerted, or one rotor such that the opening pressure is exerted between the bag opener rotor and the fixed counter-blades.

• Opening mechanisms. Rippers, which rip the bags using blades fitted in the rotors that allow subsequent emptying; and

Light weight packaging sorting plants
opening effectiveness in normal operation and maintenance conditions must be about 95%.

- Bag openers have control systems that ensure the performance of the equipment in the case of large materials that could jam the machine. The system consists of a series of inverse and consecutive turns of the rotor or an automatic stoppage of the equipment.

- There must not be any crushing as such, simply ripping of bags and packages while maintaining the original sizes of the materials contained as much as possible to prevent possible reading errors by the optical separators.

- Bag openers have a hydraulic system, either manual or driven by an electric motor, to adjust the distance between the moving rotor and the fixed counter blade. This allows variation of the minimum cut size, understood as the cut length produced by the bag opener when treating material from selective packaging collection and from the remainder fraction. The minimum cut length must be adjustable from 5 to 80 mm at least.

- In crusher type bag-openers, the number of teeth must be approximately 30.

- Rotor speed. The opening rotor speed can vary from 4 to 12 rpm depending on the working pace of the plant.

- The installed power of the bag openers installed in package waste treatment plants ranges from 20 kW to 75 kW.
**FUNCTION**
Divides the material stream into two or more categories according to grain size using specific size sieves. This allows the concentration of certain groups of materials to aid their subsequent segregation. It performs the main function of distributing or dividing the different streams of the treatment. In addition, it can also perform the bag opening function as it can include spikes for this purpose.

**DESCRIPTION**
It consists of a revolving cylindrical surface arranged in an inclined position, with one or more areas provided with orifices of equal or different size, through which materials of a smaller size can pass. The materials that have not passed through the orifices come out of the cylindrical surface on the side opposite the inlet as sieving rejected waste. This creates two currents: a sieved material current known as the passing current and a non-sieved material rejected waste current known as the overflow.

To collect the sieved material and rejected waste streams there are chutes that lead these to other areas of the sorting facility, as well as guards to prevent spillage and projection to the outside.

**TYPES**
This equipment can be classified according to various criteria. In view of the purpose of the machine in the process, they can be classified as:
- Large material trommels. In these, the mesh opening is large enough (300 to 450 mm) such that only large materials are not sifted, obtaining a sifted fraction that feeds the rest of the process and a rejected waste current of large volume material in the trommel overflow.
- Fine materials trommel. Relates to trommels with small sieve sizes (40-60 mm) meant to sift organic material and small objects.
- Mixed trommels. Trommels with a considerable sieving length and several meshes.

As relates to the number of meshes, the trommels can be sorted into:
- With one mesh passing stream and one non-passing rejected waste stream (single mesh).
- With two mesh passing streams and one non-passing rejected waste stream (two meshes).
• With three mesh passing streams and one non-passing rejected waste stream (three meshes). The need for additional streams in the feeding stream is not considered.

• Sieve slope. The sieve slope of a trommel depends on the feeding capacity, composition and physical properties of the waste, trommel rotation speed and nominal diameter. For trommels installed in package classification plants with apparent densities from 50 to 100 kg/m³ and feeding capacities from 2 to 8 t/h, the optimum slope is about 5°.

• Shape of sieve orifices. The shape of the sieve orifices in the trommel mesh can correspond to various geometric figures depending on the predominant shape of the materials to sort while seeking the maximum density of perforated surface. The most common ones are:
  - Circular orifice with nominal mesh size identical to orifice diameter.
  - Square orifice with nominal mesh size equivalent to the side of one square, although the greatest dimension of the orifice is the diagonal.
  - Rectangular orifice, often used to sieve packages in which the greatest dimension can be oriented along the longitudinal direction of motion of the material in the trommel.
  - Hexagonal orifice, to obtain the maximum density of perforated surface. The nominal mesh size is equivalent to the circle inscribed in the hexagon.

• Density of perforated surface. The density of the perforated surface with respect to the total mesh surface is determined by three factors: the shape and distribution of the orifices; the mesh strength against impact and wear; and the orientation of the orifices. Commercially available steel laminates that fulfill these requirements have 55% to 60% of their surface perforated, are made of manganese alloy steel with thickness from 5 to 8 mm and have orifices aligned along the trommel generatrix.

• Orientation of mesh orifice alignment. The orientation of the mesh orifices is mainly related to the mesh efficacy for two reasons:
  - Facilitating passage of materials to be sifted: The efficacy of this operation increases if the alignments of the orifices are perpendicular to the movement-falling of the materials. In the trommels, because the unit turns, the movement-fall is perpendicular to the shaft, such that the orifice alignments need to be parallel to said shaft.
  - The alignments allow installing fins to prevent obstruction of threadlike elements, reducing the maintenance time required for the unit.

• Installed power. The trommel power in a package sorting plant is determined by several factors, such as the rotation speed, capacity, length, etc. In package waste processing plants, the trommels have an installed power of 11-18.5 kW.

• Capacity. The capacity of the trommel depends on its dimensions and can range from 53 m³/h to 208 m³/h, which based on a package density of 70 kg/m³ represents 3.8 t/h to 14.56 t/h.

• Collection chute slope. Due to the variety of packaging material it is not possible to measure the various factors involved quantitatively, so empirical methods have been used to determine the chute slopes on which there are no obvious accumulations of material preventing the normal operation of a trommel. The slopes found for the chute walls with respect to the horizontal based on the package materials guided are as follows:
  - For passing material, with wet organic matter: 70°
  - For passing material without wet organic matter: 60°

• Rotation speed. The speed of a standard trommel for package plants is from 9 to 10 r.p.m. for diameters from 3.6 to 2.5 m.

• Bag opening systems in the trommel. In addition to the bag opener unit, the trommel can also be used to open the bags. These systems involve installing inside the blind ferrule at the inlet to the trommel, after the insertion fins, an area with pointed triangular steel parts approximately 20 cm in height and 8 cm at the base (in the form of spikes or knives), welded or screwed perpendicularly to the ferrule.
Ballistic separator

FUNCTION
Separates the stream of material by size, shape and density. Concentrates certain groups of materials to simplify the subsequent separation. Ballistic separators in sorting plants carry out the main task of dividing the various treatment streams. They are obtained in three currents:

- Fine material fraction. Constitutes the filtered current from the ballistic separator with a high fine material content.
- Fraction of rolling material, formed by material with higher apparent density and round or quadrangular shapes (mainly liquid containers). Mainly comprised of bottles, tins, beverage cartons and other 3D materials.
- Light flat material current, mainly comprised of plastic film sheets, P/C and other 2D materials.

The ballistic separators of the sorting plants can be considered to perform the main function of dividing the different treatment streams.

DESCRIPTION
In general, a ballistic separator installed in a package sorting plant consists of the following elements:

- Set of perforated paddles constituting a ramp.
- One or more crankshafts to transmit the movement to the ramps.
- Frame or assembly.
- Device for controlling the ramp inclination. This device can be actuated hydraulically or manually.
- Fans on the bottom providing a continuous blowing which helps improve the separation between rolling and light flat materials. Not all the ballistic separator models have these fans.
- They can optionally include an upper guard to prevent material from scattering.
- Collection chutes for the outlet streams.

The oscillating movement caused by the crank-shaft means that materials with a greater apparent density and more rounded shapes fall towards the bottom of the planes, while materials with flat shapes rise towards the top. At the same time, fine materials with a smaller size than the mesh perforations pass through the mesh and are considered as rejected waste from the ballistic classification. The fractions obtained are collected in chutes to be guided to the corresponding conveyors.
There are two types of ballistic separators:

- **Single group of inclined paddles driven by the same crankshaft.**
- **Two groups of inclined paddles driven by different crankshafts; the first group has a smaller inclination and sifts, distributes and regulates the stream feeding the second group of light flat materials with a greater inclination, where the rolling and light flat materials are classified and the fine materials are sifted.**
- **Two groups of inclined paddles driven by two different crankshafts with a similar inclination, performing two consecutive ballistic separations.** In this case the mesh opening of the first ramp has a greater size than the second and separates materials with a larger size. This option allows the obtaining of an additional current for larger flat materials.

**CHARACTERISTICS**

- **Capacity.** The processing capacity of the ballistic separators ranges depending on the model from 40 m³/h to 200 m³/h. Considering an input density at this machine in package sorting plants of about 50 kg/m³, maximum capacities of 3 t/h to 10 t/h are obtained.
- **Sifting area.** This constitutes the total area of the perforated blades with a specified mesh size. It has been empirically tested that the optimum mesh size in package sorting plants is 40mm, as a greater mesh size results in losing small packages, while a smaller mesh size results in increased maintenance to prevent obstructions. The sifting area of a ballistic separator is related to its capacity. Thus, ballistic separators with a smaller capacity have a sifting area of about 9 m², while those with large capacity have sifting areas of about 28 m². Blind ballistic separators are also present in light weight packaging sorting plants. This is a ballistic separator in which the ramps do not perform sifting, such that only the rolling and light flat fractions are obtained.
- **Paddles and ramp.** As mentioned above, the sifting area of the ballistic separator consists of ramps that in turn consist of paddles. Depending on the number of ramps, the ballistic separators can have one, two or more parallel ramps or consecutive ramps. The ramps are formed by paddles. These paddles generally have a size of about 450 mm. The number of paddles is related in general to capacity. Ballistic separators with smaller capacities have 4 paddles in each ramp, while those with greater capacity can have up to 12 paddles per ramp.
- **Slope.** The slope of the ballistic separator is the inclination of the ramps in which the ballistic and grain size separation is performed. The optimum inclination depends on several factors, such as the constructive details of the ballistic separator.
Ballistic separator

3. Ballistic separator with two groups of paddles with identical inclinations.


GLOSSARY OF EQUIPMENT

1. Ballistic separator with two groups of paddles with identical inclinations.


and the supply stream to the machine. Reference values for ballistic separator slopes range from 13°-20° depending on the manufacturer.

- **Installed power.** The installed power in a ballistic separator is related to capacity. Ballistic separators with low capacity generally have a single 5 kW motor, while ballistic separators with large capacity require to 5 kW motors.

- **Separation effectiveness.** A ballistic separator is considered to operate correctly when the percentage of rolling material in the rolling current is greater than 90% and the percentage of light flat material in the flat or light material current is also greater than 90%.

- **Fans.** Some ballistic separator models have fans in the top part. These fans, which can be 2 or 3 depending on the ballistic separator capacity, help improve the distribution of light flat and rolling materials, as they push light materials towards the collection chute.

- **Supply.** The supply to the ballistic separator must be performed such that it fulfills two goals: to use the maximum possible sifting area of the ballistic separator and to achieve an optimum distribution between rolling and light flat material. The drop from the supply conveyor to the ballistic separator must be arranged such that the ramp is fed at a position equivalent to one third from the end of the ramp constituting the rolling fraction collection.
**Pneumatic separator**

**FUNCTION**

The function performed by the pneumatic separator is to segregate using suction systems light and threadlike materials with a lower apparent density from other materials. These light materials are mainly film plastics and press paper, which are present in the following process flows:

- Light flat material current from ballistic separation.
- Non-passing rejected waste from trommel classification.
- Rolling element current from ballistic separation.

These light materials are transported by the air current through a pipe suitably sized for this function to a decanting or cyclone chamber in which they are separated from the air. The decanting chambers are installed in conveyor belts in which the selected film is subjected to quality control. The air separated in the decanting chamber and contaminated with suspended dust is transported to a sleeve filter where it is cleaned before returning it to the atmosphere.

The air current is generated by a fan installed at the end of the pneumatic capturing system line.

**DESCRIPTION**

It consists of suction hoods located strategically at specific points of the sorting process through which a selective air current is passed causing a depression that allows the capture and transport of lighter materials (mainly plastic film). These suction mouths are placed at conveyor drops to use the ballistics of the materials between conveyors to aid the suction. In some cases, mouths are also installed in these drops to lift the material by air blasts in order to bring it closer to the areas of greatest depression. The air current is generated by a fan installed at the end of the pneumatic capturing system line.

**TYPES**

Depending on the criteria applied, pneumatic separation systems can be classified into:

1. Fan.
2. Suction system with one suction mouth.
3. Suction system with two suction mouths.
• Automated or semi-automated. Automated when the material is placed near the air depression automatically due to the path followed when falling from a conveyor. Semi-automated when the material is placed near the air depression manually in a sorting cabin.

• According to the separation system used for the material selected from the air current, three devices can be differentiated:
  - Air and material separation by a cyclone chamber: the mixture of air and suctioned material is supplied tangentially to the top part of the cyclone. A downward circular current is created inside the chamber that decants the selected material at the bottom. This system is increasingly being abandoned.
  - Air and material separation by passing the current through a revolving circular mesh: the material suspended in the current is trapped by the circular mesh. When this mesh turns, it carries the materials away from the current, decanting them onto a conveyor belt. This system is also in disuse.
  - Air and material separation with an alveolar valve: the current with suctioned material is led through a circular perforated system in motion, located inside a vacuum chamber. The material in suspension is decanted at the bottom of the chamber as it is subjected to a depression in the air current.

• The width of the suction hood mouths, for both waste inlet and outlet, must be equivalent to the useful width of the belts transporting the waste to be treated.

• The heights of the suction hood mouths for both waste inlet and outlet must allow the waste to pass freely. This will depend on the grain size and flow rate involved.

• Suction capacity. Depending on the system suction points, which can be from one to three, the following air flows are required with a depression of 3,000 to 3,500 Pa:
  1. Suction hood: from 15,000 to 20,000 m³/h air.
  2. Suction hood: from 30,000 to 35,000 m³/h air.
  3. Suction hood: from 40,000 to 45,000 m³/h air.

  These air flows have been calculated for a safety coefficient of 25% guaranteeing the proper operation of the facility.

• The fan capacity must be enough to move a minimum air flow and a depression that can suction and transport objects with low density such as film, PET and other light material particles such as dust through pipes, as well as through the air.

• The depression at the fan must reach values from 3,000 to 3,500 Pa, depending on the distance between the fan and the capture point. In addition, the cross-section of the transport pipe and the load losses due to the various components (elbows, sights, etc.) must be considered. The power of the fans used in suction systems of standard package sorting plants range from 22 kW to 55 kW.
The pipes for light material captured in the suction hoods must not be less than 350 mm in diameter to allow passage of flexible components of film plastic and P/C with large and intermediate sizes (maximum 600 x 600 mm).

Regulation of flow rates/speeds must be performed using a valve at the system fan outlet and by changing the air inlet sections at the capture hoods.

In some cases deflection curtains are needed in the inlet and outlet mouths of the capture hoods in order to optimise sorting performance.

The air filter sleeves are made of filtering fabrics. The aim of these sleeves is to provide a filtering surface proportional to the air flow to filter and the content of dust particles and other elements contained in the air.

Normally for film capturing facilities approximately 1 m² of filtering surface is needed for every 300 m³/h of suctioned air, such that for fan suction units that can suck between 15,000 and 40,000 m³/h of air, large sleeve filters are needed, normally with 100 to 200 m² of filtering surface, with a reserve of 25%.
Magnetic separators

FUNCTION
These units segregate ferrous metals by their magnetic properties.

DESCRIPTION
The physical principle of operation of magnetic separators is a magnetic field generated by a permanent magnet or excitation electricity in a coil wound on a magnetic pole, the excitation of which on the coil generates the magnetic field. This attracts ferrous materials crossing said magnetic field towards the coil or magnet, separating them from the other materials. The attractive forces will not affect non-metallic materials or non-ferrous metals such as bronze or aluminium. The coil and the magnetic poles are located in the centre of a conveyor belt that turns at a high speed and by means of ribs provides continuous evacuation of the ferrous materials captured. The magnetic separator and the conveyor belt are suspended above a frame provided with adjustable worm gear springs to place the separator at the most effective inclination and approximation positions. The separator comprises a system of guards, chutes and closures to prevent magnetic materials from being projected out from or introduced between the core, drums and belt. Its use implies that the waste stream containing magnetic materials must pass within the radius of action of the magnetic field created. The bands that carry the waste streams to be selected must include the magnetic separators in their design (belt head drums) or must be raised above the bands that transport them (over-band).

TYPES
• Depending on the magnetic field generated the separators can be of two types:
  › Permanent induced field (permanent magnets)
  › Fields induced by an electric current (electromagnets)

Electromagnets are normally used in package sorting plants.

• Depending on the constructive system the electromagnets can be of two types:
  › Drum, placed inside the head drum of the conveyor belt carrying the stream of materials to be treated.
  › Over-band separator, placed in an independent band raised above the belt carrying the stream of materials to be treated, either in line with the belt or transverse to it.

In package waste plants, over-band electromagnetic separators are recommended. Although...
Magnetic separators

these use more power and have a higher investment cost; a single malfunction (actuation, belt, etc.) in a permanent magnet separator would stop the entire line.

**CHARACTERISTICS**

- The stream of waste transported by the belt carrying the magnetic materials must pass completely under the radius of action of the magnetic field created by the separator.
- Since the attraction force on the ferrous materials created by the electromagnet’s magnetic field is inversely proportional to the distance from the core, these units must be able to create a magnetic field density of at least 400 Gauss in view of the distance to the materials to be captured.
- The speed of the conveyor belt must be from 1.0 to 1.5 m/s. The speed of the over-band separator must be from 2.0 to 2.5 m/s.
- The layer thickness of the waste stream carried by the belt must not be greater than the average size of the magnetic materials to be selected.
- The surroundings of the field of action of the magnetic separators (drums, rollers, belt structures, etc.) must be made of non-ferrous, non-magnetisable materials (stainless steel or aluminium).
- For separators arranged in line with the conveyor belt, the angle between the slope of said belt and the separator slope must be from 20° to 25°, approximately. In addition, the line perpendicular to the core of the electromagnet that passes through the centre must be tangent to the head drum of the conveyor belt.
- For separators arranged transversely to the conveyor belt, the longitudinal slope thereof and the transverse slope of the over-band must be parallel.
- The installed power of an over-band magnetic separator for a standard package plant will be from 1.5 kW to 5.5 kW depending on its dimensions.
Optical separators

FUNCTION

Optical separation allows segregating several types of plastic (PET, HDPE and mixed plastic) in package sorting plants, although current equipment allows the separation of other plastics, beverage cartons, ferrous and non-ferrous metals, P/C, glass, organic matter, etc. Recoverable materials from plastic, beverage cartons and P/C packages with standard sizes contained in the streams classified by the preceding processes can be selected by applying automated optical devices.

DESCRIPTION

This principle involves passing a uniform stream on a belt with a controlled speed of previously classified components, generally by ballistic separators (rolling current) or trommels (passing material of medium size) within the range of action of an optical scanner or sensor. The material to be selected is stabilised in a high-speed belt, and when it is stable on a specific point of the belt the composition of the material is detected by a scanner that also determines its position. If the belt speed is known, one can calculate the time taken to reach the end of the belt, where a block of electrovalves is installed that blow the material into the corresponding chute. The technology most commonly used to conduct optical separation of materials is near-infrared (NIR), but other technologies allow separating materials of different colours using optical spectrometry (colorimetry) and separating materials by X-ray densitometry. The most widely used devices are NIR optical sorting units, which comprise the following elements:

- **Frame**: structure that supports the various elements of the equipment.
- **Software**: programme used to identify the materials. Depending on the reading, the sensor will issue a command to control the corresponding air flow. Unit parameters such as belt speed, calibration and data storage are controlled.
- **Acceleration conveyor belt**: meant to stabilise the material that is selected for detection by the scanner and subsequent...
Optical separators

- Optical separators: These are designed to transport the materials to the blowing valves. The belt must have an adjustable speed from 2.2 - 3.7 m/s, in order to distribute the materials along and across the belt and provide enough speed to favour launching and parabolic flight.

- Optical sensor: This is a scanner placed on the acceleration belt that detects the materials being transported and which, in addition to determining the position of the materials on the belt band, depending on the wavelength can determine the nature and/or colour of the material. The reading obtained is processed by the unit software.

- Illumination system: Composed of sets of bulbs that emit light (at a specific wavelength) on the transported material, which is reflected on to the sensor reader. The light intensity (Watts/cm²) is determined by the sensitivity of the scanner. Thus, the greater the sensitivity and efficiency of the scanner, the lower the light intensity needed, reducing consumption.

- Valve block: Set composed of multiple blowing valves placed after the optical sensor reading strip (scanner), at the end of the acceleration belt and under the head drum. Depending on the scanner reading, the valve corresponding to each type of material will open, blowing pressurised air to separate each identified type of material from the other types of material. Some units have two valve blocks. These are generally placed at the end of the acceleration belt, on the bottom part, although in plants where the input material to the optical separators has a high percentage of organic matter content, they can be placed at the top to prevent malfunctions due to valves getting dirty. It is also possible to place one on the top and the other on the bottom.

- Compressor unit: Unit in charge of blowing air to actuate the valves that select the materials.

- Flight box: Set of chutes and guards at the outlet of the acceleration belt, used after blowing to collect the selected and unselected material in different channels.

- Electromagnetic sensor: Placed under the acceleration belt, which receives the signal from the transported metals (ferrous and non-ferrous), processes it in the software and issues instructions to the valve block for sorting. This system complements the unit although it is strictly speaking not an optical but rather an electromagnetic separation.
**Optical separators**

The technologies used in this type of equipment with applications in light package sorting plants are the following:

- **Separation by near infra-red (NIR)**
  The reading is generally made between the wavelengths of 1,100 and 1,900 nm. This reading determines the nature of the polymer. If the sensor can detect and increase the spectrum to between 700 and 1,900 nm, it is possible to differentiate paper and wood board (cellulose).

- **Mixed separation**
  The techniques discussed above can be combined in a single unit, allowing sorting of the material not only by its nature, but also by its colour, nature or shape.

**CHARACTERISTICS**

The main parameters that need to define an optical sorting unit can be summarised as follows:

- **Useful width** of the conveyor belt. The useful width determines the treatment capacity of the optical separator. Generally, the material arriving at optical separators has a density of 50-70 kg/m³ (depending on pre-treatment and quality of the input material). In view of this density and the material treated in package sorting plants, the capacities as a function of useful width are shown in Table 13.

<table>
<thead>
<tr>
<th>Useful belt width (mm)</th>
<th>Treatment capacity (t/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>500-900</td>
<td>1.0 – 2.0</td>
</tr>
<tr>
<td>1,000-1,200</td>
<td>2.0 – 3.5</td>
</tr>
<tr>
<td>1,400-1,600</td>
<td>3.5 – 4.5</td>
</tr>
<tr>
<td>2,000-2,400</td>
<td>4.5 – 7.0</td>
</tr>
<tr>
<td>2,800</td>
<td>7.0 – 9.0</td>
</tr>
</tbody>
</table>

Keep in mind that these values can vary according to the manufacturer, the reading technology, the point of the process in which the unit is located, the quality and density of the material and the fraction to be selected.

- **Length of the acceleration belt.** This parameter depends on the speed of the acceleration belt, which must be adjustable between 2.2-3.7 m/s, in order to distribute the material along the belt and reach speeds that aid its launching. As a rule, the acceleration belt should have a length greater than 5m in case of longitudinal feeding or 6m in case of transverse feeding. These lengths must be observed when designing and installing the unit in the line, as lengths shorter than recommended can result in the material not being stable on the belt at the moment when it passes by the reading scanner, leading to reading and sorting errors.

- **Number of valve blocks.** Optical separation units can have one or two blocks of air valves. Optical separators with a single block separate two fractions, the requested fraction and the rejected waste. Optical separators with two blocks separate the stream into three fractions, two requested fractions and one rejected waste fraction. The latter have the advantage of requiring less installation space and lower investment costs as a single optical separator allows the sorting of three fractions. The number and type of air valves for each block depends on each model. The more valves per centimetre, the greater the precision of the optical separator.

- **Quality of the recovered material.** Since the purity of the selected fraction is not 100%, after the optical separation a quality control must be performed on the material. The quality control is normally performed by manual sorting operators who segregate the materials on a conveyor belt that do not belong to the requested fraction (impurity selection...
or negative sorting). This sorting is performed before storing the material. In some sorting plants, this control is performed before compacting the material after storage in the silos, either by operators or by another optical separation unit.

- **Optical separator configurations.** A different separator must be used for each type of components or group of materials, such that if the materials subjected to separation are PET, HDPE, beverage cartons and mixed plastic, the optical units required are four. The selected implementation of the various arrangements will be determined based on the number of types of materials to be separated, the space available, etc. Depending on the number of valve blocks, an optical separator will select one or two different fractions in addition to the rejected waste fraction. Consequently, for light-weight packaging sorting plants where there are normally four materials to be sorted (PET, HDPE, beverage cartons and mixed plastic) using this technique, from two to four optical separators are necessary. They arranged in sequences to sort the materials, known as optical separation chains or cascades. The necessary quality controls (QC) are added.

As a rule the sorting cascade needs to start by selecting the material to be sorted that is most present in the input fraction. This favours the sorting of the other materials in the rest of the
sequence and prevents oversizing the capacity of the rest of the optical separation chain. In plants where the rolling element current received from the ballistic separator does not contain much requested material, such as in remainder fraction treatment lines, the first optical separator is programmed to perform the separation of plastic materials from non-plastic materials. Although this separation provides a pre-treatment for the rest of the cascade, it is not recommended for light weight packaging sorting plants where the input material in the plant contains a requested material amount higher than 75%.

The separation sequences most commonly used in light weight packaging sorting plants are shown in the following figures. Although these configurations are those normally used in light weight packaging sorting plants, depending on the materials to be selected or the plant capacity it is possible to combine different sequences and units. For example, in plants in which colour and natural HDPE are selected an additional valve block is needed to separate these two materials.

In addition to the variety of configurations of the optical separators, it is possible to select with one scanner two/three materials running in differentiated streams/channels in the acceleration belt using partitions. This means that there are multichannel optical separators (double/triple channel). For example, an optical separator can be fed a first stream on one channel of the belt, segregating one material from said stream. The rejected waste from this first stream is fed to the other channel, selecting a different material.

• Effectiveness. The sorting effectiveness is the percentage of material sorted compared to the amount of sortable material at the unit inlet. Optical separation units have effectiveness rates over 90% (with values of up to 98% measured in light weight packaging sorting plants) if the...
unit is properly sized and correctly placed in the sorting process, and cleaning and maintenance tasks are performed periodically. That is, the effectiveness of the unit does not only depend on the unit features but also on the pre-treatment of the material. Some examples of processes with a low effectiveness are:

- Units installed without a previous film suction unit. The effectiveness is lower when the plastic film is placed over the material to be selected, causing reading errors or even preventing reading.

- Useful belt widths smaller than the width needed for a given capacity. Cause low effectiveness as the materials cannot be distributed along the width of the belt and will pile on top of one another.

- Acceleration belts shorter than recommended. Prevent the materials from stabilising on the belt, resulting in mistimed air blasts when the material reaches the end of the acceleration belt.

- Excessive or irregular feeding rates.

- Purity. The purity of the selected material is the percentage of requested material in the fraction with respect to all the material selected. Optical separation units have purities from 90% to 98% if the unit is properly sized and correctly placed in the sorting process, and cleaning and maintenance tasks are performed periodically. Depending on the values obtained for fraction purity and the technical specifications to be met by the selected materials, the number of quality control stations required in each facility will be determined.

- Maintenance. Cleaning and maintenance of the units is essential, as this has a direct effect on the performance of the facility. For this reason, at the end of each shift the cleaning operations specified by the supplier according to the characteristics of the unit must be performed. These are generally checking and cleaning the blowing valves, changing and cleaning the bulbs (since they are dimmed when dirt accumulates on the glass) and cleaning the scanner reading glass.

Effectiveness of the various sequences of optical separators

Each sequence of optical separators discussed above has a different overall effectiveness depending on the order in which the optical separators are placed.

8. Configuration with three single-valve and one dual-valve optical separators.

9. Configuration with one single-valve double-channel optical separator.
Thus, depending on the effectiveness and quality of each optical separator as determined by the manufacturer, the following overall effectiveness and quality is obtained for each optical separator sequence:

In view of the data, it can be said that:
- Single-valve optical separator configurations provide better results than dual-valve configurations.
- The use of "plastic/non-plastic" configurations provide lower effectiveness due to the accumulation of errors.
- Those configurations for separating mixed plastic as rejected waste from the chain obtain poor separation quality for this material.
- More quality control staff is needed in configurations that select mixed plastic as a rejected waste from the chain.
- The configuration of four single-valve optical separators provides the best effectiveness and quality, as well as requiring the fewest quality control sorting operators.
- The use of recirculation increases the performance of the configuration but requires the use of larger optical separators.

### Efectivity Purity PM purity

<table>
<thead>
<tr>
<th>Sequence</th>
<th>Efectivity</th>
<th>Purity</th>
<th>PM purity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sequence of single-valve separators</td>
<td>90.0%</td>
<td>90.0%</td>
<td>90.0%</td>
</tr>
<tr>
<td>Two dual-valve optical separators</td>
<td>87.9%</td>
<td>87.9%</td>
<td>85.0%</td>
</tr>
<tr>
<td>Four single-valve optical separators (plastic/non-plastic)</td>
<td>83.7%</td>
<td>83.7%</td>
<td>56.5%</td>
</tr>
<tr>
<td>Two dual-valve optical separators (plastic/non-plastic)</td>
<td>80.1%</td>
<td>80.1%</td>
<td>52.3%</td>
</tr>
<tr>
<td>Three single-valve optical separators (plastic/non-plastic) and dual-valve optical separator to recirculate plastics</td>
<td>91.1%</td>
<td>84.5%</td>
<td>59.8%</td>
</tr>
</tbody>
</table>
Induction separators

FUNCTION

Induction separators select non-magnetic metals, mainly those in which aluminium is the main component.

DESCRIPTION

The separation by induction of non-ferrous metals relies on the physical principle behind Foucault or eddy currents. This consists of the creation of an alternating magnetic field, that is, a variable magnetic field in which the north and south pole alternate. This variable magnetic field is created in the unit by an induction drum mainly made up of neodymium rare earths and a rotation speed greater than 3,000 rpm.

In this way if a non-ferrous material is subjected to an alternating magnetic field, internal currents known as eddy currents are generated. These currents generate a magnetic field opposite to the variable magnetic field generated by the magnet. This strong opposition of magnetic fields causes a repulsive force such that the non-ferrous material is displaced from its normal trajectory and thereby separated from the stream of the other materials.

In addition, the drum also induces secondary electromagnetic currents that attract ferromagnetic metals towards the drum. These currents can be used to separate the ferrous material fed into the unit.

An induction separator comprises two rollers: the drive roller that moves the unit belt through a gear reducer, and the head roller or induction drum, which generates the eddy currents. The induction drum is formed in turn by two drums, an outer one revolving at the same speed as the conveyor belt and an inner drum that generates the eddy currents.

Therefore, as shown in the figure on page 121, the stream of material fed into the induction separator is divided into three currents:

- Non-ferrous metals
- Ferrous metals
- Other materials

TYPES

Depending on the position of the inner drum with respect to the outer drum, the induction separators can be classified into induction separators with concentric drums and induction separators with eccentric drums. The latter design is used more often as it provides greater protection against entry of ferrous particles between the rotor and the conveyor belt, as well as having a longer service life.
Induction separators

CHARACTERISTICS

• Depending on the input stream to the unit, the useful width of the separator belt is sized such that in order to achieve the same effectiveness in sorting of aluminium with a greater flow of materials, a greater useful width is required.
• The sorting effectiveness values obtained experimentally for induction separators in packaging sorting plants are 90% aluminium separated out of the aluminium input in the unit.
• Requires feeding that is evenly dosed and distributed along the width of the belt, so that the width of the supply belt to the induction separator must be similar to the useful width of the unit.
• Requires the metals to be selected to be as free as possible from other materials, so that the belt speed must be high. The induction separator belt speed must be variable, between 2 and 2.5 m/s.
• The rotor speed is adjustable and must be at least 3,000 r.p.m.
• The necessary length between rotors of the eddy current separator in order to stabilise the material to select must be at least 2,000 mm.
• There is a separation chopper between the selected aluminium chutes and the rejected waste current chutes of the unit, with an adjustable angle.
• There is a side cowling and a front protection hood.
• At least one rib with a low height must be present along the entire belt in order to detach any ferrous materials which may have attached to the magnetisable drum area.
• The induction separator must be fitted with a scraper-cleaner for its belt, in the form of a brush or similar, placed on the return face in order to help maintain clean the separator belt and allow the transverse rib to pass.
• Dosing. It is not advisable to dose the induction separator using a vibrating tray as this reduces the transport speed in the tray compared to the conveyor belt, and therefore increases the thickness of the layer of materials. This means that the stream discharge on the separator will be irregular and the material separation effectiveness will be reduced.
• The installed power of an eddy current separator is the sum of two powers: the conveyor belt power and the rotor power. Depending on the dimensions of the machine, the total power will range from 2.5 kW for smaller models and 6.6 kW for larger models.
Sorting of materials

**FUNCTION**

Material sorting consists of manual sorting of materials on a conveyor belt installed in the cabin. Even if a plant is designed to automatically separate materials, a manual sorting is necessary at the end of the process line to reach 85% effectiveness in overall sorting.

**DESCRIPTION**

It consists of manual separation of various materials on the top band of a conveyor belt. In the primary sorting and positive sorting of the materials said belt is horizontal in a sorting cabin, flanked on either side by sorting spaces or positions for the operators and for the mouths of the discharge chutes for selected materials leading to storage containers placed under said selection cabin. In the quality control sorting the belt is normally arranged in the front of a sorting cabin, where the sorting operator is placed at the head of the belt. Manually selected materials are impurities that may be deposited in specific bins or in buckets for subsequent disposal in the corresponding silo.

**TYPES**

Depending on the type of material to be selected manually, material sorting can be classified into three different types:

- **Primary sorting or bulky material sorting:** when the materials to be sorted are very large or have an awkward shape and they must be sorting to prevent affecting the subsequent separation process. Located in the line sorting cabins (pre-treatment), although it can also be performed in the reception systems (yard or pits).
- **Positive material sorting or secondary sorting:** when the materials selected manually are those required for subsequent compacting and sale. This manual sorting is arranged at the end of the process line in automated plants.
- **Negative sorting or quality control sorting:** when the materials selected are the impurities contained in the automatically selected materials which must be removed to fulfill the Technical Specifications for Recovered Materials (TSRM). This sorting is placed in the stream of material selected by the optical separators and film suctioning.

In the diagram, you can see the distribution of sorting stations in the primary or secondary sorting cabin (positive sorting).
The material sorting must be performed in specific sorting cabins, which attempt to provide the best possible ergonomic and working positions; accordingly, manual sorting stations must have optimum conditions of climate control and lighting.

- Sorting belt speed: the optimum speeds found experimentally in facilities are from 0.3 to 0.4 m/s. Speeds greater than 0.5 m/s are detrimental to the operator’s well-being and comfort, as well as reducing performance.

- Sorting height: the conveyor belts must be at a height of 0.75 to 0.90 m from the floor on which the operator stands. Some facilities have a variable height platform that can be adjusted to the most convenient position for the operator. The height of the conveyor belt walls on which the sorting operator’s waist rests must not be greater than 0.25 m.

- Sorting belt width: due to the distance that a sorting operator can reach in the sorting belt, for useful belt widths greater than 0.6 or 0.7 m sorting stations must be provided on both sides of the belt.

- Distances between sorting stations and collection chutes: sorting operators require a total free height from 0.8 to 1.0 m in order to move unhindered.

- Sorting of materials must be performed such that a single operator can separate two to three different types of material.

- The mean operational performance for manual sorting of materials at the plant is 2,000 movements per hour and per material.

- Sorting of materials performed by sorting operators not included in the corresponding container can be collected in buckets or in conveyor belts connecting the various storage silos.
Conveyor belts

**FUNCTION**

The function performed by the conveyor belts as an essential element of the set of equipment at a sorting facility is to transport the waste flows from one equipment to another in order to complete the treatment processes.

**DESCRIPTION**

They consist of the following main elements:
- Two revolving drums placed at the forward head and return end.
- A drive system with a gear reducer, generally in the head drum.
- A strong structure made of rolled profiles with supports constituting the frame.
- Intermediate forward or upper roller stations.
- Intermediate return or lower roller stations.
- An endless rubber belt with a traction-resistant weave and anti-organic coating for the transport of the materials stream.
- An effective continuous belt cleaning system (scraper).
- A belt centering and tensioning system.
- Loading and unloading chutes.
- Set of side walls and lips to prevent spillage.
- Cover or hood when necessary.

**TYPES**

Conveyor belts can be classified according to various criteria:
- In view of their function, they can be classified into: conveyor belts designed and used exclusively to transport waste from one unit to another at the facility; manual sorting belts used to perform manual sorting or material quality control, which must be horizontal and have low speed; and acceleration belts in optical separators which have a higher speed to stabilise the material for subsequent optical reading.
- According to their position in the plant implementation, they are classified into: inclined belts, horizontal belts and mixed belts which have an inflection point at some stage in their path.
- According to their cross-section, they are classified into: V-section belts, trough-section belts, flat section belts and belts with a special cross-section for manual sorting.
- Depending on the type of coating of the band they can be classified into: smooth surface, rough surface and ribbed surface. This characteristic is related to the material transport capacity with high belt inclinations.

**CHARACTERISTICS**

- Belt slope. Experience indicates that depending on the waste to be transported, the maximum slope for smooth belts with packaging fraction should not exceed 18°. In this case, if the packaging waste does not contain fine material with moisture that can become attached to the belt, it is possible to use a standard ribbed belt with a 1 cm rib and in general reach a maximum slope of 20°. They may have greater slopes depending on the height and shape of the rib, whenever the material to be transported is not accompanied by fine material adhering to it that could become attached to the belt. The content of fine material adhering to it must be limited since the belts cannot be cleaned using conventional scrapers, which hinders equipment maintenance and cleaning tasks.
Conveyor belts

• Walls and lips. Conveyor belts in general are fitted with these elements, of great importance to the functionality of the unit. These are folded metal plate walls, supported from the belt structure by rolled profiles (angles or plates). They can also be used to fix the flexible closing lips with the necessary adjustment. The main purpose of the wall-lip assembly is to contain the waste in the band of the belt and prevent spills and projections from it. The inclination of the wall-lip assembly must not be less than 60º with respect to the horizontal, in order to prevent material from being stuck. Lips made of a flexible material with a hardness less than the belt must be attached to the walls using an adjustable system that allows them to be fitted onto the belt in an inclined (not orthogonal) position as they become worn due to the friction with the belt.

The position of incidence of the lips on the belt must be near each of the edges of said belt (about 5 cm at least) to prevent spillage due to the frequent small deviations of the belt. • Width of the conveyor belt. It should be considered that in principle the useful width of the belt is determined by the difference between the total belt width and the side margins that must be left free by the lips, plus the contact width of the lips (about 2 cm on each side). In total it is estimated that the belt total width is reduced by about 7.5 cm on each side, that is, the useful width will be 15 cm less than the total width. In general for any type of belt the minimum useful width must be greater than 2 times the maximum size of the materials transported by it, measured along at least two of their three dimensions, such that they are not wedged into the space between the lips of the sides of the belt so no undesired jams occur.

In specific belts for manual sorting and separation the useful width must not exceed 1.4 m, provided there are sorting positions on both sides of the belt, and if there are only sorting operators on one side of the belt they must not exceed 0.7 m, so that all materials can be reached by them.

• Provide the cross-section adapted to the objective (manual sorting, transport or process).
• Length of the conveyor belt. The length and slope of a conveyor belt are determined by the implementation requirements.
• Cleaning system. Conveyor belts have a scraper fitted near the drive rotor for cleaning materials attached to the belt. This system cannot be used in belts with ribs, which require the use of brushes or periodic cleaning. For this reason, ribbed belts are not recommended for transporting fine materials.
The purpose of compacting material using horizontal presses is to increase the apparent density in order to meet the Technical Specifications for Recovered Materials (TSRM) and optimise the transport of material bales to the destination recycler.

Presses are compacting units in which the materials fed to the compacting box through the feeding chute are subjected to pressure by a push plate driven by a hydraulic cylinder that moves within a compacting box with specific dimensions, compacting them to a specific predetermined pressure.

The push plate is fitted with a hydraulic unit that supplies the kinetic energy used in the machine. It consists of an oil tank, motor-pump assemblies, hydraulic distribution, regulation, filtering and cooling elements.

The compacting box is followed by an attached tunnel in which the compacting continues. At the top of the push plate are cutting blades, easy to access and replace, which together with the fixed blades placed on the fixed part of the machine loading mouth, also removable, allow the cutting of excess material above the compacting tunnel.

In the final part of the compacting tunnel path is a second vertical hydraulic cylinder, perpendicular to the former cylinder, which acts on the tunnel walls to reduce the tunnel cross-section and therefore that of the bale.

The automatic bale strapping system completes the structural equipment of the press. This system consists of a pin carriage that is lowered to the bottom part of the machine (bedplate) where the threading device is located. This device captures the wire and leads it to the strapping body, where it is tied by twisting to the second wire from the wire spools.

Once the bales have been formed and tied simultaneously and continuously, they are led out to an output ramp.

There are several types of presses used to compact material:
- Tunnel presses with vertical or lateral bale strapping systems.
- Double chamber presses with perpendicular push plates and bale strapping.
- Tunnel presses for metals without bale strapping.
- Closed box presses for metals with perpendicular compacting plates without bale strapping.

Material compacting and pressing systems are arranged at the end of the process and must therefore be oversized to prevent forming a bottleneck in the treatment process at the sorting plant. Pushing movements are performed with the chamber full of materials and return movements with an empty chamber, so that there is a limitation in the treatment process at the sorting plant.
significant time during which no compacting is being performed. To compensate this effect a storage volume is designed for the chute feeding the press with a volume greater (at least 200%) than the volume of the compacting chamber:

• This chute must have vertical walls until the compacting chamber to ensure comprehensive feeding. They are provided with a load detection cell locked with the plate actuation to ensure complete filling in each stroke.

• The chute cross-section will be equal to or less than the cross-section of the compacting chamber (loading mouth), to prevent stops in the filling operation.

• The sorting and calculation of a press system must consider the following points:
  › Apparent density of the materials to be compacted.
  › Density required by the TSRM.
  › Stream of materials to be compacted.
  › Mean size of materials to be compacted.
  › Cross-section of the bale formed (cross-section of the pressing tunnel).
  › Volume of the loading box or compacting chamber.
  › Reduction in volume with each stroke (compacting index).
  › Length of bale required by TSRM.
  › Bale strapping system if required.
Equipment for managing rejected waste

**FUNCTION**

All sorting plants generate rejected waste in the treatment which need to be managed. The purpose of this operation is to adapt the rejected waste generated in the process and evacuate it in order to ensure a continuous operation of the sorting facility. Management of rejected waste is based on increasing the density of rejected waste in order to optimise transport and dumping.

**DESCRIPTION**

The rejected waste generated generally has a low density, so that at least for capacities greater than 2 t/h, increasing the density by compacting is considered. This requires compacters with the necessary capacity to guarantee the sorting operation. In lower capacity facilities, it is enough to store the rejected waste without compacting in containers of sufficient size. Exceptionally, for greater capacities, it is possible to install a baling press exclusively for rejected waste. Compacting systems for rejected waste must be connected to each other by reversible conveyor belts so that if one of the activation units fails, the parallel management system can be activated.

**TYPES**

- Open box containers for smaller capacities.
Equipment for managing rejected waste

- Closed containers with self-compactor for medium capacities.
- Compactor for closed containers, for higher capacities.
- Exceptionally, baling press for higher capacities.
- In any of the aforementioned cases a complementary container must be provided with easy access in case of malfunction, adjacent to the conventional compacting system, from which the rejected waste is evacuated with a loading shovel to a transport vehicle.

CHARACTERISTICS

The general characteristics of the rejected waste collection systems are:

- The capacity of the containers in any of the possible cases must be as large as possible in order to minimise down time due to the changing of full containers for empty ones. For low capacity treatment plants (up to 3 t/h) it is recommended to install a compacting system based on self-compactors; for intermediate plants (3 to 6 t/h) the recommended compactor unit is a static compactor; finally, for larger plants (from 7 t/h) it is recommended to install a transfer carriage so that containers can be changed automatically.
- The surroundings of the rejected waste collection system must have sufficient surface area to allow manoeuvres by container loading and unloading vehicles.
- The rejected waste collection area must be isolated from the remaining sorting facilities, as there are often spills that could contaminate the management of other selected materials.
- The capacity of the rejected waste collection system must be sized at least for the nominal capacity of the facility, to ensure that in case of malfunction all waste arriving at the facility is evacuated.
- The number of available containers for rejected waste evacuation must be in line with the transportation system, the distance to the rejected waste treatment plant and the time required for the round trip.
The Light Weight Packaging Sorting Plants Manual is a new tool that Ecoembes has made available to waste technicians of public administrations, operating companies and engineering firms, which is also bound to become an entry point for curious individuals interested in learning more about this fascinating subject.

In this Manual, Ecoembes shares with them, and with society as a whole, the knowledge it has garnered during years of work on the design and operation of packaging sorting plants.

We trust that this will allow us to continue to improve the sorting plant every day, resulting in improved packaging recovery and therefore in the protection of the environment.

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