Demingling the mix: An assessment of commercially available automated sorting technology

Second Edition

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Introduction

This study is a census of commercially available sorting technology for plastic containers and plastic flake, pellets and other plastic fractions. The evaluation of commercially available equipment was conducted from November 2009 through February 2010, and later updated January 2011. The technologies included in this study cover mechanical and optical separation technologies, hand-held identification devices, and technologies that separate and identify resins and colors. This report considered equipment that was able to sort either whole units, such as bottles and non-bottle rigid packaging, and flake or size reduced material (to handle material such as e-plastics, or plastics from recovered electronics). This study did not consider technologies that use electrostatic or density separation methods.

The intent of the study is to provide users of sortation equipment with clear information about seven specific criteria for each commercially available sortation system. The information is laid out in a table to allow for side-by-side product comparison. With this information, a user can quickly determine which systems to pursue that might best fit their operational needs.

In total, the study identified 19 manufacturers of automated sorting equipment offering 52 different systems. Of those 52 systems, 26 systems were for sorting whole plastic containers and 26 systems handled flake, pellets or shredded plastics. In terms of hand-held identification devices, six manufacturers currently offer this type of portable equipment.

All of the data is self-reported information from the manufacturers. While it is reliable, it should be verified by any potential buyer. Research for this report was conducted by 4R Sustainability (4R) with funding support from the Plastics Division of the American Chemistry Council (ACC).

Need for automated sorting technology

In order to recycle post-consumer resin (PCR) for high-grade applications, it is necessary to obtain near-pure resin streams. This can be a challenge as more and more collection of plastics is done in a co-mingled fashion, where resins types are mixed together (Nos. 1-7) and often mixed with non-plastic materials, such as paper and metals. a record high 2.425 billion pounds in 2009, an increase of 46 million pounds over 2008 levels. Of those, 1.44 billion pounds were PET bottles, and 981.6 million pounds of HDPE bottles were recycled.[1]. And as of 2006, over 2,000 communities throughout the U.S. offered "all bottle" collection programs.[2] That number has likely grown in the past four years with the expansion of single-stream collection service. The result of these comingled collections is that much of this 2.4 billion pounds of bottles must first be "demingled" before any of it can be recycled.

[1] *2009 United States National Post-Consumer Plastic Bottles Recycling Report*. American Chemistry Council and the Association of Postconsumer Plastic Recyclers, http://www.americanchemistry.com/s_plastics/sec_content.asp?CID=1593&DID=11513.

[2] *2006-2007 All Plastic Bottles Recycling Survey*. American Chemistry Council.

Additionally, new efforts are focusing on expanding the collection of non-bottle rigid plastics which include items such as polypropylene (PP) tubs, PP cups and similar food containers. Approximately 55 percent of the non-bottle rigid plastics come from durable goods, such as pallets, crates, buckets and electronic housings. According to a study done for the ACC by Moore Recycling Associates, in 2008, 361 million pounds of non-bottle rigid plastics were collected for recycling. The same study indicated 28 of the 100 largest communities collect non-bottle rigids through curbside collection, with 16 of those collecting rigid plastics beyond bottles and containers.[3]

As of 2008, about 120 of the 570 material recovery facilities (MRFs) in the U.S. were receiving single-stream, or fully comingled, material. To handle this mixed material, MRFs have begun employing automated sorting systems to more efficiently separate the more valuable HDPE and PET containers from the remaining Nos. 3-7, and non-resin mix. When installed in a MRF, automated sorting equipment is most commonly used to generate streams of PET and HDPE, or PET and natural HDPE and colored HDPE. By 2006, 50 MRFs in the U.S. were using automated sorting technology to separate plastics.[4] That number has likely grown, and future demand for sorting equipment is expected to be strong from MRFs in coming years.

In addition to automated sorting technology saving significant labor costs in material sorting, optical and mechanical sorting technology can be highly accurate. Manual sorting can yield higher contamination, particularly in the event that resins are present in the stream that can visually be easily mistaken for another resin. This is particularly the case for PET, PLA and PVC bottles, all which can easily be mistaken for one another by the human eye.

Findings

In 2006, Ron Perkins (R.W. Beck) conducted a study of sortation equipment for the ACC's predecessor that was similar in scope. Building on the foundation of Perkin's assessment, this study standardizes and expands the evaluation criteria for sorting equipment, and includes hand-held units and equipment developed for sorting plastics from electronics.

Growth in Technology

In just four years, technology offerings increased significantly. In 2006, Perkins identified 8 manufacturers of 23 systems. The breakdown of systems was 17 whole-container sorters and 6 flake-sorting systems. Just four years later, 4R identified 19 manufacturers of 54 sorting systems. The aggregated systems breakdown into 267 whole-unit sorters and 27 flake-sorting systems. While both categories of systems grew, the availability of flake sorters grew exponentially. This 2010 calculation includes nine e-plastic sorting systems, while those systems were not included in the 2006 study. However if you normalized the data by removing those ten systems, the industry saw a three-fold increase in flake sorting systems, from six systems in 2006 to 17 systems presently available.

[3] *2009 National Postconsumer Report on Non-Bottle Rigid Plastic Recycling*, American Chemistry Council, http://www.americanchemistry.com/s_plastics/sec_content.asp?CID=1593&DID=10743.
[4] Eileen Berenyi, *The Materials Recycling and Processing Industry in the U.S. 2007-2008 Yearbook*. Published by Governmental Advisory Associates.

Technology Assessment

While each system is different, all automated sorting technologies have three core aspects. Each has a conveyor with some sort of feed regulator. The material is fed through a sensor that analyzes the material and the information is inputted into a computer system which determines how the material will be sorted. The final component is a pneumatic system that segregates material into the desired streams.

Each system was evaluated based on seven criteria, which included:

- Basis of technology
- Primary application
- Resins identified
- Colors sorted
- Throughput
- Accuracy
- Upgrades and optional features

While the information contained in this report is complete for most of the systems, not all manufacturers furnished enough information to populate each field in the matrix. When reviewing the information in the matrix, several issues are important. First, most of these systems are scalable. Many of these units can be sized with wider belts, or other configurations, that can increase capacity. Second, all automated sorting equipment must be maintained and cleaned to attain optimal function and sorting accuracy. Routine upkeep on these units is essential to maintaining optimal performance. Third, the quality of material input will affect purity of output. It is best to sort bottles before grinding it into flake. This will help reduce levels of contamination in the flake. Depending on the level of contamination, it may be necessary to double-sort flake. This can be particularly true for applications that require very high levels of purity, such as bottle-to-bottle recycling. And lastly, in terms of flake sorters, units are designed for an optimal range of flake sizes. Flake that falls outside of that range can negatively impact sorting accuracy.

Basis of Technology

Two primary forms of technology are employed to sort plastics by resin: spectroscopy and x-ray. In short, equipment that uses spectroscopy emits light and each type of plastic reflects that light with a unique signature, or wavelength. A sensor reads that signature and the processing unit decides how the plastic should be sorted. Some examples of spectroscopy technologies include: near infrared (NIR), laser raman and midrange infrared.

The second technology, x-ray, looks at the plastic on an elemental level. These units include both traditional x-ray and xrf, or x-ray fluorescence, which uses secondary (fluorescent) x-rays to analyze material. X-ray technology is particularly useful in detecting elements such as chloride (PVC) and

bromine additives, such as the brominated flame retardants, often found in plastics used in electronics. While PVC can be identified by spectroscopy, additives such as bromine cannot.

Two primary technologies are employed for color sorting. These consist of vision technology which uses cameras, such as CCD linear cameras, and spectroscopy, including visible range spectrometer (VIS). Many of these technologies can see any shade that is seen by the human eye and can differentiate between slight differences in clear PET, such as blue versus green.

What to Expect When Buying Equipment

Pricing for equipment varies based on capacity and features. Buyers can expect to pay in the range of $100,000 to $300,000 for a system that sorts whole containers. Flake sorting can be more expensive with the range averaging $150,000 to $350,000. Flake units can cost upwards of $600,000 depending on the features and manufacturer. This is the estimated cost of buying a piece of equipment from a manufacturer. Keep in mind there are additional costs that are incurred in terms of installation, shipping of the unit, employee training and downtime that may occur during installation and start-up.

In terms of lifespan, most of these units are built to last. Manufacturer warranties typically extend into the 10 to 15 year range, however, some manufacturers report systems remaining in operation 17, or more, years after initial installation. Much of the lifespan of a unit depends on adherence to routine maintenance and cleaning. While many of these systems will operate for years, obsolescence is an issue that can force a unit into early retirement. Obsolescence seems to be less of an issue for MRFs, which are often seeking to maximize the value of PET and HDPE bales, and more of an issue for reclaimers, who desire to remove contaminants down to the lowest levels. One way system manufacturers are addressing the threat of obsolescence is to provide customers with regular software updates that recognize new or unfamiliar packaging that may be introduced into the marketplace and end up in the plastic recycling stream.

Whole unit sorting equipment

There are currently 13 manufacturers offering 27 different units that will sort whole plastic containers. Two of those units are singulated feed, where containers are metered through the sensor individually, and the rest are mass-feed systems.

Whole Unit: Singulated Feed

	Rofin Australia Pty Ldt.	Green Machine
Criteria	**Rapid Sort 75**	**GreenEye**
Basis of technology	NIR and visible spectroscopy	Proprietary, patent pending
Primary application	Separating comingled and contaminated single-resin streams	Sort bottles by resin or color
Plastics identified	PET, PE, PVC, PP, PS, and others as required	Identification of all grades of plastics
Sorts non-bottle rigids in addition to bottles	Yes	
Colors sorted	Clear PET, colored PET, natural PE, colored PE, and other colors as required	Yes
Throughput (average)	Up to 5 bottles per second (equivalent to 1800 lbs./hour) per line	12,000 lbs/hour with 60” belt width
Accuracy	>99,0% (>99.8% of PVC from PET, >99.8% removal of PP from PE)	95% +

Whole Unit: Mass Feed

	MSS		Pellenc		
Criteria	**Aladdin**	**Sapphire**	**Mistral**	**Sirocco**	**Bi-Techno**
Basis of technology	NIR + Color	NIR	NIR	Vision Technology (color)	NIR and Vision technology (color)
Primary application	Obtaining pure streams of PET and HDPE	Obtaining pure streams of PET and HDPE	Obtaining pure streams of PET and HDPE	Color sort for PET or HDPE	Obtaining pure streams of PET
Plastics identified	All resins (PET, PE, PVC, PP, PS, PLA, etc.)	All resins (PET, PE, PVC, PP, PS, PLA, etc.)	PET, PVC, PS, EPS, HDPE, Beverage carton, PP, PE, PLA	N/A	PET, PVC, PS, EPS, HDPE, Beverage carton, PP, PE, PLA
Colors sorted	All colors	No	No	PET: Tri-sort into clear, green, and "other" OR blue, mixed, crystal HDPE: Natural and colored	PET: Tri-sort into clear, green, and "other" OR blue, mixed, crystal HDPE: Natural and colored
Sorts non-bottle rigids in addition to bottles	Yes	Yes	Yes	No	Yes
Throughput (average)	Up to 6 tons/hr for plastic bottles/containers	Up to 6 tons/hr for plastic bottles/containers	13,000 lbs/hour	13,000 lbs/hour	13,000 lbs/hour
Accuracy	92% - 98%	92% - 98%	< 50 ppm of PVC and metal contaminants		98%
Upgrades	All-Metal Detector, Split machine	All-Metal Detector, Split machine	Metal detector unit	Metal detector unit	Metal detector unit

Whole Unit: Mass Feed (continued)

	TITECH	EagleVizion	Visys	Best
Criteria	**Autosort**	**Aquilla Series**	**Cayman**	**NIREX**
Basis of technology	NIR and spectroscopy color detection(also available in just NIR)	NIR	NIR	NIR and vision techknology
Primary application	Obtaining pure streams of material from mixed resins	Obtain pure streams of HDPE and PET	Obtain pure resin streams from mixed plastics or wastes	Obtaining a pure resin stream from mixed plastics
Plastics identified	PET, PETG, HDPE, LDPE, PP, PVC, PLA, PS, HIPS, ABS, PC, PC-ABS, POM, PA, PPO, PMMA	HDPE (color vs natural), PP, PET, PS, PVC, Tetra, PLA, etc.	PET, HDLPE, PP, PS, PE, PVC and others	PET, HDPE, PE, PP, PVC, and others
Colors sorted	All colors	Yes	No	Yes
Sorts non-bottle rigids in addition to bottles	Yes	Yes	Yes	Yes
Throughput (average)	Up to 10 tons/hour	1 to 8 tons/hour (depends on inbound)	On average up to 5 tons/ hour depending on input and unit width	4 tons/hour
Accuracy	99.99% when using multiple machines	90%	Up to 99% depending on the input	Depends on the product
Upgrades		Can be combined with several belts		Can be combined with other sorting units into one tower.

Whole Unit: Mass Feed (continued)

	NRT				S+S	
Criteria	**MultiSort ES**	**MultiSort IR**	**SpydIR**	**VinylCycle**	**Varisort CS-P**	**Varisort NS-P**
Basis of technology	Vision based	NIR	NIR	X-ray	CCD Linear camera	NIR
Primary application	Often used for color sorting PET bottles	Purifying PET, or removing a selected resin from co-mingle	Remove selected polymers from a mixed stream	Remove PVC from PET	Purify PET streams by color	Separate mixed resin streams
Plastics identified	None	PET, HDPE, PP, PVC, PLA, PE, PS	PET, HDPE, PP, PVC, PLA, PE, PS	PVC, PET	No	HDPE, PE, PET
Colors sorted	All colors	No	No	No	All	n/a
Sorts non-bottle rigids in addition to bottles	Yes	Yes	Yes	Yes	Yes	Yes
Throughput (average)	5 metric tons/hour	5 metric tons/hour	5 metric tons/hour	3 metric tons/hour	From 1000 lbs/hour to 20,000 lbs/ hour depending on how the unit is scaled	
Accuracy	95%	99%	99%	99%	Ranges from 90% to 99.8% depending on input	
Upgrades	ColorPlus, MetalDirector	MetalDirector	MetalDirector		Different ejector modules available, up to 320 independently working air ejectors. Sensor modules can be combined in one machine, sensors including metal detector upgrade, 2- or 3- way sorting possible, Visutec Online Quality control	

Whole Unit: Mass Feed (continued)

	Eveready Manufacturing	BT-Wolfgang Binder GmbH		
Criteria	**NIRSort**	**REDWAVE NIR/C Reflection**	**REDWAVE NIR Transmission**	**REDWAVE C**
Basis of technology	NIR and vision spectroscopy	NIR Spectroscopy Color detection	NIR Spectroscopy	Vision spectroscopy with CCD Camera
Primary application	Sort mixed streams of bottles	Separation of opaque, transparent and translucent plastics (beverage containers, rigids and films)	Separation of highly transparent and translucent plastics (films, multi-layer materials)	Separation of plastics by color
Plastics identified	PP, PVC, PE, ABS, PMMA, POM, PC, PC/ABS, PS, and others	PET, PE, PP, PS, PVC, ABS, PC, POM, PU (and all other non-black plastics)	Any thin multi-layer plastic, such as PE with PVC	No
Colors sorted	Yes	Yes	No	Yes
Sorts non-bottle rigids in addition to bottles	Yes	Yes	Yes	Yes
Throughput	2,000 – 4,000 tonnes/hour	Depends on the sorting width and the input material	Depends on the sorting width and the input material	Depends on the sorting width and the input material
Accuracy	99%	Up to 99%, depending on the input material	Up to 99%, depending on the input material	Up to 99%, depending on the input material
Upgrades		REDWAVE NIR/C Reflection	REDWAVE NIR Transmission	REDWAVE C

Whole Unit: Mass Feed (continued)

	RTT Steinert GmbH					
Criteria	**UniSort C**	**UniSort P**	**UniSort PX**	**UniSort Multi5**	**UniSort P4000**	**UniSort RDF**
Basis of technology	Color sensors (Linear cameras)	NIR	NIR	NIR	NIR	NIR
Primary application	Separate PET bottles by color	Sort mixed containers (two sort)	Sort mixed containers (three sort)	Sorts mixed bottles (five sort)	Refuse derived fuel processing	Remove PVC from Refuse derived fuel
Plastics identified	No	PET, HDPE, PP, PS, PVC, tetrapak	PET, HDPE, PP, PS, PVC, tetrapak	PET, HDPE, PP, PS, PVC, and others	PVC, PE, PET, PP, PS and others including tetrapak and film	PVC
Colors sorted	Yes	No	No	Yes	No	No
Sorts non-bottle rigids in addition to bottles						
Throughput	1.5-4 tons/hour depending on sorting width	Depends on sorting width (3 meters/second)	Depends on sorting width (3 meters/second)		2.5-4.0 tons/hour	Depends on material
Accuracy	97%	90% or better	90% or better	80-98%	80-98%	90% in positive sorting
Upgrades						Available in split version

Flake and size-reduced plastic sorting equipment

Currently 14 manufacturers offer 27 different units that sort shredded plastics (this includes plastics commonly referred to as plastic flake), as well as size-reduced non-bottle rigid plastics, such as plastics from electronics.

Flake and size-reduced sorting technology

	Buhler	Pellenc	Rhewum	Unisensor
Criteria	**Sortex Z+ series**	**Mistral + Metal Sensor**	**DataSort**	**PowerSort 200**
Basis of technology	Vision-based and high-resolution infrared sensors	High resolution NIR and Vision technology (color)	CCD camera system, lighting by LED light bars available in various colors, depending on colors to be sorted (e.g. in red for sorting of red/orange/yellow/brown particles)	Ultra-High-Speed Laser Spectroscopy
Primary application	Color sort PET flakes, PVC flakes, pellets, nylon	Shredded e-scrap	Separating particles by color	Producing a high-quality product stream for applications such as bottle-to-bottle recycling
Plastics identified	No	Engineering-grade resins, including: ABS, HIPS, PC, PC-ABS, PP, PU, PMMA	All kinds of plastics, e.g. PET, PE, PP, PS, PVC…	All resins, including: PET, PVC, Nylon, Silicone, PLA and barrier layer material
Colors sorted	Yes – sees all shades of colors	Segregation of black plastics	All colors, only have to be different enough (camera is not able to see more see more than mens eye)	All colors, including black plastic
Throughput	1350 lbs/hour to 2315 lbs/hour depending on model	13,000 lbs/hour	4.0 to 7.5 metric tons/hour	up to 3 tons per hour
Accuracy	99.9% or higher	Metal detector unit	Up to 97%	98% or higher
Upgrades		Mistral + Metal Sensor		

Flake and size-reduced sorting technology (continued)

	S+S			EagleVizion	
Criteria	**Flake Purifier N**	**Flake Purifier C**	**Varisort X**	**Flake Sorter & Large shred Plastics**	**E-plastics sorter**
Basis of technology	NIR	CCD linear camera	X-ray	NIR	NIR
Primary application	Purify resin streams, identifying e-plastics	Color sorting	Identifying BFR-containing plastics	Obtain pure stream of PET or HDPE	Sort shredded plastics from electronics
Plastics identified	PET, HDPE, PLA, PVC, and more	No	BFR- and chloride-containing plastics	PE colored, PE natural, PET, PVC, PS and others	ABS, PS, PP, PA, PVC, PE, PET, PBT, PUR, PC, PMMA, PC+ABS, ABS+PVC, PPE+SB
Colors sorted	No	Yes	No	No	No
Throughput	From 1000 lbs/hour to 20,000 lbs/ hour depending on how the unit is scaled		1,000 lbs./hour to 5,000 lbs./hour	In qualifying phase	In qualifying phase
Accuracy	Ranges from 90% to 99.8% depending on input		Depends on FR content	In qualifying phase	In qualifying phase
Upgrades	Different ejector modules available, up to 320 independently working air ejectors. Sensor modules can be combined into one machine. Metal detector upgrade available.		None	Duel Ejection	Duel Ejection

Flake and size-reduced sorting technology (continued)

	Satake				
Criteria	**Scanmaster IE**	**MikroSort AF**	**ScanMaster XE**	**RGB Full Color Belt Sorter**	**PelletScan**
Basis of technology	High resolution CCD Camera	CCD Linear cameras	Proprietary InGas/Color camera technology	Full Color Cameras (RGB)	High-res CCD cameras
Primary application	Color separations (green and other colors from clear, brown from green, toasted PVC from PET)	Sorting PET flake by color	Removing clear PVC from PET, and other non-plastic contaminants	Color separation (green and other colors from clear, brown from green, toasted PVC from PET)	Used for sorting pelletized flake (looking for black specks)
Plastics identified	PET, Toasted PVC	None	PET, PVC, PLA, EBOH and other low-melts	PET, Toasted PVC	No
Color sorted	Yes	All, including slight color differences (e.g. blue, light blue and light green)	No	Yes	Yes (color sort only)
Throughput	500-10,000 Lbs/Hr	1-3 tons/hour	500-10,000 Lbs/Hr	Up to 6,000 lbs/hour	2,000 – 5,000 lbs/hour
Accuracy	Up to 99%		70% - 95% +, depending on particle size, contamination levels and other variables	Up to 99%	Up to 99%
Upgrades	Toll workers kit, Satake Everywhere remote monitoring, DataScan				DataScan

Flake and size-reduced sorting technology (continued)

	BT-Wolfgang Binder GmbH	Innov-X & BT-Wolfgang Binder	RTT Steinert GmbH	Mogensen
Criteria	**REDWAVE XRF Plastics**	**Redwave QXR**	**UniSort PM**	**MikroSort AF**
Basis of technology	X-Ray Fluorescence	XRF	NIR	CCD Linear cameras
Primary application	Separation of flame retarded plastics and Chlorides	Purify PET and WEEE streams Purify Auto Shredder Residue	Removal of PVC and metal from shredded scrap	Sorting PET flake by color
Plastics identified	BFR and chloride-containing plastics	Can remove black PVC and BFR containing plastic	PVC	None
Colors sorted	No	No	No	All, including slight color differences (e.g. blue, light blue and light green)
Throughput	Depends on the sorting width and the input material	- *	2.5 to 8.0 tons/hour	1-3 tons/hour
Accuracy	Up to 99%, depending on the input material	- *	80%	
Upgrades				

* System is currently being developed, using proven XRF technology. Expected market release is Q3 2010.

Flake and size-reduced sorting technology (continued)

	Visys			MSS	
Criteria	**Spyder**	**Python**	**Tyrex**	**E-Sort**	**L-VIS**
Basis of technology	Lasers	Lasers and cameras	X-ray	NIR, Color and metal sorting	High resolution color camera
Primary application	Separation of plastics based on structure or color differences	Sortation of various streams based on color, structure or shape differences	Density separation in applications such as ASR, WEEE and plastics	Sorts shredded plastics from electronics	Color separating flake, pellets and e-scrap
Plastics identified	No	No	BFR and chloride containing plastics	All resins, including: ABS, HIPS, PC, PC-ABS, etc.	n/a
Colors sorted	Yes	Yes	No	All Colors	All Colors
Throughput	1 – 3 Tons/hour	1 – 3 Tons/hour	1 Ton/hour	Up to 6,000 lbs/hr	Up to 8,000 lbs/hr
Accuracy	Up to 99% depending on the input	Up to 99% depending on the input	Up to 99% depending on the input	92% - 98%	93% - 99%

Flake and size-reduced sorting technology (continued)

	Best			
Criteria	**Ixus**	**Genius**	**Helius**	**NIREX**
Basis of technology	X-ray	High-res CCD cameras, lasers (including NIR, UV, LED or fluorescent lighting)	Lasers	NIR and vision techknology
Primary application	Shredded e-scrap	Purifying a selected stream, removing color contaminants	Purifying a selected stream, Removing color contaminants	Obtaining a pure resin stream from mixed plastics
Plastics identified	BFR- and chloride-containing plastics	PET, HDEP, PE, PP, PC, PVC and others	PET, PVC, others	PET, HDPE, PE, PP, PVC, and others
Colors sorted	No	Yes	Yes	Yes
Throughput	1 ton/hour	2 tons/hour	1.5 tons/hour	4 tons/hour
Accuracy	Depends on product	Depends on product	Depends on product	Depends on the product
Upgrades	Cameras and lasers can be added depending on the application			Can be combined with other sorting units into one tower.

Hand-held devices

In addition to automated sorting technology, a number of hand-held resin identification devices are on the market. These devices serve a different function than automated sorting technology, which identify and sort high volumes of mixed plastics. Rather, these hand-held units are used to identify large volumes of similar material. Many hand-held units are used to identify products such as carpet and other flooring, electronic housings and other large or bulky items. These portable devices can provide important information for buyers and reclaimers during inspection of material, providing information so they know exactly what materials they are accepting. Likewise, hand-held devices are an efficient way to identify material in bulk. Companies offering hand-held scanning devices include:

- *Advantage Analytics:* Uses NIR technology to identify 15 resins, both olefins and engineering resins.
- *Polychromix:* PHAZIR unit uses NIR to identify nylon varieties, PP and PET.
- *Axsun Anavo*: NIR technology identifies a wide variety of resins and flame retardants.
- *Spectro:* Xrf technology detects cadmium, bromine and other potentially prohibited materials under the Restriction of Hazardous Substances (RoHS) regulations.
- *PowderTech:* NIR technology identifies plastics and potential additives.
- *Innov-X:* Xrf technology for testing Waste Electrical and Electronic Equipment (WEEE) plastics for BFRs.

Future outlook for automated sorting technology

Demand for automated sorting technology for plastics will continue to grow over the next ten years. A number of factors will drive demand for these systems, including continued trends in co-mingled collection of materials, the move by more MRF toward automation, and increasing labor costs that will necessitate a switch to automation. Efforts are also underway to expand the resins that are recycled, and those efforts are reaching far beyond just PET and HDPE. As collections increase, new opportunities are created for optical sorting installations. Industry experts predict a number of trends will shape the demand and use of automation in plastics recycling.

Industry consolidation will continue. Since 2006, a number of consolidations and mergers have occurred amongst equipment manufacturers. In the past four years, Buhler acquired Sortex, TiTech purchased Commodas, a joint venture between Innov-X and BT-Wolfgang Binder GmbH was born, and a merger between RTT and Stienert occurred. Much of this activity is viewed as a result of industry maturation, and this trend will continue. More activity is expected in the development of partnerships to offer turnkey operations and installations. Such alliances have already been forged between Bulk Handling Systems and NRT, and CP Manufacturing and MSS. Alliances of this nature are expected to grow, particularly to meet the needs of MRFs as they modernize and expand.

Adoption of sorting equipment in export markets (China, India, etc.) will be slow in the near-term, but grow in next ten years. Automated sorting technology has largely not been adopted in

developing countries, such as China, because low labor costs do not justify the capital investment in equipment. However, labor costs are rapidly increasing in China, rising up to 25 percent a year in some industries.[5] As labor costs climb, and an increased push is made by the Chinese government to modernize the recycling industry, a huge opportunity may develop for equipment manufacturers to sell into China over the next ten years.

New companies offering technology for flake and size-reduced sorting will emerge. Growth in flake sorting technology is the result of a number of factors. For instance, more food sorting equipment manufacturers are diversifying into the plastics industry (the same technology that is used to sort beans can be modified to sort plastic flake).

Multi-layer bottles and barriers, and new types o f labels will likely continue to present challenges for automated sorting equipment. The current generation of optical sorting technology largely cannot identify and segregate bottles with barrier layers. Units that claim to be able to identify barriers are beginning to come to market. PVC and PETG labels also continue to be a problem for sorting equipment, causing mis identification of PET bottles with those labels, resulting in the loss of PET in the sortation process.

Technological improvements are on the horizon for black plastics. The technology behind automated sorting systems has changed drastically in ten years. The NIR capabilities of today are much broader than those offered by the last generation of equipment. Despite these advancements, there remains one fraction of plastic stream that spectroscopy cannot properly identify, and that is black plastic. Black carbon, which is the most common pigment additive for black plastic, absorbs the infrared signal, or light, rather than reflecting it back, so the plastic can be identified. New technologies are being commercialized that can better identify black plastic.

[5] Bradsher, K. "Investors Seek Asian Options to Costly China." *New York Times.* June 18, 2008. http://www.nytimes.com/2008/06/18/business/worldbusiness/18invest.html.

Appendix A: Sorting Technology Manufacturer Contact Information

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