# *Automated Sorting Systems*

**Issue:** *To meet the quality standards represented in these Best Practice specifications for PET bales and PET regrind, sorting systems should be installed that are designed to remove contaminants to the PET recycling process.*

**Best Practices:** Like manual sort systems, the efficiency and throughput of many auto-sort systems is primarily a function of incoming bale quality and debaling capacity. The effectiveness of of auto- sort systems is often a function of how well bottles are separated from one another, or "singulated," prior to passing over the detection head. Therefore it is critical that adequate debaling capacity is in place to achieve this level of bottle singulation. The density of incoming bales will determine the ease and rate at which they can be debaled and fed into the auto-sort system. Bale density will also determine the extent to which bottles are flattened which can adversely affect the performance of certain auto-sort technologies.

The rejected materials from auto-sort systems should be collected, manually sorted and passed back through the system to eliminate losses of mistakenly rejected PET bottles.

While auto-sort technologies provide a highly pure stream of PET plastic bottles and containers to feed granulating equipment, a best practice is to design an auto-sort system with one last inspection and sort for PVC just prior granulation infeed. The secondary sort can be manual or automatic.

Any facility operator that utilizes auto-sort technologies must ensure compliance with all safety and other regulatory requirements to which its use is subject. For example, all auto-sort technologies that use electromagnetic frequency (EMF) detection technologies should be properly shielded to eliminate any worker exposure to EMF. And, the use of X-ray sorting technologies requires registration with the federal Nuclear Regulatory Commission.

A discussion of automated, X-ray, and near infrared sortation systems follow.

Automated sorting technologies (referred to generically as "auto-sort" systems) are increasingly used at the intermediate processing level and even more extensively by reclaimers and end-users to obtain contaminant-free streams of PET bottles and containers for subsequent processing. There are many different types and manufacturers of auto-sort technologies on the market today, but they can be classified into three basic types. These technologies employ some type of detection signal that can differentiate plastic bottles based on chemical or physical characteristics when that signal is detected and analyzed by a sensor.

The first type of auto-sortation is through optical sensoring. Optical sorting systems use visible light to separate plastic bottles by color. The second type are systems based on "transmission technologies" whereby a signal passes directly through the bottle and is read by a sensor on the other side of the bottle. Each plastic resin has a characteristic response to the signal based on its unique chemical composition. The third type are surface scanning devices where the signals bounce off the surface of the bottle and are reflected back to the sensor for identification. Similarly, each plastic resin type has its own unique response. When a sensor detects what it is looking for, it will generally activate an air jet that will eject or direct the item it has positively identified. The major sortation technologies in use today include optical, X-ray transmission (XRT), X-ray fluorescence (XRF), and near-infrared (NIR).

Some auto-sort technologies are capable of multiple sorts, by both resin type and color, while some are known as "binary-sort" systems -- namely those that identify just one item and separate it from a stream of bottles. The first generation of auto-sort technologies were binary-sort systems primarily developed to provide reliable separation of two visually similar, yet highly incompatible plastics from a recycling perspective -- namely PVC and PET. As has been discussed, PVC is a major contaminant in PET recycling even at very low concentrations.

The current state-of-the-art in auto-sort technology combines several types of sensors to provide multiple sorting functions for streams of commingled plastic resin types. For example, one commercial system uses an XRT sensor to separate PVC bottles, then an infrared sensor that separates bottles into clear, translucent and opaque categories, followed by optical sensors that sort bottles by color, and finally an NIR sensor to separate the bottles by resin category.

A brief overview of the major types of auto-sort systems in use today at PET plastics recycling facilities follows, including their limitations and advantages.

*X-Ray Sortation*: Auto-sort technologies based on X-ray detection are generally considered to be the most reliable binary-sort method to remove PVC from a stream of predominantly PET bottles. This is because X-ray sensors only detect the presence of the chlorine atom found in PVC bottles, which is absent in PET bottles. This makes it extremely accurate for differentiating between PVC and PET, but not for identifying other plastic resin types.

There are two kinds of X-ray detectors currently available. The first is X-ray transmission (XRT) and the second is X-ray fluorescence (XRF). XRT signals pass through a bottle and are read by a sensor on the other side. Because XRT signals pass right through a bottle, they ignore such items as labels and other surface contaminants that can lead to false readings with other detection systems. This technology has

additional benefits in that it can read the chemical content of bottles when they are stuck together, which is a common occurrence when bales are packed too densely. For example, if a PVC bottle is stuck to the bottom of a PET bottle as it passes over the sensor, the signal will pass through the two bottles and detect the PVC bottle and eject both bottles from the stream.

The primary drawback to XRT systems is that flattened or partially flattened bottles can scatter the detection beam, which prevents the sensor from getting a reading on the other side. XRT systems are programmed to eject bottles that it cannot read. A good way to prevent losses of PET that may result from this or from bottles that are stuck together and ejected is to physically separate rejected bottles by hand and pass them through the system again.

In XRF detection systems, the X-ray detection signal bounces off the bottle surface and the reflected signal is read by the sensor. The limitation with all surface scanning techniques is that it will not detect a PVC bottle that is shielded from the signal by another bottle. Therefore it will not detect a PVC bottle that is stuck to the back of a PET bottle as it passes over the sensor. In addition, surface scanning signals might be affected by surface contaminants such as labels and caps and may cause PET bottles it be incorrectly ejected. If using XRF or other surface scanning auto-sort technologies it is important that the system be designed to provide a "singulated" stream of bottles (one bottle at a time) passing over the signal and sensor. This is usually a function of debaling and how well bottles are separated prior to entering the auto-sort system. This will prevent the shielding effect described above that can allow PVC to stay in the PET bottle stream.

Because X-rays are a form of radiation, precautions must be taken to protect workers from exposure. X-ray systems include sophisticated shielding to eliminate worker exposure. In addition, X-ray detection systems must be registered with the Nuclear Regulatory Commission.

*Near Infrared Sortation*: Near infrared (NIR) is a portion of the light spectrum that is invisible to the human eye. When plastic bottles are exposed to NIR signals, each plastic resin will absorb the light in its own unique way, which can then be detected by the sensors. Therefore NIR it has the ability to differentiate between a wide range of plastic resin types, depending on the specific system design.

Like XRT, NIR signals pass completely through the scanned plastic bottle and can detect bottles that are shielded by other bottles when passing over the sensor. An advantage of NIR systems is their ability to detect multi-layer and composite container structures. Some of these containers can pose contamination problems in the PET recycling process and are difficult to identify visually. The ability of NIR to distinguish these containers is

increasingly important for PET processors, given the proliferation of multi-layer and composite container constructions in the packaging waste stream.

However, also like XRT, NIR detection signals can scatter inside partially flattened containers, which prevents the signal from being read by the sensor, causing the container to be ejected. The advantage to X-ray detection systems is that NIR systems involve no known workplace hazard issues.