PATRICK ENGINEERING INC.

Best Operational Practices Manual For Materials Recovery Facilities and Recycling Drop-off Facilities

Prepared for
Illinois Recycling Association

Celebrating 25 years Recycling in Illinois

Funded By:
Illinois Department of Commerce and Economic Opportunity

September 2005

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Acknowledgments

The Illinois Recycling Association and Patrick Engineering would like to thank the following persons fro their assistance in providing review, comments and input on early drafts of this document (in alphabetical order):

Steve Apotheker, Portland Metro
Chad Braatz, Tri-County Resource & Waste Mgm't. Council
Bart Hagston, Jackson County Health Department
Paul Jaquet, Eagle Enterprises Recycling Inc.
David Kramer, Illinois Department of Commerce and Economic Opportunity (OHSA)
Greg Maxwell, Resource Management Companies
David Smith, Illinois Department of Commerce and Economic Opportunity (Recycling)

We would also like to thank the recycling facility operators who participated in this study by taking time out of their busy days to fill out a lengthy survey, conduct tours of their facilities, and answer our endless questions.

Contact the Illinois Recycling Association at www.illinoisrecycles.org

1.0 INTRODUCTION

The Illinois Recycling Association (IRA) is pleased to provide this Best Operational Practices Manual (BOPM) as a tool to further advance professional recycling in Illinois. IRA gratefully acknowledges the Illinois Department of Commerce and Economic Opportunity who provided funding for the development of this manual and their continuing support for recycling in Illinois.

Over the last two decades contemporary recycling has witnessed many changes in collection, processing and marketing of commodities. There are different processing systems that operate as a function of the differing collection systems that are in place or being considered. Furthermore, increases in the types and quantities of commodities recovered in existing or new programs may require facility technology and equipment retrofits. The purpose and intent of this manual is to assist those Illinois counties, cities and businesses that own/operate materials recovery facilities (MRFs) and recycling drop-offs to evaluate their operations in accordance with Best Operational Practices (BOPs) to reduce negative environmental impacts, advance safety consciousness, improve processing efficiencies, reduce operating costs, and increase the potential to increase revenues for the materials recovered. This manual describes systems and procedures that can be employed by recycling facilities to operate as successful commodity businesses without the need for any special or environmental protection permits.

This guide addresses operations of facilities that accept materials intentionally separated from the commodity/waste stream by generators for the purpose of recycling. Although there are some commonalities in their operations, it does not include transfer stations, resource recovery facilities or so-called "dirty" MRFs, which may separate recyclable materials from mixed waste.

Eleven recycling facility operators across the state of Illinois were interviewed to bring practical experience and practicable recommendations to this manual.

Section 2 summarizes the results of these interviews. Section 3 takes the findings of the individual interviews, as well as other documented BOPs from other MRFs and industry sources, and lays out the concepts and practices that contribute to improved processing efficiencies, reduced operating costs, and increased revenues from the sale of recovered materials. Though not applicable to all situations, most MRFs using this guide should find useful ideas and practices that will help improve their overall operations. Section 4 discusses maintenance issues. Section 5 reviews the health and safety issues that a recycling facility operator may encounter and provides and a self-assessment checklist is provided as an appendix to help evaluate compliance with safety and health standards. Section 6 discusses good neighbor practices and environmental considerations. Finally, Section 7 discusses drop-off operations.

2.0 RECYCLING OPERATION INTERVIEWS

TABLE 2.0. FACILITY COMPARISON							
Facility #	**Type**	**Ownership**	**Approx. size (Tons/Mo.)**	**Input Stream**	**Comm./ Resid.**	**Employees (full/part/vol)**	**Began Operation**
1	MRF	Private	14,000	90% single stream, 10% separated	15% / 85%	69/0/0	1997
2	MRF	Private	7000	99% single stream, 1% separated.	0% / 100%	60/0/0	
3	MRF	Private	9900	81.5% single stream/ 14% dual/ 4.5% separated	18.5% / 81.5%	90/0/0	1997
4	MRF/Drop-off	Private	125	Source separated	80% / 20%	6/4/2	1995
5	MRF	Private	2000				
6	MRF	Private	400	Approx equal single, dual and separated	5% / 95%	11/3/0	1973
7	MRF	Private	220	45% single stream/ 55% separated	55% / 45%	3/1	
8	MRF/Drop-off	Not-for-Profit	1000	Source separated	60% / 40%	3/2/4	1988
9	MRF/Drop-off	Public	90	3% single stream / 97% separated	60% / 40%	4/1/0	
10	MRF/Drop off	Private		Dual stream		13/4/0	
11	Drop-off	Public/ private	12-17	Single stream	75% / 25%	1/0/0	1992

(Notes: vol = volunteers)

Facility 1. Facility 1 was the largest and most fully automated of the MRFs visited. Located in Northeastern Illinois, it processes primarily single-stream recyclables from residential curbside programs and operate two shifts daily. The facility is still expanding and is in the process of installing additional sorting lines.

Incoming materials are dumped on a large tip floor where a wheel loader is used to move the mixed recyclables to an inclined conveyor which feeds a presort conveyor. The loader also mixes incoming loads in order to help provide a consistent feed down the line. Four sorters then remove bulky items, garbage and other throw-outs and open and remove plastic bags. From there, materials pass over a disk screen which separates OCC and then over a series of three finger-disk screens which separate out the containers and direct two streams of paper to an upper and lower sorting deck. On these decks, sorters remove sorted office paper (SOP), sorted white ledger (SWL), hard mixed paper and residues. The negative sort on the both decks is #8 newsprint. A third conveyer is used for sorting a #6 newsprint. The conveyors are equipped with variable speed controls to optimize the depth of material on the conveyors and the sorting speed. A total of 30 sorters work each shift along with a number of equipment operators.

Sorting of the container stream is fully automatic. The first stage is a trommel magnet, which removes dirt, broken glass, and separates steel cans. From there, an air classifier removes plastic and aluminum from remaining glass containers and transports them to a perforator/flattener. All materials then drop onto an accelerator conveyor where they pass through an optical sort unit that uses sensor-controlled air jets to remove all plastic bottles. Bottles are not sorted by resin type. At the end of the line a final sort for UBCs is done with an eddy current separator.

Residuals from the sorting process amount to about 7.5% of the incoming materials. The residues are either baled or compacted and disposed of daily.

The ONP products are stored in live bottom bunkers and OCC and other paper are kept in push through bunkers. Container bunkers are gravity feed to the baler in-feed conveyor. Two, twin-ram balers are used - one for fiber and one for metal and plastic containers. The balers can act as backup for each other in case of breakdowns. Fiber and plastic bales are stored indoors under roof. Aluminum and steel can bales don't get a roof. All materials are normally shipped out in a week or less, most fiber daily.

While the automated system works rapidly and efficiently – it only takes three minutes for material to get from one end to the other – it does create certain operating problems. For example:

- Disk screens do not handle shredded paper well and small paper shards can end up flying. Bags of shredded paper are pulled off in the presort area and added to the office mix manually.
- Large and flattened plastic bottles can sometimes make it over the disk screens requiring them to be manually recovered from the OCC and ONP streams.
- The finger-disks used in the paper screens are made from molded rubber and experience significant wear. They require replacement every 45 days.

Facility 2. Facility 2 is a large, mechanized MRF located in the Chicago area that processes materials from single-stream curbside collection programs. It was converted from a dual-stream system in the year 2000, and went to a double-shift to handle the extra processing and materials.

From the tip floor, a wheel-loader moves incoming material to an inclined conveyor, which feeds a presort line. The loader tries to keep material spread out so it isn't mounded on the presort line. On the presort line, eight sorters open bags and remove refuse and OCC.

Two star-disk screens then separate ONP from the mixed paper and containers, which is then positively sorted manually for quality control to produce a #8 newsprint. A third disk screen, angled and inclined, sends mixed paper over the top and containers off one side while glass falls through. The mixed paper is also positively sorted. A total of 11 sorters work the three paper lines.

The container stream passes through one more disk screen to remove fines and any remaining glass. Four sorters then separate plastics by type, followed by a magnetic cross belt to remove steel cans. An eddy current separator does a final positive sort for aluminum.

The burden depth on the sorting conveyors is controlled by variable speed drives. The bunkers under the paper lines have in-bottom conveyors, which directly feed the baler in-feed conveyor. The container bunkers have sloped bottoms that allow them to gravity-feed the baler conveyor. A single, fully automatic, high volume baler is used for all materials.

All baled materials are stored indoors. Glass is stored loose in an outdoor bunker. Residues from the sorting lines are stored in two compactors, which are dumped once or twice a shift. Residual rates run about six percent.

The operator finds labor costs to be high for this facility and would like to add additional, technologically advanced equipment to reduce labor and processing costs.

Facility 3. Facility 3 is another large MRF located in the greater Chicago area and is co-located with a transfer station, though the operations are separate. The facility processes materials that the company collects by providing single-stream, curbside collection services to 20 municipalities in the area, as well as commercial services. Trucks entering the facility dump their loads over a short knee wall down onto the tipping floor, which is on a lower level. This allows loads to be dumped on top of previous loads reducing handling of materials in the receiving area. Three such bays are used, with commercial cardboard and paper kept separate from residential mixed recyclables.

A wheel loader and four conveyers move materials from the tip floor to an inclined OCC disk screen, which begins the sort process. While some bags are removed manually on the tip floor, the OCC screen doubles as a bag breaker. An ONP disk screen follows the OCC screen. A final, tilted and inclined disk screen separates the remaining paper over the top, cans and plastic bottles off the side and glass and other residues through the bottom. All the feed conveyers, screens and sorting conveyers are variable speed. The three paper streams (OCC, ONP and other) are negatively sorted manually for quality control to produce clean OCC, #8 and #6 Newsprint, sorted office paper, and mixed paper. Eleven to twelve sorters work the paper lines. Shredded paper is not processed through the sorting line but is kept separate and added to the office paper before baling.

The glass is sent through a final trommel and is sold as mixed broken glass. The commingled metal and plastic containers are not sorted on-site, but are transferred to another MRF where they are processed under contract for $140/ton (April 2005) minus the market value of the sorted materials.

A redundant pair of two-ram balers is used to bale paper. Paper storage bunkers feed directly to the balers through chutes that are controlled remotely from a central location. All bales are stored indoors and are shipped to market within 1-3 days.

Residue rates for Facility 3 vary from 7 to 12 percent and are a concern for the facility manager. Even with the transfer station on-site, the cost of disposing of residues is high in this area. If too many recyclables are observed in the residuals, they are reprocessed. If commercial loads contain too many contaminants, the customer receives a charge for trash disposal.

Facility 4. Facility 4 is located in a small town in western Illinois and provides all the recycling services for the town and some of the surrounding areas. It operates a source-separated curbside collection program for about 3500 households and a drop-off at the main location. A mobile drop-off is also staffed at a nearby community two Saturdays a month. The main drop-off is open 7a.m.-5p.m. on weekdays and 8a.m- noon on Saturdays. Users drive up to the main entrance and staff will unload their vehicles and hand sort the recyclables inside the building. Unacceptable materials remain in the vehicles. They claim their users have become very good about knowing what they can and cannot drop off.

However, the bulk of their business is commercial materials, with cardboard from a local food packing plant their biggest account. They also handle used clothing from a charitable reuse operation in town. It is interesting to note, that since they were storing bales of clothing for long periods to get shippable quantities, there was concern about mice nesting in the bales. Adding a cat to the staff solved the problem.

Most of the pre-baling storage is done in gaylords or similar containers. Glass is sorted by color and crushed. Plastic bottles are sorted into natural and colored HDPE and PET and baled using dedicated vertical balers for each. Final contamination control is done as the balers are loaded.

Paper, OCC and metals are baled in a large horizontal baler. In a somewhat unique situation, this position was formerly held by an agricultural hay baler with hay chopper and fed by a manure spreader acting as a conveyor. The chopper and manure spreader are still in use feeding the in-feed conveyor to the baler. Magazines, steel and aluminum cans get a final manual sort for quality control on the spreader. Paper and OCC are chopped prior to baling. The operator claims chopping produces a tighter, denser bale and that some markets will pay a premium for the pre-chopped paper as it saves a step for them in their pulping process. Increased litter from tiny paper shreds appeared to be one downside. They estimate their residue rate at approximately 0.12 percent.

The operation was moved to its current location for more storage space. While the current location is located next to a rail line, they have not found the economic justification to install a spur to enable them to ship by rail. Several loading docks provide access to trailer trucks from the rear of the facility.

<u>Facility 5.</u> Facility five provides a variety of recycling processing services for one of the large central Illinois population centers. It processes materials from drop-offs countywide, single- and dual-stream residential curbside programs, commercial recycling haulers and its own commercial recycling services. The site also incorporates a metal scrap/buyback operation. Glass containers are accepted at the facility only if source-separated and are both received and stored outdoors in open bunkers.

Mixed recyclables and source-separated recyclables arriving at the facility are staged in different areas of the tipping floor. Most cardboard is picked on the tip floor and put directly on the baler in-feed conveyer. Other materials are moved to an inclined conveyer that feeds an elevated sorting line. All sorting is done manually with the exception of a self-cleaning magnet used to remove steel cans from the sorting conveyer. Beneath the sorting stations are located four bunkers (Three push-throughs and 1 live-bottom) that empty onto the main baler in-feed. One of the bunkers is also fed with aluminum cans through a pneumatic conveyer from the metal scrap/buyback side of the facility. Different grades of paper may be sorted depending on the incoming source material. Residue rates were not available but appeared to be high with a significant amount of un-recovered recyclables in the waste stream.

A single large baler handles all paper and containers. Several vertical balers are used for scrap metals and aluminum foil. All baled materials are stored indoors. The loading dock is equipped with an in-floor scale for weighing bales and dock levelers to make forklift access to trucks quick and easy.

The facility operator enforces a strong safety policy including personal protective gear and insists that good lighting, including daylighting, is an important safety aspect of his facility.

<u>Facility 6</u>. Facility 6 processes mainly residential recyclables from curbside and drop-off programs. It is one of several processors operating in one of Central Illinois' population centers. The company provides curbside service in the city and services drop-off programs over a two county area. They also accept materials from other private haulers. Recyclables are received both sorted and unsorted. The materials acceptance policy is especially broad in that all fiber, all metals, all plastics and three colors of glass are accepted.

All materials are hand sorted starting with OCC and bundled ONP, which are picked off the tip floor into three cubic yard dumpsters. A skid steer is used to load the remaining materials into a hopper, which feeds a short sorting line. The sorters start and stop the belt to load it in batches and positively sort all recyclables into containers. Residuals amount to about 5 percent of the materials received.

Prior to baling, plastic bottles are stored in six cubic yard nylon bags and other materials in dumpsters. All materials except glass are baled. Sorted glass is stored in gaylord boxes but is not crushed. Sorters were observed throwing bottles into sorting containers to manually break glass. Since the facility suffers from a lack of indoor space, all sorted materials are stored outdoors, with fiber and plastic bales and gaylord boxes under tarps. There is no loading dock at the facility.

The operator is in the planning stage of a major expansion of Facility 6 to include a large increase in floor space and storage bunkers or silos for sorted materials to help eliminate double handling and lean-to structures for covered storage. With these improvements he plans to significantly increase his throughput with no increase in labor.

<u>Facility 7</u>. Facility 7 operates and receives materials from a single-stream curbside collection program in one of the middle-sized population centers in central Illinois. They also receive materials from commercial accounts and from drop-off boxes from surrounding communities.

Facility 7 has recently mothballed its sorting line in favor of an agreement with a much larger MRF in Northeastern Illinois. All commingled recyclables, including glass, from the curbside and drop-off programs are loaded, loose and unprocessed, into a transfer trailer for shipment to the larger MRF. They are paid at a rate averaging about $33 a ton (March 2005).

Materials from their commercial accounts consist primarily of paper, OCC, and chipboard and bookbindery cuttings, which are source separated. The commercial paper is stored and shipped in gaylords. OCC is baled in a horizontal baler and the cuttings are baled in a high-density vertical baler. OCC bales are stored outdoors.

The operator wishes to eventually remove the sorting line and a compactor that was previously used for residues, and install a pit and loading dock to make loading the transfer trailer easier and more efficient. A loading dock is currently in use but it is not attached to the building, making loading weather-dependent.

Facility 7 is located alongside a rail line, but it does not have the volumes that would make rail shipment practical.

Facility 8. Facility 8 is a not-for-profit operation located in a large, mostly rural county in southwestern Illinois. The facility operates both as the recycling drop-off for the largest city in the county and as a processing center, accepting recycling trailers from other communities. They also operate a subscription (fee) residential curbside collection program, collect from commercial accounts and provide several surrounding communities with "Drop-off Saturday" collections. The curbside program serves 170 households and represents about 10% of their incoming material. The organization also operates drop-off and processing operations in two other towns in the county. They collect and process cardboard, magazines, newspaper, office paper, aluminum and steel cans, glass and plastic containers and scrap aluminum at each location.

The drop-off is staffed 8-5 on weekdays but is open to the public 24/7. Two cubic-yard, self-dumping hoppers are the primary collection containers. Dumping of trash has not been a severe problem but they do occasionally receive unwanted materials. Since all the material the MRF receives is source-separated, there is no sorting line, however employees routinely monitor drop-off bins and the conveyor to the horizontal baler and remove unwanted materials. Their residual rate is estimated at less than 5 percent.

All materials except glass are baled. Glass is sorted into clear and mixed, and crushed. Their market for clear glass requires no caps or rings, but manually removing caps and rings proved too labor intensive. So clear bottles with caps or rings are added to the mixed glass stream.

With the exception of OCC and steel cans, baled materials are stored indoors. OCC and steel cans are moved to market rapidly enough to avoid weather-related degradation. Though the facility achieves a good throughput for its size, they have had to hold some materials for an extended time to achieve transportable quantities. For example, they can go over a year between shipments of mixed plastic bales.

Improvements that are planned for Facility 8 include expanding the storage building, improving the drainage and surfaces of the driveways, parking and shipping areas, and establishing a regular schedule of operations. The facility has a portable loading dock and has just recently added a second permanent dock.

Facility 9. Facility 9 is a county-owned and operated MRF and drop-off that provides recycling services to a large rural county in southwestern Illinois. The facility is subsidized by landfill tipping fee surcharge funds. In addition to drop-off collection at the facility, they also provide commercial collection in two cities and service drop-off locations in five other communities. The drop-off is open to the public at all times but staff is only available during the MRF operating hours. They accept a variety of fiber products, metals and #1 and #2 plastics, but no glass. Gaylords are used as drop-off containers and for storage of materials prior to baling. Some commercial customers have their own small balers and some paper and OCC arrives prebaled. They do not often re-bale these materials. The operator has made personal visits to customers if contamination levels get too high. Residuals are estimated at about two percent.

They do very little sorting, except for contamination control on the baler in-feed, but do bale several different grades of paper. Plastics are baled mixed. Sorting HDPE from PET manually did not prove economical. All materials are stored inside the building, where a ramp leads to a single loading dock. Like most, this operator wanted more storage space.

Facility 10. Facility 10 is a regional processing facility in southern Illinois that handles materials from dual-stream residential collection programs, drop-off facilities and commercial collection programs. This facility incorporates an indoor drop-off and electronics waste drop-off and was the smallest visited that had its own truck scales.

Paper and commingled containers are received on different tip floors. There is no sorting line for paper except to separate cardboard on the tip floor, but different grades of paper may be baled depending on incoming material. Commingled containers are moved to an elevated sorting line where all containers are positively sorted. First, plastics are sorted manually, after which a cross-belt magnet removes steel cans. Sorters then remove glass containers, and finally aluminum is removed with an eddy current separator. Residue rates were not available but they appeared to be high with a significant amount of un-recovered recyclables in the waste stream.

Containers are stored in inclined bottom cages, which are moved to the baler when full. One baler is used for all containers and paper and a second is reserved for OCC. A small vertical baler, located near the drop-off, is used to recover plastic film and bags.

All materials are stored indoors or in staged trailers. The facility has five loading docks available. The facility also has a rail spur available but it is not currently in use.

Facility 11. Facility 11 is a staffed drop-off located in a large urban community in northeast Illinois. A curbside collection program already services the community, but the drop-off is provided to service apartment dwellers and small businesses. While located on public property, a private recycler manages all operations. An area MRF operator sites two, 30 cubic yard roll-offs for paper and containers and provides the attendant, and a local scrap dealer spots a dumpster for bulky scrap metal. The MRF operator also provided site improvements including concrete paving. The location is fenced and is open Tuesday, Thursday and Saturday from 8 a.m. to 4 p.m. The attendant helps people unload their vehicles, watches for unwanted materials and litter, and answers questions and hands out flyers to those who bring material. Residue rates from the drop-off are estimated at less than two percent.

3.0 OPTIMIZING EFFICIENCIES IN MRF DESIGN AND OPERATIONS

One of the goals of this manual is to take the knowledge gained in the facility assessments, combine it with other "best management practices" from within the industry, and develop a guide that other facilities, both public and private, can consider to improve operations

It is very important that recycling facilities accept only materials that have been specifically separated from the commodity/waste stream by generators for recycling. Facilities that accept commodities that contain a "high" level of contaminants could be subject to extensive regulatory permits and oversight. Therefore facilities should cooperatively work with haulers and/or local governments to maintain an acceptable level of public education so that participants are aware of what commodities are acceptable and which are not. This section presents systems, procedures and practices that should be considered to optimize efficiencies in design and operations. [In this section "source-separated" is not used to distinguish between recycled material collection methods, as in the previous section but means commodities that have been intentionally separated from waste by generators.] Essential best practices include the following:

1. Have systems and procedures in place to identify and confirm that only source-separated commodities are delivered to the MRF.
2. Incorporate operational efficiencies to achieve processing of commodities in the most economical manner.
3. Maintain operational effectiveness to ensure that commodities are recovered to meet market specifications.
4. Have operational adaptability to adjust processing systems and procedures to process and market commodities to sustain operational efficiencies and effectiveness.

Operational efficiency centers on the use of resources (labor and capital) in sorting and processing materials delivered to the MRF. Operational efficiency focuses on reducing sorting and processing costs while still maintaining (or increasing) the desired throughput of materials. Improved efficiencies can be implemented with a short-term return on investment in mind (removing plastic film at the beginning of a sort line to aid in seeing and capturing more recoverable materials down the line) or with a more long-term return on investment in mind (purchasing a baler to achieve a higher revenue for the materials sold and to reduce transportation costs for getting materials to market).

Producing the desired result and meeting customer expectations is an example of **operational effectiveness**. As it applies to a MRF, this can be equated to maintaining or improving the product quality of commodities sold to markets. Often this translates to higher revenues, positive long-term relationships with markets, and a decreased potential for a reduction in market revenues or having commodities rejected. Operational effectiveness can also be applied on a micro level within an operation. For example, training line workers to do a good job in sorting will improve the quality of the materials sent to the baler. This in turn will help improve the efficiencies in the baling operation with less time spent sorting contaminants out of commodities being baled or having to re-bale commodities to meet market specifications.

Operational adaptability refers to the ability to adapt to changing customer or business needs. A good example is the availability of markets for segregated HDPE and PET plastic containers, which pay a higher price for these materials versus markets that deal primarily with a mixed plastic product. The best choice is made by determining the per-ton cost for both processing and market values of recovered materials. In other words, is the added per ton cost to process and separate PET and HDPE worth the price differential in marketing PET and HDPE as separate commodities, or is a market available for mixed PET and HDPE that allows your MRF to avoid additional processing costs and provides a better per ton net value?

The following subsections address various components of MRF siting, design and operational procedures from the perspective of concepts, principles, and practices that help improve the efficiency, effectiveness, and adaptability of MRF operations. The information presented below comes from both the insights and thoughts derived from observing the MRFs participating in this study as well as other best management practices from within the industry. Not every item discussed below will be applicable in all situations. The intent of the IRA is that all facilities receiving this guide will find some useful suggestions or validation of methods that improve operations.

3.1 LOCATION, SITE CHARACTERISTICS, AND DESIGN EFFICIENCY CONSIDERATIONS

Siting and designing a materials recovery facility should be undertaken with efficiency and operational safety considerations in mind. This means addressing such issues as location, site characteristics, local zoning and permitting requirements, facility design and layout, process/operational flow, employee/visitor safety; and - if a MRF is going to be placed into an existing structure or added onto a transfer station or WTE facility - the characteristics of existing buildings.

Incorporating these items into the planning process will provide both short-term and long-term economic and safety benefits. The location, site characteristics and design efficiency considerations discussed below are not all inclusive nor will they be applicable in all situations. However, the considerations outlined in Table 3.1 will provide some guidelines in the upfront planning process when a MRF is being considered.

TABLE 3.1. MRF LOCATION, SITE CHARACTERISTICS AND DESIGN EFFICIENCY	
Considerations Concepts/Principles/Practices	**Potential Benefits/Comments**
Location-Materials: The facility should be located in close proximity to population centers and the collection sources.	Minimizes transportation distances to and from the collection sources. This leads to less time spent servicing routes, a reduction in vehicle fuel consumption in getting materials from generation sources to the processing facility, and less wear and tear on collection vehicles. This concept is particularly valid when the same entity that owns the facility provides for collection services but is also valid for merchant facilities that want to attract the business of others providing the collection service. However, some larger facilities can receive materials from long distances away via transfer trailers.
Location-Roads: The facility or site for a proposed facility should be located near major highways or other transportation arterials, and provide for easy access/egress to the facility.	Location on major transportation routes and easy access/egress to the site will add to convenience and efficient delivery of materials to the site as well as shipment of process materials to market. Additional benefits may include less road weight and vehicle restrictions, and easier access for emergency vehicles in case of fire, police, or health emergencies.
On-site Traffic: On-site roadway system should minimize the number of traffic intersections and merges. To the extent possible keep personal vehicle traffic, material delivery traffic, and tractor-trailer traffic separate.	Efficiently moves traffic on and off site and will add to safety of site personnel, customers, and visitors.
Codes: The site and/or building should meet local zoning requirements and fit in with surrounding land uses.	Less time and cost involved in obtaining local permits and approvals.
Site acreage should be large enough to accommodate the physical structure, outside storage space for materials and/or equipment, sufficient space for safe and orderly vehicle movement (including vehicles delivering materials, tractor-trailers moving materials to markets, and employee/visitor parking), potential expansion area, and buffer areas (either natural or manmade) to adjacent properties.	Sufficient space for all the activities occurring at a MRF is crucial. A site that is too small will add to safety concerns, inefficient processing and movement activities, potential environmental and aesthetic concerns with neighbors, and limited space for processing and storage Limited processing space will impact not only the quantities of materials processed but also the adaptability of the facility. Insufficient storage space will limit how long finished product can be stored before marketing and could lead to product quality issues and diminished revenues.
Utilities: If not already present, the site should have close access to utilities (water, sewer, power, phone). If utilities are already on-site determine the adequacy and potential upgrades to those utilities.	Is the wastewater collection and treatment system (on-site and off site) capable of handling and permitted to handle the wastewater coming from this type of operation? Is the electrical service at the facility appropriately sized for the type and size of equipment that will be used in the operation?
Controlled Access: If the site does not have restricted access from neighboring properties or frontage roads, security fencing or other barriers should be placed around the property perimeter.	Controlling access to the site is important for both operational and liability issues.

TABLE 3.1. MRF LOCATION, SITE CHARACTERISTICS AND DESIGN EFFICIENCY (CONT'D)	
Considerations Concepts/Principles/Practices	**Potential Benefits/Comments**
Rail: If available, consider a site with rail access.	Rail access will give added flexibility for receiving materials for processing from more distant sources and also provides added marketing flexibility. Both of these considerations (increasing materials input and product output) could provide operational economies of scale and increased revenues that would improve the overall operation. The economic benefits of rail access and loading mechanisms need to be carefully evaluated.
Scales: Consider installing a vehicle scale to weigh both incoming delivery vehicles and outgoing shipments.	As with rail access, a site with a vehicle scale already in place or adding a vehicle scale to the development of a facility will add to the initial upfront cost. Most contracts with suppliers and markets require weight-bases accounting and scales are thus required, not optional. On-site scales have the ability to accurately track input of materials, recovered materials, residue, quantities of final product marketed, and individual truck/customer accounts.
Docks: Consider installing dock levelers on loading docks 	Levelers provide quicker and safer mating of docks to trucks and ease the movement of materials and vehicles into and out of the trailers.
Process Design: Design the MRFs receiving, sorting, processing, and storage functions to meet anticipated throughputs and market specifications (quality and delivery). Layout the process flows to minimize handling of materials.	A processing and equipment layout that follows a logical sequence, flows in a straight line, and limits the backtracking and repeated handling of materials, will minimize the inefficient use of resources and energy.
Systems Approach: Take a systems approach when designing the processing systems of a MRF	This requires an understanding about how the materials will be collected and what the desired end products will be. For example, if materials are compacted at the source or during collection, then design the MRF to handle this type of material.
Collision Protection: Incorporate collision protection into building for doorjambs, walls, and supports.	In accordance with Murphy's law, if it can be hit, it will be hit.

TABLE 3.1. MRF LOCATION, SITE CHARACTERISTICS AND DESIGN EFFICIENCY (CONT'D)	
Considerations Concepts/Principles/Practices	**Potential Benefits/Comments**
Process Space: Provide sufficient space for all operations including pre-processing materials storage and post-processing product storage. If there are seasonal variations in the amounts of incoming materials delivered to the facility receiving, storage, sorting and processing functions should be designed for the peak volume periods. Find out how much space may be available at supplier locations in the event that the MRF must temporarily back up materials during scheduled or unscheduled downtime.	See comments above under site acreage potential benefits and comments. Suppliers may have storage space available to hold shipment of materials until the MRF is ready to accept their materials.
Conveyers: Avoid using excessive numbers of conveyors and keep conveyor runs straight, avoiding angled transitions.	Fewer conveyors require less maintenance and fewer conveyor-conveyor transitions result in less spillage.
Conveyers: Choose heavy-duty conveyors with adequate width and durable synthetic belts.	Light-duty conveyor frameworks will not withstand normal MRF operations. Too narrow belts result in excessive spillage. Natural rubber belts will wear out quickly due to abrasion from glass, metal and corrosion from liquid residues. Belts with shoulders are recommended to keep glass from getting between the belts and slide plates or into drive chains.
Flexible Design: Design flexibility into the facility layout that can quickly adapt to changes in incoming material amounts, material quality, or market specifications.	Changes in incoming materials, fluctuations in quantities (both seasonal and over time), regulatory requirements, product specification changes, pricing, and new markets are all things that cause the need for flexibility.
Process Elevation: When it can be done safety and with minimal product damage take advantage of gravity and free fall to move materials (i.e., tipping floors at higher grades than infeed hoppers, falls of a few feet from transfer conveyors to sorting conveyors or bins/roll-off containers).	Examples of the potential benefits of doing this include: • Easier and quicker to push materials into hopper than to lift materials and dump into hoppers. • Free fall of paper from transfer conveyors onto sorting conveyors will breakup up slugs of materials and help regulate burden depth for sorting. • Free fall of recovered glass from conveyors into bins or roll-off containers will help break the glass (if desired) improving densities and weights for delivery to markets.
Process control: Incorporate variable speed equipment	Variable speed equipment allows flexibility to slow belt speeds or speed up to match flow and upstream and downstream demands while using only the energy required for the given speed.
Worker Protection: Incorporate ergonomic principles (people/equipment interface) and health and safety considerations into the design.	A facility designed with proper worker ergonomics in mind will help in reducing worker strain, worker compensation claims, and lost time (worker productivity).

TABLE 3.1. MRF LOCATION, SITE CHARACTERISTICS AND DESIGN EFFICIENCY (CONT'D)	
Considerations Concepts/Principles/Practices	**Potential Benefits/Comments**
Energy Use: Incorporate energy conservation principles into the design, layout and equipment specifications for the MRF. This includes building and site considerations such as building orientation on site as well as procuring high-quality, energy efficient equipment.	Over a 15, 20 or more years operating life, the cost of energy in facility operations can be a significant cost. It is likely that this will be even more so in the future. Some of the concepts, principles and practices under this category include: • Utilize site geography and building placement to minimize heat loss in winter by avoiding doors (or minimizing their usage) on the north side of buildings or in the direction of prevailing winds. This is especially relevant if a drive through concept is used for the tipping floor (design to avoid wind tunnel effects). • Utilize natural barriers (pine trees, hills, berms, etc.) to protect facility from prevailing winds. • If possible, enclose sorting areas (modular shells) to minimize the amount of heat or air conditioning needed to maintain a comfortable and safe working environment for sorters. • As an alternative to this last point, isolate areas where doors leading to the outside environment may be open much of the time (receiving areas and shipping areas) from areas where workers are sorting materials or operating other processing equipment. • Specify and purchase equipment that has a high-energy efficiency rating. The capital cost may be more but the long term operating costs should be less. • Purchase equipment that is properly sized for the peak throughputs of materials. A higher rated capacity baler will likely have a higher energy efficiency rating, a quicker cycling time, and will not be operating as much as a baler that is undersized for the facility's throughput. • Take advantage of natural daylighting. Design or choose buildings with skylights and windows. • Ensure materials being baled are of a consistent quality and have little or no contamination, and use baling wire strong enough to hold the bales together for whatever material is being baled. This will reduce the amount of material that needs to be re-baled. An added benefit is the improved marketability of the finished product.
This and following tables edited and adapted from: "*Materials Recovery Facilities Operational Assessment Final Report and Optimization Guide",* Minnesota Office of Environmental Assistance, St. Paul, MN, August, 2003.	

Many small to medium size MRFs utilize retrofitted existing structures. Finding an existing facility that fits all the desirable criteria is difficult, however, the capital cost could be substantially less than a "greenfield" facility. Site-specific analyses are required to determine costs of new versus retrofit costs.

If an existing building is used to house the MRF, items to consider include:

- Building shell type. Pre-engineered steel buildings are desirable. Typical types of former building uses suitable for conversion into a MRF include warehouses and distribution centers, maintenance shops, and light industrial manufacturing facilities.
- Clear span buildings are preferred for flexibility. Equipment, conveyors, storage etc. can be more easily repositioned for operational flexibility and there are no support pillars for vehicles to run into.
- Eave heights should be a minimum of 25 feet to accommodate the tipping of roll-of containers and other self-dumping vehicles.
- Overhead doors providing access and egress to the facility should be of sufficient height and width to accommodate the types of vehicles and equipment anticipated to use them.
- Sufficient loading dock space should be available to accommodate delivery of supplies as well as the staging/loading of several tractor-trailers. Four to six loading docks are ideal.
- HVAC, lighting, and electrical service adequate for the building and equipment used.
- Adequate space within the building should be available to incorporate a process layout/materials flow that is logical, efficient, minimizes backtracking or multiple handling of materials, and accommodates all operations efficiently and safely.

3.2 MATERIALS RECEIVING AND STAGING

The materials receiving and staging area (tipping floor) design, layout and operations are dependent on the type and quantity of materials received at the facility and how those materials are delivered to the facility.

The receiving and staging area for a MRF may include as few as one tipping area for mixed fibers and rigid containers (single-stream collection and delivery), two separate tipping areas on the tipping floor – one for fibers and one for rigid containers (dual stream collection and delivery), or up to five or more separate tipping areas/bunkers for various combinations of commingled or source separated collection and delivery.

Whatever the delivery mechanism (single-stream, dual-stream, or source-separated) the major considerations in running an efficient receiving and staging operation include:

- Move delivery vehicles in and out of the tipping area as quickly as possible. This will lessen tipping floor congestion, maintain a safer working environment for the operators and drivers on the tipping floor as well as allow for quicker and more efficient movement of materials from receiving to staging to processing;
- Provide sufficient segregation between the various delivered materials streams to avoid or minimize cross-contamination. By minimizing cross-contamination of material streams from the beginning less time and cost will be spent on sorting and processing materials.

- Move materials off the tipping floor and into sorting/processing in a direct and timely manner. This prevents backlogs of materials that increase the sorting and processing inefficiencies (increases in burden depths on the sorting line, decreased recovery of materials and increased production of residues, overtime labor in sorting and processing functions). Additionally, if there is an issue with dirt, mud and other such contaminants getting mixed in with materials sitting on the tipping floor or in pre-processing storage, material revenues could be negatively impacted.
- Provide enough incoming materials storage space to allow for at least two days of storage. Although this may be too generous in some instances, it will allow for extended storage over weekends/holidays or when equipment downtime (scheduled or unscheduled) shuts down the processing line. If possible, work with suppliers to find out how much space may be available at their locations in the event that the MRF must temporarily back up materials during scheduled or unscheduled downtime.

Table 3.2 outlines these and some of the other concepts, principles and practices that can aid in efficient operations of the materials receiving and staging function.

TABLE 3.2. MATERIALS RECEIVING AND STAGING EFFICIENCY CONSIDERATIONS

Concepts/Principles/Practices	Potential Benefits/Comments
Establish a load checking policy and procedures for providing feedback to sources of excess contamination.	Consider using video or still photo records to give feedback to suppliers regarding the quality of materials received. Showing actual video or photos of actual contamination gives the suppliers the information they need to recognize the specific materials that are not acceptable so they can go back to the collection sources with education to prevent future contamination.

TABLE 3.2: MATERIALS RECEIVING AND STAGING EFFICIENCY CONSIDERATIONS (CONT'D)	
Concepts/Principles/Practices	**Potential Benefits/Comments**
Move materials off the tipping floor and to sorting/processing in a timely and consistent manner. Aim for processing all materials the same day they are received.	Storing materials means double handling, reducing efficiencies. Slugs of material often lead to inefficient sorting, and times when workers are waiting for materials. Processing efficiencies in both manual and mechanical sorting will be improved with consistent material flows, resulting in fewer residues generated.
Provide for two days of incoming materials storage at peak flows. This storage can be on-site or possibly at supplier sites.	Allows for storage over extended weekends or when processing is halted due to equipment repair or maintenance.
Provide for segregation of incoming materials by the use of material bunkers or specified areas where certain types of materials are dumped.	Minimizes cross-contamination of materials making it easier to sort by material types and grades (i.e., metal food and beverage containers, plastic containers, OCC, other fibers, etc.)
If necessary, contain separation of incoming materials at peak flows by using portable traffic barriers.	Potential benefits include: • Minimizes interference with vehicles maneuvering around the tipping floor and unloading their contents. • Minimizes cross-contamination of incoming materials, which could add to the time and effort involved in sorting operations.
Provide for safe, quick and easy traffic control to move vehicles on to and off of the tipping floor. This could include a one-way drive through concept with traffic entering through one door and exiting through another.	A good traffic flow and control plan will keep vehicles and materials moving in a safe and efficient manner. If considering the one-way drive through concept, take into account such things as the potential for wind tunnel effects and the ability of vehicles to maneuver on the tipping floor.
If the facility will serve the general public as well as commercial and public haulers, consider a separate drop-off area for the public.	The benefit in doing this is to minimize congestion on the tipping floor by designating it for larger volume deliveries as well as to provide for a safe tipping area for the general public.
Provide for safe, quick and easy unloading of vehicles on the tipping floor.	The goal is to minimize the time vehicles are on the tipping floor and to provide for an unloading plan that will quickly and safely move materials from vehicle to pre-processing storage.
Keep tipping floors and receiving areas away from other facility functions such as materials sorting, materials baling, and product storage.	When a variety of facility operational components share the same space or are adjacent to each other without sufficient barriers or buffer areas there is a loss of efficiency due to operational congestion and potential cross contamination. Additionally, with more cross traffic and greater points of interface between vehicles, equipment, and pedestrians, facility safety is compromised.
Utilize gravity and free fall to move materials from staging to processing.	The use of below-grade conveyor systems minimizes the handling of materials and makes it easier to move materials out to processing.

TABLE 3.2: MATERIALS RECEIVING AND STAGING EFFICIENCY CONSIDERATIONS (CONT'D)	
Concepts/Principles/Practices	**Potential Benefits/Comments**
If utilizing gravity and free fall to move materials from staging to processing, take steps to minimize glass breakage if glass is to be color sorted.	Minimizing glass breakage will result in safer, more efficient sorting operations, increase glass recovery, and decrease residue amounts requiring disposal. Ways to do this include: • If sorting mixed containers, collect and dump glass along with plastics to help cushion the glass during dumping. • Adding deflection ramps and rubber baffles at impact points. • Utilizing drop chutes that reduce drop distances and encourage glass containers to roll rather than break.

3.3 MATERIALS SORTING CONSIDERATIONS

The sorting of materials at a MRF is the heart of the MRF. Whether the sorting process is accomplished manually, mechanically, or a combination of the two, it is usually the operational component of the MRF that is the largest cost center and offers the greatest potential for both short-term and long-term savings. The sorting process is also the component where quality control becomes an important consideration. The following subsections provide ideas into improving efficiencies in both manual and mechanical sorting functions. Smaller MRFs, many of which are located in rural or small town areas, typically rely mainly on manual sorting techniques. Though there are opportunities in these types of operations to add equipment that will improve overall sorting efficiencies and offer long-term savings, due to the lower throughput of materials at small MRFs, the application of mechanical sorting techniques is limited and cost prohibitive for some facilities. As the throughput of a MRF increases, adding mechanical sorting equipment becomes more cost-effective.

3.3.1 MANUAL SORTING OF MATERIALS

Improving the efficiencies of manual sorting is more than just proper training of the workforce and providing a safe and comfortable work environment for the sorters. It also involves providing the right equipment and procedures to make the sorting process more effective. Productivity levels can be significantly enhanced with the right combination of personnel training, procedures, and equipment.

Some of the factors that will contribute to increased efficiencies in manual sorting include such items as:

- Design and operation of conveyance systems;
- Control of the burden depth and uniformity of the materials crossing the sorting belt;
- Sorter experience and training;
- The level of mechanical sorting supplementing manual sorting; and
- Policies, procedures, and practices employed in the sorting operation.

The concepts, principles and practices that can impact the efficiencies and effectiveness of manual sorting are listed in Table 3.3.1. It should be noted that the extent to which these ideas can be applied to a specific operation is dependent on local factors such as the types of materials collected and delivered, the method of collection and delivery, the design and layout of the MRF,

the level of manual sorting versus mechanical sorting, and the level of processing required to meet market specifications.

TABLE 3.3.1. MANUAL SORTING EFFICIENCY CONSIDERATIONS	
Concepts/Principles/Practices	**Potential Benefits/Comments**
Provide appropriate training and instruction to sorters.	Training materials should include pictures and words in English, Spanish or other native languages as necessary describing targeted recyclables and prohibitives. Have posters showing the flow of materials through the plant and pictures of targeted materials in the appropriate sorting stalls. For new or temporary workers provide immediate feedback in the first 2-3 hours of work.
Provide an environmentally comfortable and safe working environment. This includes: • Space that is heated in the winter, cooled in the summer, and has good air exchange (ventilation). • Anti-fatigue mats to reduce the physical discomfort of standing in one place for long periods of time. • Sufficient lighting to reduce eyestrain. • Gloves, safety glasses, hearing protection, steel-toed boots, and, if applicable, hardhats.	Potential benefits include increased productivity as tiredness and strain are reduced, and overall physical comfort is maintained or increased. Additionally, the use of personal protective equipment (PPE) reduces the risk of injury, which in turn reduces the potential of worker compensation claims, lost time on the job, and increased insurance rates.
Sorting conveyors should be less than 36” wide if sorting from one side of the conveyor.	Being able to comfortably reach across the width of the conveyor to remove items will increase the amount of materials recovered while reducing “missed items” that end up in the residue stream. If sorting from one side of the conveyor a 36” stretch is about the furthest one can reach without causing undo physical strain. If sorters are working both sides of the conveyor belt widths of up to 60” are acceptable. Wider belts can be acceptable if sorting large materials such as OCC.
Sorting stations and conveyors should be ergonomically designed and worker friendly. For example: Conveyor belts should be between 36"and 42" in height as measured from the floor to top of belt.	Conveyor belts below 36" in height may put excessive back strain on sorters. Belts greater than 42" in height will limit the extent to which an average person can lean over while reaching for an object, thus causing strain while stretching to sort materials. Proper surface height for an average worker sorting large materials such as OCC should be 36”-38”. Sorting of smaller items should be done at a height of 40”-42”. Make safe risers available to sorters below average height or they may improvise unsafe platforms to reach a comfortable position.
A four to six inch vertical sidewall extension should protect sorters from moving conveyor belt and provide a barrier so that materials don't falloff the side of the conveyor. This extension should be padded where the sorter’s body may lean against it.	Workers will come into contact with the sidewall extension during the course of the sorting operation. This contact (between hips and waist) can cause a physical strain on the body. Rubber or foam padding will minimize the strain.

TABLE 3.3.1. MANUAL SORTING EFFICIENCY CONSIDERATIONS (CONT'D)	
Concepts/Principles/Practices	**Potential Benefits/Comments**
Sorting conveyors should have variable frequency drives (VFDs) to allow for adjusting the speed of the conveyor. Sorting conveyor belt speeds are generally set to run between 10 feet and 60 feet per minute depending on the particular circumstances governing the sorting line.	Sorting conveyors whose speeds can be adjusted will improve sorting efficiencies. If sorters are having trouble keeping up, the belt can be slowed down. If they have too much slack time the belt can be sped up. Being able to increase and decrease the conveyor speed will better control burden depth.
Perform periodic sorter efficiency studies to determine the rate (throws/hour or pounds/hour) various sorters/stations on the sorting line are performing.	By conducting such observations various adjustments to the sorting operation can be done. Examples include: • Reassigning sorters specific materials to concentrate on as a way to improve recovery rates. • Adjusting belt speeds as needed to improve sorting rates, reduce slack time, and reduce "missed items". • May allow for decreases in staffing the sorting line or show the need for increasing staffing on the sorting line.
Establish explicit quality control procedures for each commodity	On a regular basis, e.g. weekly, sort a sample of each commodity to determine the % of wrongly sorted and prohibitive materials in your output. This is especially important in negatively sorted materials. One such study found as much as 6.5% of their negatively sorted ONP was recyclable containers.
Design inclined conveyors to have no more than a 40^{o} pitch (rate of incline).	Inclines greater than this can cause tumbling or fall back of light materials, while heavy materials fill spaces between the cleats. This causes alternating peaks of light and heavy materials crossing the belt. Sorter efficiency is reduced, as they are alternately overwhelmed then underutilized as the peaks shifts from one to the other. Flattening plastic bottles during collection can also help alleviate this problem.
Remove film plastic and other large materials that could cover up recyclables at the beginning of a sorting line.	Removing plastic film at the front end makes materials more visible to downstream sorters and also reduces the amount of double or triple handling of this material as it travels down the line.
When possible, remove contaminants during curbside collection and prior to sorting at MRF.	Even slight reductions in contaminant levels can reduce labor requirements and increase sorting productivity. One study of 6 MRFs determined that while residues averaged only 3.7% of the incoming material, they accounted for 37% of the sorting activity.
If plastic film cannot be eliminated during collection, consideration should be given to installation of a bag breaker, with subsequent film removal either manually or by vacuum.	Properly used, bag breakers do not significantly impact glass breakage and can help meter flow to the inclined feed conveyor. A combination of a vacuum removal system supplemented by a single laborer provides the most efficient film removal.

TABLE 3.3.1. MANUAL SORTING EFFICIENCY CONSIDERATIONS (CONT'D)	
Concepts/Principles/Practices	**Potential Benefits/Comments**
Control burden depth of materials crossing the sorting belt. The burden depth of fibers, as an example, should be less than 12" deep. A variety of methods can be used to control burden depth and the amount of materials presented to sorters for sorting. These include such things as: • Slow down or speed up the rate at which materials are fed into hoppers or onto inclined conveyors. • On fiber lines allow for a drop from one conveyor to the next of two to three feet. This helps break up clumps of materials. • Adjust speed of conveyor belts to either increase the amount of materials presented to a sorter or decrease the amount of materials presented to a sorter. To decrease burden depth, a sorting conveyor should run at a higher speed than the conveyor feeding it. • Utilize other physical or mechanical means such as hanging chains or rotating cleated drums to help knockdown or breakup large slugs of materials traveling up the feed conveyor.	Problems with controlling burden depth have been an issue in several MRF studies. Without adequate controls for monitoring and adjusting burden depth a variety of efficiency issues can occur including: • Overwhelming workers to the point where they need to push materials back up the line or stop the line altogether in order to catch up. • Decreasing the amount of recoverable materials captured while increasing the amount of process residue requiring disposal. • Allowing contaminant levels to increase in recovered products resulting in lower revenues for recovered products or rejection of recovered products. • Resorting of materials in order to capture more product or clean product up. • Periods of very low levels of materials passing by sorters, which have them sorting at very low rates, or not sorting at all, due to the lack of anything on the sorting belt (sometimes referred to as "black belt"). Items to the left are all methods that have been employed to adjust burden depths and equalize the flow of materials across the sorting belt. Implementing these methods help achieve peak efficiencies in the sorting operation.
On a mixed fibers line (excluding OCC) negative sort the highest volume of materials (usually ONP or a mixed paper grade).	With fibers especially, allowing the highest volume of material to flow off the end as a negative sort will minimize the amount and effort of trying to sort this material. Sorting efficiencies will be improved.
Sorters should be throwing forward into a bunker/bin/gaylord and not pulling materials back off the belt.	Sorters that must twist or reach behind them to deposit materials in a chute or bin are subject to more strain and tire quicker. In addition to being more ergonomically correct, one study that compared sorting rates determined that a sorter throwing forward could maintain a sorting rate up to three times the sorter pulling the material back.
Install backsplashes on openings to chutes or bins.	Less time is wasted in retrieving mis-thrown materials from the wrong bin or from the floor and sorters can move faster if less time is spent targeting the opening.
Assign sorters specific items to sort, rather than assigning all sorters on a line to sort all materials.	Sorting efficiencies and recovery rates will improve if sorters have fewer materials they have to concentrate on sorting. Additionally, fewer bins or gaylords will be required thus easing congestion and improving overall operation of the sorting line.

TABLE 3.3.1. MANUAL SORTING EFFICIENCY CONSIDERATIONS (CONT'D)	
Concepts/Principles/Practices	**Potential Benefits/Comments**
Discontinue activities on the sorting line that provide little to no value and aren't directly related to materials sorting (e.g., removing caps from plastic bottles).	Sorting rates will be improved and the amount of materials recovered may increase if less time is spent on "no value added" activities such as this. In this example, if the goal of removing the plastic caps is to prevent trapped air from reducing baling densities, purchasing a plastics perforator and perforating the plastics prior to baling will likely be more cost effective in the long-term.
If quantities of some recovered materials are very low (even with relatively high prices), the economics of sorting these materials should be reviewed and consideration given to continuing sorting these items.	The incremental cost of recovering smaller volumes of some recyclable materials is negligible. It is always better to recover the materials for recycling than to throw recyclable materials away. For example, aseptic packaging may represent a small percentage of recyclable materials compared to other recyclable commodities; however, the cost to recover these materials is small since most MRFs are already presenting these materials on a conveyor sorting line where the material can be easily picked along with other commodities. However, the cost of sorting, preparing, storing and marketing a material needs to be balanced with the additional revenues received for recovery or upgrading of that material. If the quantities received are too small, it may be more cost effective to handle some marketable materials as residues.

A joint American/Canadian Study of MRF operations (See references 4. and 10.) established benchmark manual sorting rates. These benchmarks are defined as the highest, continuously sustainable sorting rate by a single sorter under optimum conditions. It should be noted that the highest rates for plastic were seen where air classifiers were used to separate "lights" from "heavies. The numbers in Table 3.3.2 are based on the observations in that study.

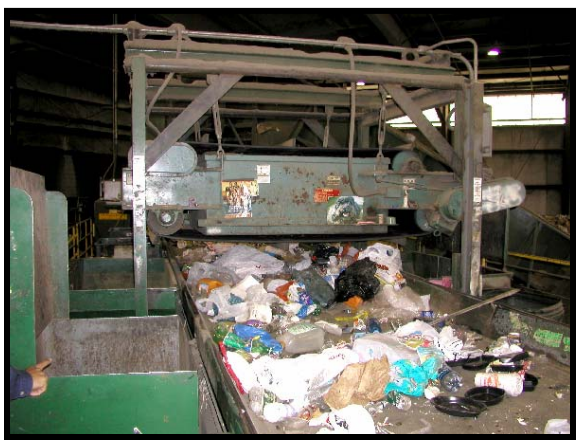
TABLE 3.3.2. MANUAL SORTING BENCHMARK SORTING RATES	
Material	Benchmark (lbs/hr/sorter)
HDPE (natural)	990 (lbs/hr/sorter)
HDPE (colored)	925 (lbs/hr/sorter)
HDPE (mixed)	990 (lbs/hr/sorter)
PETE	990 (lbs/hr/sorter)
Tubs (mixed plastics)	440 (lbs/hr/sorter)
Glass (flint)	1320 (lbs/hr/sorter)
Glass (colored)	1320 (lbs/hr/sorter)
Cardboard (OCC)	880 (lbs/hr/sorter)
Boxboard (OBB)	660 (lbs/hr/sorter)
Mixed Waste Paper (MWP)	990 (lbs/hr/sorter)
Hardpack (OBB/OCC)	770 (lbs/hr/sorter)

3.3.2 MECHANICAL SORTING OF MATERIALS

Whether or not to employ mechanical sorting methods in a MRF, and to what extent mechanical sorting should be implemented, will depend on a number of factors including, but not limited to:

- Type of incoming material
- Facility throughput;
- Marketed materials specifications and anticipated revenues;
- Design/layout of the facility; and
- Available labor pool and local labor costs.

Mechanical sorting methods commonly employed at MRFs include such things as screens (trommel screens, disk screens, star screens, vibrating or shaker screens); air knives and classifiers, magnets (suspended magnets, magnetic drums, magnetic head pulleys both stationary and portable units), and eddy current separators. These methods of sorting various feedstock and material streams are typically based on different physical properties such as size, weight, density, or magnetic properties. Some OCC and paper sorting machinery relies on differences in rigidity or stiffness. A second type of automated sorting method involves electronic sensor devices. The electronic scanners sort out materials based on color, density, or chemical composition as determined from various spectrographic or electromagnetic signatures. The sensors then trigger mechanical or pneumatic devices to remove the identified items from the conveyor. These systems are quite expensive and are typically used only in the largest MRFs.



Though some level of manual sorting is still required, mechanical sorting methods can supplement the hand sorting of materials. In many situations mechanical sorting of incoming materials, especially at the front end of the processing line, can be very effective in breaking down the feedstock into smaller or concentrated components that can be efficiently sorted manually. This can lead to reductions in the labor needed to manually sort materials and the associated reduction in labor related costs (wages, benefits, insurance, and worker compensation claims, etc.). On the other hand, mechanical sorting equipment can have a high capital cost as well as ongoing operational costs associated with maintenance, repairs, energy usage, and downtime due to mechanical failure.

The best practice is to use size separation whenever possible. A trommel, finger screen or disc screen can be used to filter out smaller objects from larger objects. For example, a screen can be sized to separate broken glass, bottle caps, grit and smaller containers (such as aluminum cans and single serve PET beverage containers) from larger containers (such as HDPE milk jugs and detergent containers). After size separation, the best practice is to use negative sort techniques, where the highest volume materials are left on a sorting conveyor and other objects are removed by optical or hand sorting methods, thereby reducing overall labor and equipment costs. An example of negative sorting is to remove HDPE colored detergent containers by hand, while allowing HDPE natural containers to fall off the end of the conveyor (in this case, the HDPE natural containers are the negative sort, since no positive action is needed to remove these containers).

Most MRFs use some form of mechanical sorting for the removal and or separation of metal containers. Some use self-cleaning suspended magnets for sorting ferrous directly off the line while others use portable magnetic head pulleys as a supplement to hand sorting of ferrous and aluminum. In this latter case the facilities run the hand-sorted aluminum fraction through portable units to remove any ferrous containers that may have been mis-sorted. Typically only larger MRFs utilize eddy current separators for the recovery of aluminum.

Some of the things to consider when looking at the use of mechanical methods for the sorting of metals are summarized in Table 3.3.2

TABLE 3.3.2. MECHANICAL SORTING OF METALS EFFICIENCY CONSIDERATIONS

Concepts/Principles/Practices	Potential Benefits/Comments
When using a self-cleaning suspended magnet to pull ferrous metals from mixed containers flowing across a sorting belt, remove large items (plastic film, bagged materials, bulky HDPE plastic containers) prior to the magnet.	This will prevent larger materials from jamming the conveyor under the magnet's head, expose more metal for recovery by the suspended magnet, and increase the ferrous recovery rate.
Take extra care to remove plastic film bags before magnetic or eddy current separation.	Entangled film can prevent separation of materials and drag unwanted contamination along with separated materials. Film also wraps around rotating machine parts.
The ideal installation of a suspended magnet is over the trajectory of material discharged from a conveyor belt. In this position the material is moving directly toward the magnetic face and its momentum increases the recovery of the ferrous.	This assumes a rapid belt speed. As the belt speed decreases the trajectory of the material becomes more nearly vertical. This requires the repositioning of the magnet back over the head pulley in a vertical position.
Providing a clearance height of 12 inches to 15 inches from magnet head to top of belt should allow nonferrous items such as aluminum, glass and residue to pass under the unit without interfering with the recovery of ferrous containers.	The pulling strength of many suspended magnets can be adjusted to compensate for various clearance heights. Doing so will allow for the effective recovery of ferrous containers passing under the magnet.
When using a suspended magnet, the effective magnetic width of the device should provide full coverage of the sorting belt.	If the effective magnetic width of the magnet doesn't cover the entire width of the sorting belt, recovery rates will be less.

TABLE 3.3.2. MECHANICAL SORTING OF METALS EFFICIENCY CONSIDERATIONS (CONT'D)	
Concepts/Principles/Practices	**Potential Benefits/Comments**
If the sorting conveyor used for sorting containers is also used for sorting fibers, consider mounting the suspended magnet on a ceiling track or on a swinging arm or gate.	During sorting of fibers or of segregated container streams (i.e., all plastics, all glass, etc.), moving the magnet out of the way will make the sorting process much more efficient.
When sorting fibers or segregated container streams, turn the magnet off.	Reduces energy consumption.
As aluminum beverage containers are generally the most valuable commodity recovered at a facility on a per ton basis, running sorted aluminum through a portable magnetic head pulley unit will improve product quality and revenues at little extra cost. Though not generally cost-effective in a small MRF, the addition of an eddy current separator may be cost effective in larger facilities. If putting in an eddy current separator, install the unit as close to the end of the line as possible and conduct most of the other screening and sorting prior to this stage. It is recommended that magnetic separation be done both before and after the eddy current separator.	Increases recovered product quality that could increase revenue received for the materials. A cost/benefit analysis should be performed beforehand to determine if the extra time and cost are worth it. Due to the high cost of eddy current separators and the relatively low volumes of aluminum recovered at small MRFs, it is difficult to justify the upfront cost in these applications. Limit the tonnage of materials going to the unit (through screening and sorting efforts) to reduce the expense by purchasing a smaller eddy current unit.

The primary difference between single-stream and dual-stream MRFs is that mechanical separation systems, usually disc screens or trommels, are used to make the initial separation of the single-stream material back into the dual streams of fiber and containers. Sometimes multiple screens are used to subsequently separate OCC from ONP and mixed paper.

Fiber is typically recovered as a negative sort following the initial separation of containers and fiber. Since compaction during collection and MRF handling tends to flatten many plastic bottles and aluminum cans, many of these types of containers remain in the fiber stream at this point in processing. Recovering these containers usually requires a positive separation (either manual or mechanical) of the recyclable containers that remain in the fiber stream before baling.

Single-stream MRFs that most effectively separate recyclable containers from the fiber stream employ one or more of the following techniques:

- Perform a manual presort before the disk screens to remove troublesome materials. Large and heavy items such as phone books and scrap metal can damage disks. Shredded paper, film plastics, hangers and wire many become tangled in and clog disk screens. Shredded paper may also become airborne.

- Separate broken glass and other fines by running incoming material through a trommel before the disc screen.
- Adjust disc spacing, deck inclination angle, and feed velocity to accommodate the various conditions of incoming containers and fiber such as material moisture content.
- Use a separate and specialized disc screen to separate OCC from the rest of the incoming material in tandem with the more conventional paper disc screen. This not only yields a separate OCC stream to manually remove containers from, but also improves the exposure of plastic bottles and other containers to manual sorters on the paper line.
- Run the separated fiber through a trommel after the initial separation that violently tosses material and facilitates removal of material smaller than three inches in diameter.
- Use a sufficient number of quality control manual sorters on all fiber lines to remove both plastic and other containers to a level compliant with fiber grade specifications. A study in Oregon found that MRFs operating the standard single stream sort line (multiple disk screens) at 20 tph with 11-15 sorters had big problems with contamination in ONP. When they increased to 19-22 sorters, their contamination was reduced by half or more.
- Provide a working environment that enables and motivates the productivity of manual sorters. Manual sorters in facilities without any climate or emissions controls are less able or motivated to perform separation activities well, resulting in higher contamination of negatively sorted recyclables or higher inclusion of recoverable materials in residue streams.
- Operate conveyor belts at speeds that yield fiber flow at a rate and depth that optimizes the manual separation of plastic bottles and other containers taking into account the number and sorting rate of sorters. Speeds vary significantly depending on the number of sorters.
- Provide a final quality control inspection at the point prior to where fiber is fed to the baler.
- Audit bales on a random basis to benchmark performance and identify the need for system adjustment.

Selection of the techniques applicable to any particular MRF depends on a number of factors, including the makeup of the incoming material, the types of separation equipment currently used and end-market specifications. Processing technology is evolving rapidly and single-stream processors that invest in state-of-the-art technology can produce container and fiber commodities as contaminant free as dual-stream processors. However, doing so requires commitment to proper operation and maintenance of mechanical equipment, and to utilize sufficient manual labor for quality control.

3.4 SPECIAL MATERIALS CONSIDERATIONS

The following subsections discuss processing issues relating to glass, plastic and aluminum.

3.4.1 GLASS RECOVERY AND PROCESSING

Glass breakage during handling at material recovery facilities (MRFs) decreases the ability to effectively identify and remove contaminants and to sort for color. Reduction in breakage means lower production of unsortable mixed color glass. This residual material cannot be sorted and must be removed in processing and handled for disposal, or channeled to lower value applications. Inexpensive design and procedure modifications can boost program revenues (or reduce the loss) from the sale of cullet to manufacturers.

Major points of breakage after collection include "tipping" activity, where glass containers are unloaded at the MRF, at feeding and conveying points within processing lines, and whenever containers are handled with heavy equipment.

Studies have shown that modifications in glass handling at recovery facilities can reduce breakage rates, lowering production of mixed residuals. The modifications include changes in design such as lowered tipping heights, the addition of deflection ramps, and the installation of rubber baffles at impact points. Procedural changes include reducing tipping and handling speeds, collection vehicle compaction strategies, and tipping floor loader operation. Minimizing handling steps is the key strategy for achieving efficient recovery of glass containers.

Deflection ramps placed below tipping points effectively reduce drop distances and can be faced with abrasive-resistant, shock-absorbent plastic to further reduce impact. Drop chutes also reduce drop distances and encourage containers to "roll" rather than break on each other, and can be implemented at in-feed hoppers or conveyor ends. Ramps and chutes should be angled between 30 and 45 degrees to achieve impact reduction with enough slope to prevent hang-ups.

Rubber or synthetic baffles represent one of the most effective and least expensive methods of reducing glass breakage. Baffles reduce impact speed and deflect drop angles, and can be installed at nearly any impact point within a processing line. Such points include between the in-feed conveyor and trommel or bar screens, and any other conveyor interface. Baffles should be made of durable abrasive resistant material. Bumper guards installed on steel shaker tables and conveyors succeed to soften the impact of containers on the steel edges.

Procedural changes include using greater care in handling, including slow dumping and gentle in-feed loading by both manual handlers and heavy equipment such as end-loaders. The recommendations for loaders focus on operating speeds, encouraging operators to slow loading or "scooping" and avoiding running over the piles. While seemingly contrary to throughput objectives, studies suggest that a small reduction in speed can yield a net increase in recovered material throughput, by reducing breakage.

However, the trend in modern recycling collection methods use compaction vehicles to collect all recyclable materials together, which fracture glass containers during collection. In this case, the use of trommel or finger screens can be used to separate the broken glass by gravity away from the other recyclable materials.

MRFs in large metro areas face market challenges with glass and MRFs in rural areas often face a greater challenge in recovering and marketing glass. Generally, large volumes of glass are not generated by downstate MRFs and the glass that does come through these MRFs is often broken and contaminated with other materials. Additionally, the weight of glass and the distance from generation to the major markets directly impacts the economics of transportation to markets.

A variety of the MRFs have found ways to improve the economics of glass recovery operation though the gross revenue they receive for their glass ranges from 0% up to 6% of the annual revenues they receive. Based on the recovery and processing methods utilized by these MRFs, Table 3.4.1 provides some examples of concepts, principles and practices that can be considered.

TABLE 3.4.1. GLASS RECOVERY AND PROCESSING EFFICIENCY CONSIDERATIONS

Concepts/Principles/Practices	Potential Benefits/Comments
Take steps to minimize glass breakage such as having glass stored in bunkers with other materials such as plastic containers to provide cushioning, adding deflection ramps and rubber baffles at impact points, and utilizing drop chutes that reduce drop distances and encourage glass bottles to roll rather than break.	Increases the amount of glass that can be effectively and efficiently recovered and decreases the amount of residue requiring disposal.
Move commingled containers from tip floor to processing as quickly as possible, avoiding pre-processing storage.	The percentage of broken glass increases as the length of time the material is stored on the tipping floor increases due to breakage from storage "management".
If distances to major glass markets are too great, consider alternative local markets such as municipal highway departments, gravel pit operations, and sandblasting companies.	May not have to color sort glass or remove all contaminants. Transportation costs may also be reduced. Glass crushing may or may not be necessary depending on the local market.

TABLE 3.4.1. GLASS RECOVERY AND PROCESSING EFFICIENCY CONSIDERATIONS (CONT'D)	
Concepts/Principles/Practices	**Potential Benefits/Comments**
Conduct an analysis to determine if crushing the glass prior to shipment to market could reduce long-term transportation costs.	In one example, a community is not crushing its glass prior to delivery to market. Revenues received for the glass do not cover the cost of transportation. Crushing improves over-the-road weights and transportation costs resulting in net revenue for materials. The investment payback period for purchase and operation of a glass crusher was estimated at approximately one year.
If there is little to no difference in the price received for color sorted glass (green and amber) and mixed glass, do not color sort.	Improves sorting efficiencies and materials handling in moving containers of sorted glass around.
If no markets are available for certain categories of glass (i.e., green glass, mixed glass), minimize its handling by negatively sorting it off the end of the conveyor with other residues going to disposal.	Reduces handling costs.
Additional glass containers can be recovered using a bin nearby while sorting other materials (i.e., fibers, metals, plastics) and throwing the occasional glass container in the bin.	Utilize a specially fabricated chute toward the front of the sorting line. When sorting other materials the first sorter will pull out the occasional glass container and throw it down the chute, which empties into a designated bin for glass just below the elevated sorting line.
If the identified glass markets do not require color sorting or crushing, eliminate these activities to minimize the handling of glass as much as possible.	For example, the glass stream, which comes into the facility as a separate stream, is pushed into a bunker that empties into an inclined conveyor hopper. The material travels up the conveyor and out the sidewall of the facility. From there it drops 10 feet into a roll-off box, which is delivered to the local highway department for use as roadbed aggregate. In this case the drop of 10 feet into the roll-off box breaks up the glass and helps improve the transportation costs by increasing the over-the-road weight of the load.
If glass is crushed prior to marketing, consider a feed system that will automatically feed the glass to the crusher with minimal labor involvement. An example is a specially designed holding container that the glass is thrown into during the sorting process. The holding container is designed so that it fits in the hopper of the glass crusher and has a manually operated trap door toward the bottom of the holding container. Using a forklift, the container is positioned in the crusher hopper and the operator pulls a cord to lift the trap door. The glass self-feeds into the hopper.	Quicker, safer, and more efficient than hand feeding glass containers into the glass crusher.

3.4.2 PLASTICS RECOVERY AND PROCESSING

Most purchasers of recycled plastic understand the difficulty for suppliers to produce bales that are 100 percent pure, particularly HDPE and PET bottles generated from curbside collection programs where different recyclable materials are commingled. Most allow some flexibility in the types and levels of contaminants they accept. While some contaminants may be allowable, every reasonable effort should be made to remove contaminants prior to baling. Adhering to the following guidelines will improve the likelihood of producing bales of plastic bottles that meet the majority of buyer specifications:

- Design educational materials to help minimize the inclusion of non-acceptable resin types.
- Make reasonable efforts to have generators remove caps, closures, rings and safety seals.
- Determine if oil and other automotive fluid bottles are acceptable.
- Containers should be completely free of contents before baling.
- Train sorters to recognize specific contaminant items such as PVC bottles.
- Produce bales with densities between 15 and 20 pounds per cubic foot.
- Produce bales with dimensions of 30"x42"x48" or 30"x48"x60" to optimize truckload shipping weights.
- Use non-corrosive galvanized metal wire for baling.
- Use the minimum number of bale wires required to maintain bale integrity.
- Apply single wires wrapped in one direction to facilitate debaling.

TABLE 3.4.2. PLASTICS RECOVERY AND PROCESSING EFFICIENCY CONSIDERATIONS

Concepts/Principles/Practices	Potential Benefits/Comments
Forced air separation of plastic and glass containers is preferable to mechanical separation.	Properly designed air classifiers can separate plastics from glass with limited crossover of glass to the light line or plastic to the heavy line. In general, it may not be possible to achieve size and weight based separation in one step for materials that have similar size and weight. For example, a screen may be used to screen out smaller containers (such as UBCs and single serve PET containers) from larger containers; but then a second process device (such as an Eddy Current) may be needed to separate the UBCs from the single serve containers.
Use two levels of sorting on plastics before considering granulating.	The average measured contamination levels after manual sorting are generally too high to meet minimum specifications for sale of flake or pellets to most reclaimers or end users. Evaluation of granulating plastics at a MRF should include secondary sorting (either manual or automated) to further reduce contamination levels.

For a more extensive and technically detailed discussion of best practices in recycling HDPE and PET, the reader is referred to the guides prepared by the Clean Washington Center. The full text of these guides is available on-line at http://www.cwc.org/.

3.4.3 ALUMINUM RECOVERY AND PROCESSING

Due to the high value of recovered aluminum, buyers are not interested in paying UBC prices for broken glass and chips of plastic. Buyers wish to purchase only contaminant-free aluminum cans and have stringent quality expectations that include quantification of levels of moisture, heavy metal, dirt and ferrous metal concentrations in UBC shipments.

When mechanically separating UBCs, there are seven essential processing elements needed to generate high-quality UBCs from a residential commingled container stream:

- Agitation and tumbling action for dirt and moisture reduction and drying of the UBCs
- Screening of UBCs prior to manual quality control to remove remaining non-UBC fragments,
- Size classification and screening, upstream of the eddy-current separator, to optimize the eddy-current process.
- High-strength electromagnetic separation upstream and downstream of the eddy-current separator.
- A manual (visual) quality control inspection prior to baling or flattening, and
- Visual inspection after baling and if required reprocessing.
- Quality control checkpoints established throughout the line with trained workers.

3.5 BALING MATERIALS

If a recycling facility is going to own only one piece of stationary machinery, a baler will likely be the equipment of choice. Baling of sorted fibers, metals, and plastics offers a wide variety of advantages in the operation of a MRF. Among these are improved on-site storage, improved efficiencies in getting materials to market, and, in most cases, wider marketability and higher pricing.

3.5.1 PRE-BALING STORAGE

Sorted materials are often stored temporarily to accumulate sufficient quantities of individual materials prior to conveying materials to the baler. Having adequate pre-baling storage is essential to maximizing baler productivity and reducing the labor costs associated with emptying bunkers and cages. It is at this stage that inefficiencies in double-handling materials are often encountered as materials are moved from sorting areas to storage, then from storage to baling operations. This is frequently seen at smaller MRFs that sort into gaylords, and then stack them for storage until baleable quantities are accumulated.

Some MRFs have employed dedicated balers with hoppers for each baleable container commodity. However this system suffers from lack of sufficient storage in the hoppers, extra maintenance associated with the balers, and low bale densities associated with the smaller balers used.

Cages and bunkers, sometimes with live-bottom or sloped-bottom designs, have been the standard for many MRFs. Push through bunkers cost less to install than live bottoms, but the additional labor and loader maintenance costs associated with pushing the material from the bunker to the baler feed conveyor outweigh the capital savings.

Containers are preferably stored in sloped-bottom cages since the materials tend to flow out better than from a flat, live-bottom bunker. Design for accessibility underneath the bunkers and cages for maintenance and housekeeping activities.

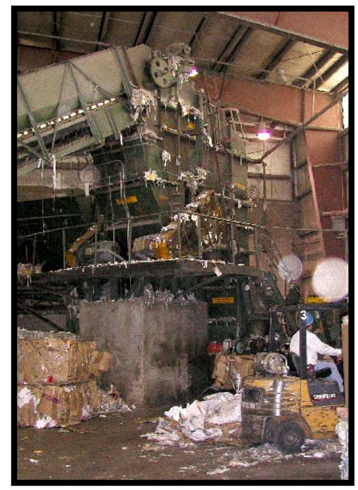
3.5.2 BALER SELECTION AND OPERATION

In determining the best baler for a specific application or facility there are a number of important considerations that need to be taken into account including:

- Type and characteristics of the materials being baled. Will the baler be used strictly for OCC or will it be used for baling other fibers as well? Will it bale other materials such as metals or plastics? These factors will determine how much compression (force) is required, what plane of compression is utilized (vertical or horizontal), and the requirement for materials conditioning (fluffing of paper, as an example) prior to baling.
- Volumes and desired throughput of materials. How fast will the baler run (cycle time) in order to process the volumes of materials anticipated? Balers should be capable of sufficient tonnage per hour to handle the expected loads at the MRF while allowing adequate downtime for maintenance.
- Size of material being fed to the baler. The hopper opening needs to be big enough to handle the type of material baled, or bridging of material will become a continuous problem.
- Physical size of the baler in relation to the space it's placed in. For example, a baler may physically fit into a space with a 12-foot ceiling height but if it needs a 14-foot clearance at the top for loading the hopper it won't be functional. Additionally, space needs to be factored in for the ejection and handling of bales. Baling up against a short wall with no space for material handling equipment will also impact the baler's functionality.

- Size and densities of the bales produced. Will the bale produced meet the physical specifications of the markets you are selling to?
- Location. One MRF operator complained about overheating of his baler. It is located too close to a concrete wall, restricting airflow needed to cool it.

Knowing the type and volume of material requiring baling, along with any space limitations, will help in determining whether a horizontal baler or a vertical baler would be the appropriate choice for a given application. Due to the cost and the need to handle varied materials, many smaller facilities rely upon a single large, single-ram horizontal baler.



Vertical balers are often used in applications where space is tight, materials less varied, and throughput is low. There have been applications, however, where a small MRF has been able to produce a variety of marketable products using several vertical balers, each dedicated to a specific material, in their operations. In addition some facilities will use dedicated briquetters for aluminum and ferrous cans. However the dedicated smaller balers and briquetters require a higher level of maintenance, are less reliable to operate than large balers, and produce lower bale densities.

Two-ram, horizontal balers for plastic and metal containers are highly recommended. While more expensive, they provide additional density and bale weight and are expected to experience fewer bale pops. Single-ram balers remain the standard for paper.

Regardless of the type of baler used, properly maintained baling equipment improves operating efficiency, equipment lifetime, workplace safety, and bale quality. Implement a schedule for regular and preventive maintenance for baling equipment. At least one state, California, has passed legislation that requires daily cleaning of balers at recycling processing facilities to prevent unsanitary conditions. Some manufacturers recommend installing an air compressor nearby the equipment to blow off debris.

Depending on the actual equipment used, regular and preventive maintenance may include such items as lubricating parts, cleaning out wire tie-guides or automated wire-tie mechanisms, checking all visible screws, nuts, and fix pins for integrity and loosening, and checking belt tensions.

Of particular importance for hydraulic systems is scheduling regular checks and necessary replacement of hydraulic fluid and filters. Over time, hydraulic oil can become contaminated due to dirty filters or break down due to excessive heat. Oil temperature and clarity should be watched carefully and checked once or twice a month.

Table 3.5 provides examples of some of the concepts, principles and practices that will contribute to improved efficiencies in baling operations.

TABLE 3.5. BALING EFFICIENCY CONSIDERATIONS	
Concepts/Principles/Practices	**Potential Benefits/Comments**
For added long-term cost savings, utilize a conveyor system to move materials into the baler hopper.	Upfront cost is higher, but there is likely to be a quick payback related to reduced labor needs. A conveyor system should have a faster feed rate than manual loading resulting in the baler performing closer to its rated cycle time (i.e., 10 bales/hour, 20 bales/hour, etc.).
Develop and maintain a preventive maintenance program/schedule for each baler.	Benefits include less costly repairs and maintenance over the long-term, potential longer life of equipment, and long-term high levels of performance and efficiency.
For balers that are used for a variety of materials, don't feed materials into the baler until you have enough for a successive run of bales. The more constant the feed the more productive the machine.	Loading materials into a baler and storing them there until sufficient quantities are available to produce a bale will result in the baler remaining idle when it could be used for baling other materials.
When buying a new baler, consider a more powerful machine that makes denser bales.	If you can take the same amount of material that went into 20 bales and fit it into 13 bales this could reduce handling costs, the space needed for bale storage, and over-the-road transportation costs (maximize truck loads for a reduced cost per ton mile).
Consider motor size (HP) and energy efficiency ratings in selecting a baler.	Energy usage is one of the biggest costs in baling operations. Using energy efficient equipment will help reduce this cost.
The type of material being baled, the size and density of the bales, and the type of baling wire used all have an impact on the amount of baling wire used. When wiring paper bales a lighter gauge wire is adequate (14 to 12 gauge). Because plastics have more memory (e.g., they expand more to their original shape after baling), a heavier wire (9 gauge) is usually recommended. It is also recommended to wire plastic bales with non-corrosive, galvanized baling wire especially if the bales will be stored outdoors.	The cost of baling wire is another large cost in baling operations. Obtaining good densities and using the right type and amount of wire for the product being baled can help control wire usage costs. Not only will this result in less wire required when a material is first baled, it will also reduce the need for re-baling materials that have broken apart because of the incorrect type or amount of wire used.
Consider installing a perforator or Twister® upstream of the baler when baling plastic bottles.	When baling plastics, the use of a perforator or Twister® prior to baling can increase densities up to 20%. Increased bale densities could reduce the number of bales that need to be made, handling costs, space needed for bale storage, and over-the-road transportation costs. The baler will no longer be required to burst bottles or pop caps reducing wear and energy costs.

Table 3.5 Baling Efficiency Considerations (con't.)	
Concepts/Principles/Practices	**Potential Benefits/Comments**
For in-feed quality control checks, instead of stationing pickers adjacent to below-grade conveyor hoppers or standing on above grade hopper frames, construct safe and secure elevated platforms along the inclined conveyors for retrieval/removal of contaminants or for breaking up bulky slugs that could cause bridging.	An elevated platform will eliminate the need for excessive bending, stretching, and balancing on structures being used for purposes other than what they were designed for. This in turn should lead to an improved efficiency and effectiveness in the quality control operation.
Maintain proper clearances for door swing on closed-end hydraulic balers. A best practice is to outline the door swing area with paint on the floor of the facility to identify the area in which to stay clear.	Baler doors are under pressure and they open with tremendous force. Operating personnel must maintain a safe distance from the door swing area when ejecting bales.

Following these simple rules will assist in providing uniform bales that will improve de-baling operations and reduce processing wastes at the end-user's mill. In addition, proper maintenance will maximize the performance, economics and safety of baling operations.

Safety Issues**.** There are a number of safety issues related to operating a baling system. All employees feeding or operating baling equipment should be trained in proper equipment operation. Equip all balers and feed mechanisms with emergency shut-off switches that will cut power to the system in the event of an emergency or safety hazard, or when maintenance is needed.

Operating personnel should never climb into or place any portion of their body into the baler chamber, unless the operator is absolutely certain that power to the system has been cut and locked out. Serious and sometimes fatal accidents have occurred as a result of an operator entering the baling chamber or trying to clear blocked material during a compaction cycle. There are proper procedures for clearing jammed materials, and all operators should be thoroughly trained in those procedures.

Due to the number of injuries and deaths involving balers and other compaction equipment, the National Institute of Occupational Safety and Health (NIOSH) has prepared a report that illustrates the safety risks of operating baling equipment and provides recommendations for preventing injury: "*NIOSH Alert: Preventing Deaths and Injuries While Compacting or Baling Refuse Material*," DHHS (NIOSH) Publication No. 2003-124. This publication is available from 1-800-35-NIOSH or from the NIOSH web page at http://www.cdc.gov/niosh/docs/2003-124/ .

3.6 PRODUCT STORAGE

Once incoming materials have been received and processed they go into product storage to await delivery to markets. Having adequate storage space for final product that will also protect the product from degradation while awaiting delivery to market is crucial. If such storage space is not provided, a variety of problems can occur including selling product prematurely (when not enough has accumulated to provide a full load or to take advantage of rising commodity prices) and receiving low prices or having loads rejected due to poor quality and product contamination. This last issue can lead to further problems with markets not wanting to purchase products from a particular MRF or purchasing materials only on a spot market basis.

Preferably all materials awaiting marketing should be stored inside or at least under cover. This is especially true of fibers, which will absorb moisture when wet resulting in a degraded product. Excessive moisture can skew material weights or lead to the formation of ice, making baled material more difficult to handle and process.

Materials that are stored outside should be stored in such a way as to minimize contamination (i.e., away from other materials that could contaminate the stored product, on concrete pads to minimize the accumulation of dirt and mud, etc.) and should be delivered to market in as short a time period as possible. If a product will be in storage for an extended period of time it should not be stored outside. Ferrous will rust over time when wet and HDPE plastics will be degraded when exposed to ultra-violet light for several weeks. Commodities such as glass are more weather resistant but even then the outside storage of uncovered bins or roll-off containers of glass will be prone to collection of dirt and other contaminants.

3.6.1 BALE HANDLING AND STORAGE

Properly handled and stored bales help maintain the quality of prepared commodities prior to sale and help improve workplace safety. In general, baled materials should be stored in a fashion that keeps them clean and dry with limited exposure to sunlight (sunlight can cause ultraviolet degradation of fiber and plastics). Bales should preferably be stored indoors. If they must be stored outdoors, they should be covered to limit exposure to moisture or sunlight. Bales should be stored on pallets or on clean, dry surfaces to avoid introduction of contaminants. This is particularly true in materials recovery facilities where many different types of materials are processed.

Bales should always be transported in a fashion that keeps them elevated off the floor surface. When transporting bales throughout a facility, take caution not to push bales directly across the floor surface, as this may embed unwanted contaminants into the bale. Do not store bales in close proximity to granulators or other processing equipment to prevent the introduction of airborne contaminants.

Minimizing the number of times a bale is handled is the best practice for maintaining bale integrity through storage, loading and shipping. Excessive handling increases the probability of bale breakage and introduction of contaminants. For these reasons, when stacking bales of recyclable materials, each commodity must be stacked independently from the other, so that when bales of a particular material are removed from the storage area, the other stacks of materials will remain safely intact.

Proper stacking of bales is imperative to safe operations within a facility. Improperly stacked bales can fall, causing serious injury to workers or damage to plant equipment. The safe stacking height in a facility is a function of bale integrity, bale dimensions and ceiling height. In addition, there may be a number of regulatory limits to stack height and configuration based on local fire codes or building codes. For example, fire codes require such provisions as adequate clearances from sprinkler heads, and that stored materials do not block aisles or points of exit or egress. Building codes may limit the amount of floor space that can be occupied with stored materials, or the load capacity for storage floors that are not on grade. Finally, the federal Occupational Safety and Health Administration (OSHA) requires compliance with all state and local requirements.

When stacking bales against a wall, do not place the bottom bale of the first stack flush against the wall; set it out at least 6 inches so that the upper bales on a stack can lean into the wall and not away from it. When bale stacks are not placed against a stationary wall, many facilities "build" stacks sequentially. That is, a forklift operator will not go to full height on an individual stack before starting another stack. In this way subsequent stacks reinforce the integrity and help brace the previous stack.

Although not a common operation, baled material could be weighed and "tagged" or labeled prior to storage. This helps in ensuring that legal shipping weights for over-the-road transport are not exceeded, or in resolution of possible disputes regarding shipment weights. None of the MRFs visited acknowledged the use of bale tagging.

Some MRFs do employ bar code scanning systems and bale labels for bale inventory management. Bar code systems contain specific information about each bale produced by a supplier. Given recent advances in bar coding technology, it is now feasible to achieve effective tracking of recycled materials for quality control, accounting and inventory management purposes. The use of bar coding systems for inventory management will be a function of system design, throughput and program budget.

Some of the things to consider when looking at product storage are summarized in Table 3.6.

TABLE 3.6. PRODUCT STORAGE CONSIDERATIONS	
Concepts/Principles/Practices	**Potential Benefits/Comments**
Keep final product storage area free of unprocessed materials and accumulated supplies and equipment.	This will reserve space for product storage during the intervals between shipping to markets and it will improve storing/loading efficiencies if other materials don't need to be moved or gone around during the storage/loading process.
Materials that are stored outside should be: • Stored on a concrete pad or other impervious surface to minimize contact with dirt/mud (surface should be slightly sloped to promote positive drainage). • Covered to protect against degradation from moisture or light. • Limited to materials that have a quick turnaround time from storage to market (a month or less)	Reduces the potential for product contamination or degradation. This in turn can lead to higher prices for materials and a lessened potential for rejected loads.
Avoid storing glass containers in outdoor piles for long periods.	Glass container piles can attract animal and insect vectors due to food or beverage residuals on the surface areas of exposed broken glass fragments. A best practice is to ship out glass as soon as at least one truckload quantity is available for shipment.
As noted previously, consider baling materials to improve densities.	The benefits of baling include: • Baled materials typically generate a higher per unit revenue ($/ton) than loose materials. • Baled materials take up less room in storage. • Baling allows more weight per volume to be shipped translating to a reduced over-the-road transportation cost.
Stage a tractor-trailer or other delivery vehicle on-site and store baled or processed materials in them. Store materials that have the quickest turnaround time from storage to market nearest the loading dock or in the delivery vehicles.	Storage space will be preserved for other commodities. Double handling of materials during the storage/marketing operation is reduced and operational efficiencies in loading materials for delivery to market will be improved.

3.7 RESIDUALS MANAGEMENT

Even the best recycling facilities generate a waste stream. Excess residuals, however, can be a costly inefficiency. A study of MRF operations by the American Plastics Council pegged the mean cost of processing residues at $85 a ton.

Residues from recycling facilities result from two major sources; unwanted materials mixed with incoming recyclables and recyclables that are not recovered. In the latter case, a periodic inspection of the residuals from your facility can provide clues to inefficient operations, which can be corrected internally. Generally resorting residuals is not cost effective, however, a regular, e.g. weekly, sort of a sample of residues to determine the percentage of recoverable recyclables and the percentage of unwanted or prohibitive materials.

Reducing incoming contamination requires constant education and communication with the generators. Whether your source of materials is commercial accounts, curbside programs or drop-off boxes, public education can have a dramatic effect on the quality of materials coming in the front door. An Oregon MRF was finding large quantities of scrap metal in its residues before discovering that one of its curbside programs was targeting scrap as a recyclable.

Establish a load checking policy and procedures for providing feedback to sources of excess contamination. MRFs should use video or still photo records to give feedback to suppliers regarding the quality of materials received. Showing actual video or photos of actual contamination gives the suppliers the information they need to recognize the specific materials that are not acceptable so they can go back to the collection sources with education to prevent future contamination.

Develop brochures or other educational materials describing materials that are acceptable, unacceptable and why. If you are a private operator, seek out partnerships with public agencies interested in promoting recycling to assist in public education efforts.

The type of collection program selected for a community program can also impact the amount of residuals received. A March 2004 American Forest and Paper Association report found an average “residue percent” of 14.4 percent for programs using single-stream collection compared to 6.8 percent for dual-stream collection. (Note: The residual rates reported by the single stream facilities interviewed for this manual reported rates much lower than this average.)

Handling the inevitable rejects and residue material is usually done in one of three ways: depositing them in dumpsters or roll-offs, baling them or using compactors. Transporting loose material in roll-offs can be expensive and baling can reduce this transportation cost. However, these rejects often contain materials such as glass fragments and metals that can cause excessive wear and maintenance on the baler. Baling also risks introducing contaminants into following bales of recyclables and interrupts the baler's normal operations. Compactors are preferred as their maintenance costs are lower and their use is less disruptive of MRF operations.

3.8 MAINTENANCE

For a materials recovery facility, next to operating costs, the second highest cost is equipment and facility maintenance. Profits can be wiped out by the cost to replace or repair equipment that was not properly maintained and failed prematurely. A good preventive maintenance program is the best way to keep equipment on-line and functioning. Common threads to an effective program include:

- Ensure equipment has adequate capacity to allow for scheduled downtime. When equipment runs at 99% capacity from day one, maintenance suffers.
- Maintenance can be scheduled so as not to impact operating efficiency. Take advantage of days when incoming material is lighter than average to shut down early. Alternate lunch breaks between processing and maintenance crews. If necessary, sacrifice some overtime on the weekend.
- Teach equipment operators to "get in tune" with how the machines run and to keep alert for maintenance concerns. By noticing an incorrectly tracking belt, a wearing part, or an unusual noise or vibration, knowledgeable staff can identify potential problems that might eventually manifest themselves in a breakdown.
- Develop daily, weekly and monthly schedules for common maintenance tasks such as visual inspection, lubrication, tightening belts and rollers, wear parts replacement and cleaning confined spaces. Follow equipment manufacturer maintenance schedules and if they are not adequate for the operation, adjust the schedule to reflect the equipment wear rate.
- Consider the use of computer software to schedule and monitor maintenance activities and control parts inventories. Maintain logs of maintenance, problems and downtime associated with each piece of equipment. Historical records can provide clues to chronic problems.
- Give maintenance staff the support they need to diagnose and fix problems to prevent them from recurring.

3.9 TRANSPORTATION

Properly loaded trucks can ensure regulatory compliance with maximum legal shipping weights, lessen the possibility of contamination, and prevent costly material losses and clean-up expenses due to improper loading. Proper paperwork and weight verification for shipments can help reduce disputes over material quality or quantity.

Prior to loading a truck, sweep the truck floor to remove any potential contaminants. Never push bales across the truck floor surface to prevent imbedding potential contaminants in the bales. Shipments should always be accompanied with a complete bill of lading, certified weight slips, and preferably, a detailed packing list from the shipper.

Work with your markets to be sure the bale sizes proposed in their specifications will allow for the most efficient truck loading and unloading. Make sure required bale configurations will not require special loading, such as standing bales on end, to achieve required minimum shipping weights or result in excessive “air” space in trailers.

Facility operators should never load broken or partially broken bales. Never "jam" or wedge bales into trucks, as this will adversely affect unloading and could possibly damage equipment. Based on the actual bale density and the particular truck's legal gross shipping weight, it may not be necessary to fill the truck to capacity. This can be determined by calculating the number of bales that can be accommodated without exceeding the maximum legal shipping weight provided by the carrier, based on the sum of individual bale weights. In addition, a best practice is to record individual bale weights on a packing list that can be attached to the bill of lading for the shipment.

In cases where the truck cannot be filled to capacity, bales should be distributed evenly throughout the truck. This may require stacking some rows only two bales high instead of three. The best practice is to distribute the bales along the entire truck floor, that is, from the nose to the tail, even if the maximum stack height is not achieved.

In addition, when scheduling trucks for outgoing shipment, a best practice is to always request that the carrier be equipped with "load locks" that are placed across the width of the truck to prevent bales from falling and potentially breaking open during transport. It is also important to specify the truck size you require when scheduling a shipment to make sure that you receive a truck that can accommodate the required minimum shipping weight of your particular supplier. While most trucks use either 48- or 53-foot trailers, some carriers use 45-foot trailers.

When loading bales three-high in a truck, it is recommended that the bottom bale of each stack in a row be loaded singly, with the remaining two bales placed on top as a pair in a separate pass. In this way, forklifts with two-stage hydraulic systems will not hit and possibly puncture the roof of the truck. Similarly, when unloading, operators should take off the top two bales of a stack first and then return for the bottom bale.

When receiving baled materials, trained personnel should visually inspect the load prior to accepting it. Visual inspection will quickly identify the presence of excessive levels of contaminants, such as unacceptable containers of other material types, moisture, or product residues. Visual inspection can also assess general bale quality in terms of bale integrity. Broken strapping or broken bales are easily identified. The basic rule of thumb throughout the industry is that if contamination is visible on the exterior of the bale it is likely to be contained in the interior of the bale. Therefore, poor bale appearance usually indicates poor overall material quality. Visual identification of excessive levels of contamination on the bale exterior is grounds for load rejection. To avoid disputes, it is always best to take photographs of any rejected materials.

The best practice for determining the weight of a shipment is to weigh trucks empty and full (referred to throughout the industry as the light and heavy weight) on certified 65-foot truck scales. Certified scales are those that have been inspected by their respective regulatory agency for weights and measures for accuracy. A general rule within the recycling industry is that the receiver's weight takes precedence.

In cases where trailers are dropped for loading and unloading and picked up at a later time, light and heavy weights can be taken on the trailer only. Many carriers that provide trailers in this fashion have the trailer's empty weight documented.

TABLE 3.9. TRANSPORTATION CONSIDERATIONS

Concepts/Principles/Practices	Potential Benefits/Comments
Maximize material weight delivered to market. Increase load densities by baling (i.e., fibers, plastics, aluminum, etc.) or crushing (i.e., glass). Ensure loads are "full" loads.	In addition to improved over-the-road transportation costs, many markets have a minimum load weight requirement. Not meeting this requirement can often lead to a financial penalty.

4.0 MARKETING

Established and secure long-term markets for materials are crucial to operating efficiencies at MRFs. Those markets dictate how much and what kind of processing is required as well as providing reliable outlets for processed materials and the necessary revenue for continued operation of the MRF.

Materials to be marketed should be prepared in such a way as to meet delivery specifications to the market (i.e., bales of a certain size and density, clean, minimal to zero contaminants, etc.). Regardless of whether materials are sold to local markets (e.g., insulation manufacturer), directly to larger regional, national markets (e.g., paper mills, glass cullet markets), to a variety of markets via a commodity broker, or exported, having a written contract will offer some protection from fluctuating prices or from having the market reject loads without good reasons.

The conditions and requirements in a marketing agreement will vary widely. Items that should be addressed in a marketing agreement, though not all-inclusive, include such things as:

- Material Specifications that need to be met by the processor (definition of contaminants, allowable percentage of contaminants, preparation specifications, etc.)
- Minimum quantities and frequency of collections/deliveries;
- Delivery or pickup site;
- Price to be paid for materials and, if applicable, the formula used to determine the price to be paid;
- Price reduction for non-spec material;
- Minimum per unit revenue (floor price) seller will receive for materials;
- What to do when value of commodity falls below the floor price;
- What party arranges for and pays for loading and transportation of materials to markets;
- Procedures for handling rejected loads; and
- Term of contract.

TABLE 4.0. MARKETING CONSIDERATIONS

Concepts/Principles/Practices	Potential Benefits/Comments
If insufficient quantities of materials are recovered to interest potential markets, consolidating those materials with materials from other counties or municipalities could help attract the necessary markets. This approach is termed "cooperative marketing."	The concept of cooperative marketing has been very effective in a variety of locations and has given smaller generators of recyclables more leverage in obtaining secure markets and relatively stable prices.
If the economics associated with traditional markets are unattractive (i.e., too costly to process materials to meet specifications, too costly to transport materials to distant markets, etc.) consider developing local alternative markets for some of the recovered materials.	Historically examples of alternative markets have included animal bedding or local cellulose insulation manufacturers (newspaper) or roadbed aggregate (glass). Though the revenue received for these materials is generally low, the processing and transportation costs are also generally low and there is a cost avoidance if material is not disposed.

TABLE 4.0: MARKETING CONSIDERATIONS (CONT'D)	
Concepts/Principles/Practices	**Potential Benefits/Comments**
Balance marketing decisions for specific materials on quantity of materials recovered, processing cost, and revenue received.	For example, if the additional revenue generated from marketing natural HDPE recovered in an operation is $3,000 more than if it was marketed along with the pigmented HDPE but it costs $4,000 to sort and process this material the added effort is not worth the added revenue.
Considering the types and quantities of materials generated, assess the advantages and disadvantages of marketing directly to an end-market versus a broker or versus another MRF with attractive processing.	There are a variety of advantages and disadvantages in going directly to an end-market versus going through a broker. Some of these include: • An end-market, such as a paper mill, is likely to give you a higher price for a specific grade(s) of material if you can guarantee the quality and the quantity they demand. Going through a broker will usually result in a lower price per ton since the broker takes a portion of the revenue. • Going through a broker will generally offer a wider variety of markets (market diversity) and as a result they can shop around for the best price. Selling directly to a mill may limit the grades of paper they will be willing to purchase and the price they can pay for that paper.
Communicate with other operations to see how their contracts are structured and what their markets offer in the way of service.	There are a variety of conditions and items that should be addressed in a market contract to protect the seller from wild fluctuations in the price paid for a specific commodity. Understanding specifications that need to be met, the recourse a seller has if a load is downgraded or rejected, responsibility for arranging and paying for transportation to market, etc., should be addressed in the contract to offer shared risk (and reward) between the parties.
Beware of being "over-brokered".	Brokers may offer prices significantly below going market rates. It pays to be aware of market prices and the price other facilities are being paid for materials. Join marketing associations to exchange ideas and information. Learn to ask questions and read the trade journals. Negotiate equitable brokerage fees.
Make sure that your buyers are reliable and will pay you for the material they purchase at the price they quoted.	Buyers that acquire your material and then go bankrupt do not help you at all.
Don't change markets frequently for small changes in prices.	If you are jumping around from buyer to buyer in a hot market, you may lose your only market during the downturns. Markets prefer reliable, long-term suppliers in the same way MRFs like reliable, long-term markets.
Look globally for markets.	Emerging markets, such as China, appear to be where the new demand will continue to come from.

5.0 HEALTH AND SAFETY CONSIDERATIONS

Health and safety are crucial components in all aspects of MRF operations. From the delivery and tipping of materials on the floor through processing and on to storage, loading and transporting of recovered materials attention to health and safety issues should be in the forefront of all operational functions.

The day-to-day operations of a MRF has a variety of potential safety hazards including:

- Tipping floor operations where people are working in close proximity to vehicles delivering materials and mobile equipment pushing and carrying materials into processing areas or short-term storage.
- Handling of a wide variety of materials, which have the potential for cuts, abrasions, sticks, and injuries associated with heavy items falling.
- Sorting operations where, in addition to those injuries noted above, there is a potential for physical strain, getting caught in material transfer and conveying equipment, or exposed to other biological or chemical hazards.
- Baling and other processing equipment operations where there is a potential for injury or death, when safe operating procedures are not practiced.
- Injury due to unsafe materials storage and loading procedures.
- Forklift and other vehicle operation.
- Injury due to lifting.

In general terms, best practices for health and safety require that operators seek out and prevent the ways in which workers can be injured.

- Designate a health and safety officer or committee to ensure that regulations and recommended safety practices are followed.
- Investigate the causes of all accidents and “near misses” in order to better control the hazards.
- Provide adequate safety training and personal protective equipment to all employees.
- Discipline unsafe conduct and reward contributions to the safety and health program.

Rather than list and discuss <u>all</u> the recommended safety practices that should be routinely applied in the operation of a MRF, the reader is referred to Appendix A. The checklist in Appendix A provides a quick self-assessment of health and safety practices. Too many “NO” answers indicates more attention to this issue could be warranted.

For a source of more detailed information and discussion, the Environmental Industry Associations (EIA) has published a “*Manual of Recommended Safety Practices*” of which the “Landfill, Transfer Station, and Material Processing and Recovery Facility Operations Section” is available separately. The intended purpose of the manual is to familiarize the reader with OSHA and USDOT regulations that are related to waste service operations, related safety standards such as the American National Standards Institute (ANSI) Z245 standards for waste and recycling equipment, and to provide some guidance in improving the safety programs at waste service facilities.

The manual covers such areas as safety basics, core practices, mobile operations, processing equipment operations, landfill operations, transfer station operations, and MRF operations. The section dealing with MRF operations addresses such topics as training, personal protective equipment, vehicular traffic management and tipping floor operations, processing operations, and restricted work areas.

The Waste Equipment Technology Association (WASTEC), a member organization of EIA, holds the Secretariat for the ANSI Z245 Committee. This Committee develops all of the safety standards for the waste industry and sets out requirements for manufacturers, distributors, installers, maintenance personnel, employers, and employees. The seven ANSI safety requirements dealing with the waste services industry include:

- ANSI Z245.1 – Mobile Wastes and Recyclable Materials Collection, Transportation, and Compaction Equipment.
- ANSI Z245.2 – Stationary Compactors.
- ANSI Z245.21 – Stationary Compactors – Safety Requirements
- ANSI Z245.30 – Waste Containers.
- ANSI Z245.41 – Facilities for the Processing of Commingled Recyclable Materials.
- ANSI Z245.5 – Baling Equipment.
- ANSI Z245.60 – Waste Containers (Compatibility Dimensions).

To obtain more information on the Manual of Recommended Safety Practices and the ANSI Z245 equipment safety requirements, or to order a copy of the manual and/or the ANSI Z245 requirements, the EIA can be contacted at 1-800-424-2869 or through their website at www.envasns.org. The standards can also be purchased and downloaded on-line from the ANSI eStandards Store at http://webstore.ansi.org/ansidocstore.

The Occupational Safety and Health Administration (OSHA) which enforces Federal safety standards reports that scrap and recycling facilities are most frequently cited for violations of the standards listed below:

Standard	**Description**
1910 0178	Powered Industrial Trucks
1910 1200	Hazard Communication
1910 0147	Control of Hazardous Energy, Lockout/Tagout
1910 0023	Guarding Floor and Wall Openings and Holes
1910 0095	Occupational Noise Exposure
1910 0212	Machines, General Requirements
1910 0305	Electrical, Wiring Methods, Components and Equipment
1910 0132	Personal Protective Equipment, General Requirements
1910 1025	Lead
1910 0146	Permit-Required Confined Spaces

Free assistance in understanding and meeting OSHA safety standards is available from the Illinois Department of Commerce and Economic Development's Onsite Safety and Health Consultation Program. This onsite consultation program is designed to identify potential hazards and recognize existing precautionary measures your company is already taking to keep your workplace safe. Their services include providing onsite safety surveys, industrial hygiene surveys, health and safety program audits, training and education, and management program development and assistance. The consultants are state employees and have no authority to issue citations or fines to employers for violations found or to file reports to OSHA (except under extreme circumstances). More information on this program may be obtained from their website at http://www.illinoisbiz.biz/osha/index.htm. Check the resource list for downloadable copies of many useful manuals. The "*Forklift Safety Guide*" is especially recommended.

Due to the number of injuries and deaths involving balers and other compaction equipment, the National Institute of Occupational Safety and Health (NIOSH) has prepared a report that illustrates the safety risks of operating baling equipment and provides recommendations for preventing injury: "*NIOSH Alert: Preventing Deaths and Injuries While Compacting or Baling Refuse Material*," DHHS (NIOSH) Publication No. 2003-124. This publication is available from 1-800-35-NIOSH or from the NIOSH web page at http://www.cdc.gov/niosh/docs/2003-124/ .

6.0 POLLUTION CONTROL AND GOOD NEIGHBOR PRACTICES

A recycling facility can potentially impact the surrounding air, water and land quality if designed and operated improperly. While many facilities will not need to be permitted, they have the same responsibilities as any business or industry to handle the materials they use, and dispose of the wastes they produce, in a manner that protects the environment. Recyclers need to be prepared to handle unwanted (and potentially polluting or hazardous) wastes received in incoming loads or drop-off boxes. Recyclers that handle materials such as lead-acid batteries and used oil must be especially aware of proper procedures for handling and storing hazardous waste and controlling spills. The following practices will help your facility prevent pollution problems.

Inbound Material Control.

- Establish procedures for inspecting and rejecting materials.
- Create a program for inspecting, handling, storing and disposing of lead-acid batteries, hazardous wastes, and other non-hazardous residual liquids. Procedures should describe handling of cracked and broken batteries and disposal of leaking battery acid.
- Prevent scrap metals such as industrial turnings and cuttings that may be contaminated with cutting oils and metallic fines from coming in contact with stormwater runoff.
- Educate generators of recyclables to drain residual liquids and remove semi-solid and liquid residues in aluminum, plastic and steel containers prior to bringing the material to the facility.

Facility Operations.

- Drain and collect liquids in a designated area. Put a cover over and secondary containment around all liquid transfer facilities.
- Conduct processing operations indoors or place process equipment under cover and prevent runoff from coming in contact with the equipment.
- Prohibit discharges and dumping to floor drains that are connected to the storm drain system.
- Keep loose fiber away from open doors to prevent litter.

Inspections and Maintenance.

- Regularly inspect material storage, handling and transfer areas, equipment, containment areas, storage and waste containers/drums, and bulk liquid tanks for spills, leaks, signs of corrosion, worn parts or components, deterioration of flanges, and leaking seals and gaskets. Immediately repair any problems
- Conduct routine preventative maintenance of process equipment, of control equipment such as oil/water separators, and storage and containment areas.

- Conduct periodic nondestructive testing of all bulk storage tanks for signs of deteriorating structural integrity.

Spills and Facility Clean-up.

- Establish spill prevention and response procedures and use dry methods to clean up spills. Keep an adequate supply of dry clean up materials readily accessible.
- Schedule frequent cleaning of accumulated fluids and particulate residue around all processing equipment, storage containers and high traffic areas.
- Regularly sweep all traffic and storage areas to minimize particulate and residual materials buildup.
- Prohibit washing down of material storage and tipping floor areas, unless a washwater collection system is in place or approval is granted by the wastewater treatment plant to discharge wash waters to the sanitary sewer

Material Storage.

- Store all materials and waste indoors or in covered areas with curbing, berms or other containment measures.
- Surfaces of secondary containment areas should be adequately sealed to prevent leaks.
- Separate all scrap batteries from other scrap materials and segregate hazardous and flammable wastes to comply with National Fire Protection Association (NFPA) guidelines.
- Store materials in appropriate containers near the point of use or production of the materials (i.e. shredded materials and fluff).
- Make sure that all storage containers and drums are in good condition and meet NFPA guidelines.
- Clearly label all containers and include necessary warnings and special handling instructions
- In the storage areas, put individual containers on pallets. Limit the stack height of individual containers/drums and put straps or plastic wrap around the drums to provide stability.
- Provide adequate clearance to allow material movement and access by material handling equipment.

Waste Disposal.

- Segregate any potentially hazardous wastes or residues from non-hazardous wastes.
- Make a determination of your hazardous waste generator category and follow state regulations for your category:

  - CESQG's: Conditionally Exempt Small Quantity Generators accumulate less than 220 pounds per month of hazardous waste and less than 2.2 pounds of acutely hazardous waste.

- SQG's: Small Quantity Generators accumulate less than 2200 pounds per month of hazardous waste.
- LQG's: Large Quantity Generators accumulate more than 2200 pounds per month of hazardous waste.

More information on managing special wastes may be found on the Illinois EPA's website at: http://www.epa.state.il.us/land/waste-mgmt/special-waste.html.

Most common citizens' concerns about recycling facilities include noise, odor, traffic, dust, vectors, litter, and aesthetics. Other concerns include water pollution, fire concerns and hazardous waste.

The issues of noise, litter and odor should be addressed during the design and operations plan. Noise and litter can be controlled or minimized by fully enclosing the receiving and processing areas and requiring all vehicles to tarp their trucks. Vector control may require periodic professional treatment but many facilities find natural, organic controls effective. Odor control chemicals that react with and neutralize odors should be considered, as well as utilizing a negative air pressure system inside the building. If necessary, exhaust air can be treated using activated carbon filters prior to being exhausted into the atmosphere.

Dust is created from tipping and loading operations. Misting and using air handling and filtering equipment can control dust. If necessary, dust collection ducts with filter or baghouse installations can be installed over the tipping floor and processing equipment to collect airborne particulate matter. Prevention techniques are generally less costly than treatment and remediation. Table 6.0 lists common concerns and mitigation measures.

TABLE 6.0. POTENTIAL IMPACTS ON NEIGHBORS AND MITIGATION MEASURES

Concerns	Mitigation Design Features	Mitigation Operational Procedures
Aesthetics	• Setback distances/buffer zones • Landscaping and man-made screens • Building exterior • Fencing	• Keep entrance and visible areas clean • Maintain building exterior • Maintain building and grounds
Fire	• Automatic sprinkler systems • Fire extinguishers at key locations • Area for hot load segregation	• Plan approval by local fire department • Employee training • Load inspections
Odor	• Orient building considering predominant wind direction • Setback distances, greater in direction of prevailing winds • Exhaust fans with air filters • Mist system to treat odors • Automatic door operators	• Immediate handling of odorous loads • Processing inside building only • Load tarping requirements • Removal of all residuals by end of day • Site road and tipping floor cleaning • Operate exhaust system during operating hours
Dust and Mud	• Automatic misting system • Building orientation with respect to predominant wind direction • Paved access roads	• Daily sweep of roads • Wet roads as required • Process materials inside building

TABLE 6.0. POTENTIAL IMPACTS ON NEIGHBORS AND MITIGATION MEASURES		
Concerns	**Mitigation Design Features**	**Mitigation Operational Procedures**
Traffic	• Intersection/entrance design with adequate sight distance and stopping distance • Signs, signals, and pavement markings • Acceleration/deceleration lanes exiting or entering facility • Designated routing of vehicles • Sufficient internal queuing area for vehicles • On-site traffic patterns that minimizes crossing	• Driver instruction • Compliance with site rules, signs, etc. • Adherence to designated routes • Operating hours and delivery schedules
Noise	• Calculated proper setback distances • Structures to block noise (berms, walls, absorbing materials)	• Limit processing to inside building • Mufflers and noise abatement on trucks and equipment • Measure noise and address excessive sources
Vectors	• Building design and construction to eliminate points of entry	• Routine inspection and treatment by professionals • Residual removal by end of day • Tipping floor (and site) cleaning/washing • Indoor and limited term storage of materials
Unacceptable Waste	• Signs at facility entrance • Random inspection area	• Employee training • Load screening • Notification to haulers • Rejection of loads from repeat offenders

MRF operators serious about their environmental reputation can seek certification of their environmental management plans under the International Standards Organization's (ISO) Standard 14001. Receiving certification of ISO environmental standards requires independent confirmation that a company has met the six key elements of an internationally accepted environmental management system. Those elements are:

- An environmental policy, in which the organization states it intentions and commitment to environmental performance;
- Planning, in which the organization analyzes the environmental impact of its operations;
- Implementation and operation: the development and putting into practice of processes that will bring about environmental goals and objectives;
- Checking and corrective action: monitoring and measurement of environmental indicators to ensure that goals and objectives are being met;
- Management review: review of the EMS by the organization's top management to ensure its continuing suitability, adequacy and effectiveness; and
- Continual improvement.

Compliance with ISO standards is certified by independent third-party auditors. More information on the standard and certification procedures may be found on their website at http://www.iso.org/iso/en/iso9000-14000/index.html.

7.0 OPTIMIZING DROP-OFF OPERATIONS

Drop-off centers are used to provide recycling service in different communities for different reasons: in smaller communities or rural areas where curbside collection is impractical or unaffordable; or in conjunction with a curbside program for multi-family residences, residences outside service areas, for residents unwilling to pay subscriber fees, for small businesses or for additional materials not collected at curbside. Optimizing the operation of any drop-off center involves maximizing participation while minimizing the receipt of unwanted, non-recyclable materials.

Use convenient locations to enhance participation:

- Select locations in population centers that are easily accessible and have high traffic. Examples include shopping centers and industrial complexes, schools, recreational areas, fire stations, post offices, churches, major intersections, landfills or any other location frequented by a large portion of the populace. Shopping centers work especially well because they conform to typical traffic patterns of area residents and enable people to combine other errands with recycling. The less the distance participants must travel to sites, the greater their participation.
- In rural areas where residents take their trash to a central trash collection facility or transfer station, the recycling drop-off should then be located there for the convenience of the residents.
- Be aware of security concerns both for the participants and the collected materials. Chosen locations should be clearly identifiable from main roads and in full view for security and to discourage improper disposal and contamination. Fencing, nighttime lighting, limited hours of operation and on-site staff will all increase security.

Design drop-off centers to improve overall performance:

- Designs should provide hassle-free traffic flow and site use. A circular flow or flow-through design is preferred to prevent backing into or crossing incoming traffic.
- Allow for five cars to use the site simultaneously, as well as ample space for the recycling collection truck or service vehicles to maneuver.

- Use concrete pads for large roll-off containers. They will last longer and will not rut like asphalt or gravel surfaces.
- Collection containers should be selected to be easy to use by participants (no high lifts, heavy lids or highly restrictive openings), adequately protect materials from the weather, and interface quickly and easily with collection equipment. A gated or fenced site and 24-hr lighting will limit after-hours scavenging and fly dumping.

Accept as many materials as possible at one site to increase recovery:

- A one-stop-drop is preferable to taking different materials to different locations and will increase participation.
- Consider including or partnering with swap shop or reuse operations to allow collection of reusable items.
- Periodic drives or special collection events can collect products with unstable markets, such as mixed paper, or with seasonal disposal patterns, such as telephone books or Christmas wrap.

Maintain a clean and attractive site:

- Maintain adequate collection and storage space and provide reliable service and pickup of materials at the drop-off stations. Overflowing and dirty recycling bins are unsightly and negatively affect participation and neighborhood acceptance.

- Well-drained and paved surfaces are preferred. No one likes tramping through mud and water to get to drop-off containers.
- Provide a trash can for unacceptable items and incidental waste and to help reduce litter. This trash can is vital to help reduce contaminants. Plastic bags used to bring the recyclables to the site are the most common contaminant. If a trash can is not there for these materials, people may put them in recycling bins rather than carry them back home. It may cost to dispose of this trash but losing markets to excess contamination, or having to sort it out then dispose of it anyway, will cost more. Inspect the site frequently and remove any litter or dumped trash promptly. Also repair or remove vandalism promptly.
- Consider landscaping for a more attractive site. Flowerbeds could feature locally produced compost.

Provide education to the user both before and after they arrive at the site.

- Distribute informational material to the target communities so people are thoroughly familiar with the specific recyclables wanted before they arrive at the site, or they may deposit unacceptable materials just to avoid taking them back home for disposal. Ensure that the educational material lists acceptable items, drop-off locations, preparation instructions, time and day when the drop-off site is open, and who to contact with questions. Simple, active language and simple line graphics in the printed material is very important.
- To get the information out about the recycling program, use radio and TV spots, newspaper ads and articles, and billboard ads; visit and give presentations to neighborhood associations, schools, churches and civic organizations to promote and explain the program; put quarterly flyers, leaflets and/or newsletters in the water/sewer bill, bank statement or by separate mailing by the water/sewer

- department; train community volunteers on the program so they educate neighbors and others; produce a video on local waste management/recycling program and provide video free to video stores and setup a display information booth on weekends at the local malls, discount stores and/or food centers.

- On-site, use highly visible signage to direct traffic and label collection containers with their desired contents. Clear signage is important. Instructions on the recycling bins should be attractive, simple and well marked to identify materials acceptable for the containers. Large signs and large lettering are suggested. Signs at eye-level are more frequently read than signs above or below. Avoid using technical jargon. Instead, specify exactly what materials are accepted. "Baiting" containers with appropriate materials helps users know the material that goes in each bin. Where standardized containers are used and swapped out, magnetic signs can be used and transferred to new, empty containers.

Some of the underlying causes of high contamination include 1) people frequently misinterpret the signs because the wording is unclear, 2) people place unacceptable materials in the recyclables bin because no disposal container was available, and 3) people find heavy container lids awkward to hold open while attempting to place individual bottles and containers inside so it is easier to toss the whole bundle in along with the bag or box. Some operators suggest that collection containers should have restrictive openings to limit which items can go in. Others note that users often object to the time it takes to feed items in one at a time and would rather dump full bags or boxes into a large opening. The latter approach risks additional contamination unless the users are well informed to dump only the recyclables and not to include the bags or boxes as appropriate.

One of the most significant decisions in operating a recycling drop-off is whether to staff it or not. Many sites operate adequately without staffing but are frequently subject to high contamination levels and fly dumping. If a site has a limited operating schedule (Wednesdays, Saturdays), then staffing is less of a challenge. A staffed site has less contamination than an un-staffed site. On-site staff adds costs but also provides better control and service opportunities, such as:

- Educating citizens on the items to recycle, the proper ways to do it, and the importance of waste reduction and reuse. They can hand out literature, answer questions, and provide information on ways to reduce wastes; for example, to compost food scraps, yard waste, and other organic materials.
- Controlling litter, maintaining the site and preventing scavenging and excess contamination/dumping.
- Assisting users with unloading vehicles.
- Operating compactors or other special equipment.

- Tracking participation data.
- Checking addresses if facility use is restricted to community residents.
- Operating swap shop, reuse exchanges or special collection events.

Whether the staff is paid or volunteer, ensure the staff is well trained in the specifics of what is accepted and not accepted. Consider creating a site manual with this information in detail, answers to users frequently asked questions, and other operational procedures.

If a site is open 24 hours, or for other reasons cannot be continuously staffed, monitor the traffic at the site and provide staff during the periods of peak usage.

8.0 CONCLUSION

This manual identifies a number of ways that MRFs can improve operational efficiencies. Not all concepts and practices listed in this guide will be applicable to all MRFs though MRFs will find some useful information in the concepts and practices discussed. Additionally it should be noted that the information presented in this guide are by no means the only methods MRFs can use to optimize their operations.

Each MRF has unique conditions associated with quantities and types of materials accepted and processed, the design/layout of the MRF, the type of sorting and processing methods used, and the end markets. There's little doubt that other methods for improving efficiencies can be identified in assessing operations in a specific MRF. Based on the experience of the MRFs participating in this study there were a number of common operational areas that were targets for efficiency improvements. These areas included:

- Materials Receiving: Provide adequate space for unloading materials from collection vehicles. Move unloaded materials to processing or incoming materials storage as quickly and safely as possible while minimizing cross-traffic with other operations. Flow of materials through the MRF should proceed in fashion that minimizes backtracking or multiple handling of materials.

- Materials Sorting: In small MRFs that are not heavily mechanized the efficient use of labor is critical in the overall sorting operation. Provide training to all sorters. Adjust transfer conveyors, sorting line conveyors, and other related equipment so that materials to be sorted are easy to see and sort. Find the optimum conveyor speeds to control burden depth and maximize sorting efficiencies. When it's economical to do so, add automation to the sorting procedures (e.g. screens and magnets) as a way to reduce labor costs.

- Materials Processing: The types and quantities of materials to be processed along with the materials specifications will determine the type and size of the processing equipment needed. High quality equipment that can meet the product specifications is a must. Undersized, underpowered equipment will add to overall operating costs such as labor and energy usage. Oversized equipment may lead to that equipment being idle much of the time and has initial costs higher than necessary. Match the equipment to the quantities and flow of materials so it is in use much of the time but still has the capacity to meet peak flows when needed.

- Product Storage: Provide efficient procedures for moving finished product to storage and stored product into trailers or other containers for delivery to markets. Adequate indoor storage space should be available to keep products susceptible to degradation from exposure to the elements, dirt, and other contaminants. Adequate storage space should also be available to ensure full loads of materials are available for shipment to markets as well as to riding out poor short-term market conditions.

- Product Marketing: Viable, long-term markets should be available for all materials recovered. Ensure that market contracts are structured to provide a fair price for all commodities and protection against falling prices (i.e., floor price received for materials, ability to wait out market conditions without being penalized for not shipping in a given month, etc.). If quantities are large enough, diversify markets to allow flexibility in marketing materials. This can be accomplished a number of ways including contracts with multiple markets, moving materials through a broker, or participating with others in cooperative marketing efforts.

- Health and Safety Considerations: Make health and safety considerations an overriding issue in MRF operations. Provide the necessary health and safety training to all employees as well as the appropriate personal protective equipment. Operating a MRF with health and safety in mind will help control costs associated with workers compensation claims, rising insurance rates, lost productivity, and regulatory/legal issues.

- Environmental Responsibility: In an industry that sells itself as being good for the environment, it is especially important that the public not perceive recycling facilities as an environmental nuisance. Make your best effort to maintain a neat and clean operation.

APPENDIX A: HEALTH AND SAFETY SELF-ASSESSMENT QUESTIONNAIRE

SAFETY AND TRAINING

HEALTH AND SAFETY PLANS	Yes	No	Unsure	N/A
1. Do you have an active safety and health program?	[ ]	[ ]	[ ]	[ ]
a. If yes, is one person clearly responsible for the overall activities of the safety and health program?	[ ]	[ ]	[ ]	[ ]
b. Do you have a safety committee?	[ ]	[ ]	[ ]	[ ]
c. What is the frequency of safety meetings?				
2. Do you have a written safety and health plan?	[ ]	[ ]	[ ]	[ ]
3. Do you have a working procedure for handling employee complaints regarding safety and health?	[ ]	[ ]	[ ]	[ ]
4. Do you provide safety training for employees?	[ ]	[ ]	[ ]	[ ]
a. If yes, please check all that apply:				
First Aid [ ] Blood borne Pathogen [ ] Hazard Communication [ ] Fire Safety [ ]				
Personal Protection Equipment [ ] Ergonomics [ ] Forklift Operator [ ]				
Lock-out/Tag-out [ ] Quality Improvement [ ] Material Identification [ ]				
Confined Space [ ] Spill Control [ ]				
Other, Please list: ____				
MEDICAL SERVICES AND FIRST AID	**Yes**	**No**	**Unsure**	**N/A**
5. Is there a written emergency contingency plan for what to do in case of a medical emergency (other than calling 911)?	[ ]	[ ]	[ ]	[ ]
6. Do you require each employee to have a pre-employment physical examination?	[ ]	[ ]	[ ]	[ ]
a. Are hearing tests included in the exam?	[ ]	[ ]	[ ]	[ ]
7. Is there a hospital or clinic in the proximity of your workplace?	[ ]	[ ]	[ ]	[ ]
a. If yes, how far away is the hospital? __________miles				
b. If medical and first aid facilities are not in the proximity of your workplace, is at least one employee on each shift qualified to render first aid?	[ ]	[ ]	[ ]	[ ]
8. Is there a phone at the facility to use in case of an emergency?	[ ]	[ ]	[ ]	[ ]
9. Are emergency phone numbers posted?	[ ]	[ ]	[ ]	[ ]
10. Are first aid kits easily accessible to each work area?	[ ]	[ ]	[ ]	[ ]
a. If yes, are the necessary supplies periodically inspected and replenished?	[ ]	[ ]	[ ]	[ ]

11. Are means provided for flushing the eyes in the area where materials are being handled that may injure the eyes?	[ ]	[ ]	[ ]	[ ]
12. Are employees CPR trained?	[ ]	[ ]	[ ]	[ ]
FIRE PROTECTION	**Yes**	**No**	**Unsure**	**N/A**
13. Does your facility have a fire alarm system?	[ ]	[ ]	[ ]	[ ]
a. If yes, is it tested annually?	[ ]	[ ]	[ ]	[ ]
14. Does your facility have an automatic sprinkler system?	[ ]	[ ]	[ ]	[ ]
a. If yes, are automatic sprinkler system water control valves, air and water pressure checked weekly or periodically?	[ ]	[ ]	[ ]	[ ]
15. Are portable fire extinguishers provided?	[ ]	[ ]	[ ]	[ ]
a. If yes, how many are there? #______________				
b. Are all extinguishers serviced, maintained and tagged at intervals not to exceed one year?	[ ]	[ ]	[ ]	[ ]
c. Are employees periodically instructed in the use of extinguishers and fire protection procedures?	[ ]	[ ]	[ ]	[ ]
d. If yes, how often?				
GENERAL WORK ENVIRONMENT	**Yes**	**No**	**Unsure**	**N/A**
16. Are all work sites clean and orderly?	[ ]	[ ]	[ ]	[ ]
17. Are work surfaces kept dry or are appropriate means taken to assure the surfaces are slip-resistant?	[ ]	[ ]	[ ]	[ ]
18. Are all spilled materials or liquids cleaned up immediately?	[ ]	[ ]	[ ]	[ ]
19. Are covered metal waste cans used for oily waste?	[ ]	[ ]	[ ]	[ ]
20. Are all toilets and washing facilities clean and sanitary?	[ ]	[ ]	[ ]	[ ]
21. Are all work areas adequately illuminated?	[ ]	[ ]	[ ]	[ ]
22. Are pits and floor openings covered or otherwise guarded?	[ ]	[ ]	[ ]	[ ]
23. Is there a public drop off area for materials?	[ ]	[ ]	[ ]	[ ]
a. If yes, does the drop off area present any noticeable safety concerns for the public. List concerns:				
ENVIRONMENTAL CONTROLS	**Yes**	**No**	**Unsure**	**N/A**
24. Is all water provided for drinking and washing potable?	[ ]	[ ]	[ ]	[ ]
25. Are all outlets for water not suitable for drinking clearly identified?	[ ]	[ ]	[ ]	[ ]

26. Are employees prohibited from smoking or eating in any area where contaminants, which could be injurious if ingested, are present?	[ ]	[ ]	[ ]	[ ]
27. Is machinery cleaned with compressed air?	[ ]	[ ]	[ ]	[ ]
a. If yes, is air pressure controlled and personal protective equipment or other safeguards utilized to protect operators and other workers from eye and body injury?	[ ]	[ ]	[ ]	[ ]
28. Is vacuuming used for dust removal instead of lowing or sweeping?	[ ]	[ ]	[ ]	[ ]
29. Are employees' physical capacities assessed before being assigned to jobs requiring heavy work?	[ ]	[ ]	[ ]	[ ]
30. Are employees instructed in the proper manner of lifting heavy objects?	[ ]	[ ]	[ ]	[ ]
31. Where heat is a problem, have all fixed work areas been provided with spot cooling or air conditioning?	[ ]	[ ]	[ ]	[ ]
32. Are employees screened before assignment to areas of high heat to determine if their health condition might make them more susceptible to having an adverse reaction?	[ ]	[ ]	[ ]	[ ]
WALKWAYS	**Yes**	**No**	**Unsure**	**N/A**
33. Are aisles and passageways kept clear?	[ ]	[ ]	[ ]	[ ]
34. Are aisles and walkways marked?	[ ]	[ ]	[ ]	[ ]
35. Are wet surfaces covered with non-slip materials?	[ ]	[ ]	[ ]	[ ]
36. Are holes in the floor, sidewalks or other walking surfaces repaired properly, covered or otherwise made safe?	[ ]	[ ]	[ ]	[ ]
37. Is there safe clearance for walking in aisles where motorized or mechanical handling equipment is operating?	[ ]	[ ]	[ ]	[ ]
38. Are aisles or walkways that pass near moving or operating machinery, welding operations, or similar operations arranged so employees will not be subjected to potential hazards?	[ ]	[ ]	[ ]	[ ]
39. Is adequate headroom provided for the entire length of any aisle or walkway?	[ ]	[ ]	[ ]	[ ]
40. Are standard guardrails provided wherever aisle or walkway surfaces are elevated more than 30 inches above any adjacent floor or the ground?	[ ]	[ ]	[ ]	[ ]
ELEVATED SURFACES	**Yes**	**No**	**Unsure**	**N/A**
41. Are signs posted, when appropriate, showing the elevated surface load capacity?	[ ]	[ ]	[ ]	[ ]

42. Are all elevated surfaces (beneath which people or machinery could be exposed to falling objects) provided with standard 4-inch toe boards?	[ ]	[ ]	[ ]	[ ]
43. Is a permanent means of access and egress provided to elevated storage and work surfaces?	[ ]	[ ]	[ ]	[ ]
44. Is material on elevated surfaces piled, stacked or racked in a manner to prevent it from tipping, falling, collapsing, rolling or spreading?	[ ]	[ ]	[ ]	[ ]
EXITING	**Yes**	**No**	**Unsure**	**N/A**
45. Are all exits well marked with an EXIT sign?	[ ]	[ ]	[ ]	[ ]
46. Are the directions to exits, when not immediately apparent, marked with visible signs?	[ ]	[ ]	[ ]	[ ]
47. Are all exits kept free of obstructions?	[ ]	[ ]	[ ]	[ ]
48. Are there sufficient exits to permit prompt escape in case of emergency?	[ ]	[ ]	[ ]	[ ]
ELECTRICAL	**Yes**	**No**	**Unsure**	**N/A**
49. Are electrical appliances such as vacuum cleaners and vending machines grounded?	[ ]	[ ]	[ ]	[ ]
50. Do extension cords being used have a grounding conductor?	[ ]	[ ]	[ ]	[ ]
51. Are flexible cords and cables free of splices or taps?	[ ]	[ ]	[ ]	[ ]
52. Are all cord, cable, and raceway connections intact and secure?	[ ]	[ ]	[ ]	[ ]
53. Are ground-fault circuit interrupters installed on outlets in wet areas?	[ ]	[ ]	[ ]	[ ]
54. In wet or damp locations, are electrical equipment and tools appropriate for the use, or location or otherwise protected?	[ ]	[ ]	[ ]	[ ]
55. Are all disconnecting switches and circuit breakers labeled to indicate their use or equipment served?	[ ]	[ ]	[ ]	[ ]
56. Are all energized parts of electrical circuits and equipment guarded by approved cabinets or enclosures against accidental contact?	[ ]	[ ]	[ ]	[ ]
57. Is sufficient access and working space provided and maintained about all electrical equipment to permit ready and safe operations and maintenance?	[ ]	[ ]	[ ]	[ ]
58. Is the location of electrical power lines and cables (overhead, underground, underfloor, other side of walls, etc.) determined before digging, drilling, or similar work is begun?	[ ]	[ ]	[ ]	[ ]
59. Are employees who regularly work on or around energized electrical equipment or lines instructed in the cardio-pulmonary resuscitation (CPR) methods?	[ ]	[ ]	[ ]	[ ]

60. Has the facility been inspected by an electrician within the last 3 years?	[ ]	[ ]	[ ]	[ ]
HAND AND POWER TOOLS	**Yes**	**No**	**Unsure**	**N/A**
61. Are appropriate safety glasses, face shields, gloves, etc. used while using hand tools or equipment, which might produce flying materials, or be subject to breakage?	[ ]	[ ]	[ ]	[ ]
62. Are grinders, saws and similar equipment provided with appropriate safety guards?	[ ]	[ ]	[ ]	[ ]
63. Are rotating or moving parts of equipment guarded to prevent physical contact?	[ ]	[ ]	[ ]	[ ]
64. Are all cord-connected, electrically-operated tools and equipment effectively grounded or of the approved double-insulated type?	[ ]	[ ]	[ ]	[ ]
PERSONAL PROTECTIVE EQUIPMENT (PPE) AND CLOTHING	**Yes**	**No**	**Unsure**	**N/A**
65. Is personal protective equipment provided for the employees? (Check all that apply)	[ ]	[ ]	[ ]	[ ]
Goggles [ ] Safety Glasses [ ] Face Shields [ ] Aprons [ ] Steel Toe Boots [ ]				
Hard Hats [ ] Ear Plugs [ ] Respirators [ ] Gloves [ ] Other:				
66. Are employees required to wear PPE ?	[ ]	[ ]	[ ]	[ ]
67. Are employees wearing personal protection equipment?	[ ]	[ ]	[ ]	[ ]
68. Is personal protective clothing or equipment that employees are required to wear or use of a type capable of being easily cleaned and disinfected?	[ ]	[ ]	[ ]	[ ]
69. When employees are required to change from street clothing into protective clothing is a clean change room with separate storage facility for street and protective clothing provided?	[ ]	[ ]	[ ]	[ ]
NOISE	**Yes**	**No**	**Unsure**	**N/A**
70. Has there been a determination that noise levels in the facilities are within acceptable levels?	[ ]	[ ]	[ ]	[ ]
71. Are there areas in the workplace where continuous noise levels exceed 85dba?	[ ]	[ ]	[ ]	[ ]
72. Have work areas where noise levels make voice communication between employees difficult been identified and posted?	[ ]	[ ]	[ ]	[ ]
73. Are steps being taken to use engineering controls to reduce excessive noise levels?	[ ]	[ ]	[ ]	[ ]
74. Is approved hearing protective equipment (noise attenuating devices) available to every employee working in noisy areas?	[ ]	[ ]	[ ]	[ ]
75. Are employees wearing hearing protection?	[ ]	[ ]	[ ]	[ ]

76. If hearing protectors are used, are employees properly fitted and instructed in their use?	[ ]	[ ]	[ ]	[ ]
HAZARDOUS SUBSTANCES COMMUNICATION	**Yes**	**No**	**Unsure**	**N/A**
77. Have hazardous substances been identified which may cause harm by inhalation, ingestion, skin absorption or contact?	[ ]	[ ]	[ ]	[ ]
78. Are employees aware of the hazards involved with the various chemicals they may be exposed to in their work environment?	[ ]	[ ]	[ ]	[ ]
79. Is there a list of hazardous substances used in your workplace?	[ ]	[ ]	[ ]	[ ]
80. Is there a written hazard communication program dealing with Material Safety Data Sheets {MSDS), labeling, and employee training?	[ ]	[ ]	[ ]	[ ]
81. Is there an employee-training program for hazardous substances?	[ ]	[ ]	[ ]	[ ]
82. Is each container for a hazardous substance {i.e., bottles, tanks, etc.) labeled with product identity and a hazard warning {communication of the specific health hazards and physical hazards)?	[ ]	[ ]	[ ]	[ ]
CONTROL OF HARMFUL SUBSTANCES BY VENTILATION	**Yes**	**No**	**Unsure**	**N/A**
83. Is the volume and velocity of air in each exhaust system sufficient to gather the dusts, fumes, mists, vapors or gases to be controlled, and to convey them to a suitable point of disposal?	[ ]	[ ]	[ ]	[ ]
84. Is the source point for makeup air located so that only clean, fresh air will enter the work environment?	[ ]	[ ]	[ ]	[ ]
85. Are areas, in which motorized vehicles using internal combustion engines are operated, sufficiently ventilated to avoid dangerous accumulation of exhaust fumes?	[ ]	[ ]	[ ]	[ ]
SPILL CONTROL	**Yes**	**No**	**Unsure**	**N/A**
86. Do you have a spill control plan for materials used at the facility and/or for unknown and potentially hazardous materials that may be received inadvertently?	[ ]	[ ]	[ ]	[ ]
87. Are spill control equipment and materials available and located where spills are most likely to occur?	[ ]	[ ]	[ ]	[ ]
88. Are employees trained in spill control procedures?	[ ]	[ ]	[ ]	[ ]
FLAMMABLE AND COMBUSTIBLE MATERIALS	**Yes**	**No**	**Unsure**	**N/A**
89. Is proper storage practiced to minimize the risk of fire, including spontaneous combustion?	[ ]	[ ]	[ ]	[ ]
90. Are combustible scrap, debris, and waste materials stored in covered metal receptacles?	[ ]	[ ]	[ ]	[ ]

a. Are they removed from work areas daily?	[ ]	[ ]	[ ]	[ ]
91. Are approved containers and tanks used for the storage and handling of flammable and combustible liquids?	[ ]	[ ]	[ ]	[ ]
92. Are all flammable liquids kept in closed containers when not in use (e.g. parts cleaning tanks, etc.)?	[ ]	[ ]	[ ]	[ ]
93. Are fire extinguishers selected and provided for the types of materials in areas where they are to be used?	[ ]	[ ]	[ ]	[ ]
94. Are extinguishers free from obstructions or blockage?	[ ]	[ ]	[ ]	[ ]
95. Are all extinguishers fully charged and in their designated places?	[ ]	[ ]	[ ]	[ ]
96. Are NO SMOKING signs posted where appropriate?	[ ]	[ ]	[ ]	[ ]
FUELING	**Yes**	**No**	**Unsure**	**N/A**
97. Is it prohibited to fuel an internal combustion engine with a flammable liquid while the engine is running?	[ ]	[ ]	[ ]	[ ]
98. Are fueling operations done in such a manner that likelihood of spillage will be minimal?	[ ]	[ ]	[ ]	[ ]
99. When spillage occurs during fueling operations, is the spilled fuel washed away completely, evaporated, or other measures taken to control vapors before restarting the engine?	[ ]	[ ]	[ ]	[ ]
100. Are fuel tank caps replaced and secured before starting the engine?	[ ]	[ ]	[ ]	[ ]
101. Is handling or transferring gasoline in open containers prohibited?	[ ]	[ ]	[ ]	[ ]
102. Is smoking prohibited in the vicinity of fueling operations?	[ ]	[ ]	[ ]	[ ]
MOTORIZED VEHICLES	**Yes**	**No**	**Unsure**	**N/A**
103. Are only employees who have been trained in the proper use of industrial trucks allowed to operate them?	[ ]	[ ]	[ ]	[ ]
104. Are lift truck operating rules posted?	[ ]	[ ]	[ ]	[ ]
105. Are motorized vehicles with internal combustion engines operated in enclosed areas carefully checked to ensure such operations do not cause a harmful concentration of dangerous gases?	[ ]	[ ]	[ ]	[ ]
106. Are motorized vehicles inspected daily or prior to use?	[ ]	[ ]	[ ]	[ ]
a. If yes, are inspections documented?	[ ]	[ ]	[ ]	[ ]
107. Are trucks shut off and the brake set prior to loading or unloading?	[ ]	[ ]	[ ]	[ ]
108. Are bollards or other similar devices used to protect the building or machinery inside the building from collision with a moving vehicle or forklift?	[ ]	[ ]	[ ]	[ ]

109. Does each motorized vehicle have a warning horn, whistle, gong, or other device which can be clearly heard above the normal noise in the areas where operated	[ ]	[ ]	[ ]	[ ]
MATERIAL HANDLING	**Yes**	**No**	**Unsure**	**N/A**
110. Is there safe clearance for equipment through aisles and doorways?	[ ]	[ ]	[ ]	[ ]
111. Are aisle ways designated, permanently marked, and kept clear to allow unhindered passage?	[ ]	[ ]	[ ]	[ ]
112. Are trucks shut off and the brake set prior to loading or unloading?	[ ]	[ ]	[ ]	[ ]
113. Are trucks and trailers secured from movement during loading and unloading operations?	[ ]	[ ]	[ ]	[ ]
114. Are dock plates and loading ramps constructed and maintained with sufficient strength to support imposed loading?	[ ]	[ ]	[ ]	[ ]
115. Are hand trucks maintained in a safe operating condition?	[ ]	[ ]	[ ]	[ ]
116. Are chutes equipped with sideboards of sufficient height to prevent materials from falling off?	[ ]	[ ]	[ ]	[ ]
117. Are skids and pallets inspected before being loaded or moved?	[ ]	[ ]	[ ]	[ ]
MACHINE GUARDING	**Yes**	**No**	**Unsure**	**N/A**
118. Is there a training program to instruct employees on safe methods of machine operation?	[ ]	[ ]	[ ]	[ ]
a. If yes, are employees tested or otherwise certified in someway that they have been properly trained?	[ ]	[ ]	[ ]	[ ]
119. Is there a regular program of safety inspection of machinery and equipment?	[ ]	[ ]	[ ]	[ ]
a. If yes, How often are inspections?				
b. Are they documented?	[ ]	[ ]	[ ]	[ ]
120. Are provisions made to prevent machines from automatically starting when power is restored after a power failure or shutdown?	[ ]	[ ]	[ ]	[ ]
121. Is all machinery and equipment kept clean and properly maintained?	[ ]	[ ]	[ ]	[ ]
122. Is sufficient clearance provided around and between machines to allow for safe operations, set-up and servicing, material handling, and waste removal?	[ ]	[ ]	[ ]	[ ]
123. Is equipment and machinery securely placed and anchored to prevent tipping or other movement that could result in personal injury?	[ ]	[ ]	[ ]	[ ]

124. Is there a power shut-off switch within reach of the operator's position at each machine?	[ ]	[ ]	[ ]	[ ]
125. Can electric power to each machine be locked out for maintenance, repair, or security?	[ ]	[ ]	[ ]	[ ]
126. Are foot-operated switches guarded or arranged to prevent accidental actuation by personnel or falling objects?	[ ]	[ ]	[ ]	[ ]
127. Are switches and valves used by a machine operator clearly identified and readily accessible?	[ ]	[ ]	[ ]	[ ]
128. Are all emergency stop buttons colored red?	[ ]	[ ]	[ ]	[ ]
129. Are all pulleys and belts that are within 7 feet of the floor, or at the working level, guarded?	[ ]	[ ]	[ ]	[ ]
130. Are methods provided to protect the operator and other employees in the machine area from hazards created at the point of operation, ingoing nip points, rotating parts, flying chips, and sparks?	[ ]	[ ]	[ ]	[ ]
131. Are fan blades protected with a guard having openings no larger than one-half inch when operating within 7 feet of the floor?	[ ]	[ ]	[ ]	[ ]
LOCKOUT/TAG OUT PROCEDURES	**Yes**	**No**	**Unsure**	**N/A**
132. Is all machinery or equipment capable of movement required to be de-energized or disengaged and blocked or locked-out during cleaning, servicing, adjusting or setting up of operations?	[ ]	[ ]	[ ]	[ ]
133. Is the locking-out of control circuits in lieu of locking-out main power disconnects prohibited?	[ ]	[ ]	[ ]	[ ]
134. Does the lockout procedure require that stored energy (mechanical, hydraulic, air, etc.) be released or blocked before equipment is locked-out for repairs?	[ ]	[ ]	[ ]	[ ]
a. Are appropriate employees provided with individually keyed personal safety locks?	[ ]	[ ]	[ ]	[ ]
135. Are employees required to keep personal control of their key(s) while they have safety locks in use?	[ ]	[ ]	[ ]	[ ]
136. Is it required that only the employee, exposed to the hazard, place or remove the safety lock?	[ ]	[ ]	[ ]	[ ]
137. Are employees required to check the safety of the lockout by attempting a start up after making sure no one is exposed?	[ ]	[ ]	[ ]	[ ]
138. Is there a means provided to identify any or all employees who are working on locked-out equipment by their locks or accompanying tags?	[ ]	[ ]	[ ]	[ ]
139. Are a sufficient number of tags and padlocks provided for any reasonably foreseeable repair emergency?	[ ]	[ ]	[ ]	[ ]

140. When machine operations, configuration, or size requires the operator to leave his or her control station to install tools or perform other operations, and that part of the machine could move if accidentally activated, is such a component required to be separately locked or blocked out?	[ ]	[ ]	[ ]	[ ]
141. In the event that equipment or lines cannot be shut down, locked-out and tagged, is a safe job procedure established and rigidly followed?	[ ]	[ ]	[ ]	[ ]

APPENDIX B: GLOSSARY OF TERMS

Bale- A compacted and bound cube of recycled material.

Baler- Equipment that compacts and binds recyclable materials to reduce volume and transportation costs. A glossary of technical terms regarding baler types and operations may be found at http://www.recyclingtoday.com/articles/article.asp?MagID=1&ID=3600&IssueID=80.

Beneficiation- The mechanical processing of waste glass to decontaminate it and crush it to a more uniform size (see cullet).

Bimetal Can- A food or beverage can with a steel body and an aluminum lid: it is 100% recyclable by the steel industry.

Boxboard- Paperboard used for fabricating boxes. Different boxboard grades are classified as to the composition of the top liner, filler (middle layer), and back liner. It includes folding boxboard (cereal boxes), setup boxboard (shoe boxes), and foodboard (milk cartons).

Broke- Paper that has been discarded anywhere in the process of manufacture in the paper mill.

Brown Goods- Obsolete electronic products, such as radios and televisions. The term is losing ground in common usage to e-waste or e-scrap as computers become the dominant electronic waste.

Buy-Back Center- A recycling facility that purchases small amounts of secondary materials from the public.

CESQG- Conditionally exempt small quantity generator. Businesses that generate hazardous wastes in such small quantities they are exempt from certain disposal regulations.

Co-Collection- The collection of bagged recyclables together with other municipal garbage, separated later for recycling or disposal.

Commingled- Mixed recyclables that are collected or processed together.

Containerboard- The component materials used in the fabrication of corrugated cardboard.

Conveyor- a mechanism, usually a motorized belt, used to continuously move materials from one point to another. An excellent glossary of technical terms relating to conveyors and conveyor types can be found at http://www.flostor.com/library/glossary_a-b.htm or http://www.cisco-eagle.com/systems/conveyors/glossary/glossary.htm

Corrugated cardboard- Layers of paper glued together with a ruffled or grooved inner liner. This is the material, which makes corrugated cardboard boxes (the most recycled product in the country).

CPO- Computer print out paper.

Crusher/blower- A machine that flattens aluminum cans then pneumatically transfers the material to a trailer.

Cullet- Crushed glass which can be added to a batch of new materials in the manufacturing of new glass products. It increases the rate of heat gain by batch and reduces fuel costs. Domestic cullet if produced in house during the manufacturing process. Foreign cullet if it comes from an external source.

Curbside Collection - the collection of solid waste, recyclables, or other materials placed in front of the property (curbside) by the generator who then returns the container to their normal location after they have been emptied. Curbside collection is generally used in the collection of residential solid wastes and recyclables, or other materials. It is not normally used in commercial, institutional or industrial solid waste collection.

Deinking- A process that removes inks, dyes or other contaminants from collected wastepaper.

Detinner- A company that buys tin mill products, removes the tin through appropriate processes and sells the detinned steel, to steel mills and foundries and the recovered tin on the tin market.

Disk Screen- A device used to separate materials by size and weight. A series of disks are spaced on a series of spaced axles to form a screen bed. As the axles and disks spin they propel oversized material across the bed while undersized materials fall between the disks. Inclining and tilting the bed allows a weight-based separation as heavier materials move down the tilt as lighter materials are propelled up the incline by the disks. Disk and axle spacing, disk shape and size (oval, finger, star), disk material, incline and tilt may all be varied to optimize the sorts desired. Frequently used in MRFs to separate OCC and paper from containers.

Eddy current separator- A separation device which uses either powerful spinning, permanent magnets or pulsed electromagnets that produce repelling forces on non-ferrous metals. They are typically used by recyclers to positively-sort aluminum cans or to remove bits of metal contamination from granulated plastics or glass cullet.

E-scrap (e-waste)- obsolete electronic equipment including computers, monitors, VCRs, televisions, etc. (see: brown goods)

Ferrous Metals (FE)- metals, which are predominantly composed of iron. Most ferrous metals, with the exception of some stainless steels, are magnetic.

Filestock- A specialty grade of (mixed) office type papers that is derived from discarded files. These may come from offices, record storage, records centers, archives, libraries, etc. Mostly white and colored ledger but may also include carbonless paper, bleached file folders etc.

Flow Control Law- Local ordinance controlling, or giving a municipal official authority to control, the collection and/or disposal of municipal solid waste produced in a specific geographical area.

Gaylord Container- The trade name for a large, reusable corrugated container used for shipping materials - usually about one cubic yard in size.

Hard mixed paper- This classification of recovered paper typically includes Kraft paper, corrugated cardboard, and office paper—all paper with longer fibers. Paperboard packaging can also be included.

High Density Polyethylene (HDPE)- Used to make plastic bottles, milk cartons and other products. It produces toxic fumes when burned. Often referred to as No.2 Plastic.

High grade papers- Usually deinked, these primarily include printed and unprinted white papers collected from converting operations, printing plants and offices.

Linerboard- A paperboard used as the facing material in the production of corrugated shipping containers. See also: Test Linerboard.

Low Density Polyethylene (LDPE)- Often referred as No.4 Plastic.

Materials Recovery Facility (MRF)- A recycling facility that sorts and processes collected mixed recyclables into individual streams for market. Also known as an intermediate processing center (IPC).

Mixed paper- The commingling of various paper grades, such as old mail, paperboard packaging, magazines, copy and computer paper, egg cartons, etc. for recycling.

Negative Sort- Refers to when a desired recyclable is left on the sorting belt while contaminants and other recyclables are removed. Negative sorts are used to minimize handling when the bulk of the stream to be sorted consists of one material. Often used after mechanical separation for quality control.

Newsprint- Alternate term for the low-grade paper used to make newspaper.

#6 News- Baled newspaper typically generated from news drives and curbside collections. Prohibitive materials may not exceed 1%. Total outthrows may not exceed 5%.

#8 News- Baled, sorted, fresh newspapers, not sunburned, free from magazines, white blank, pressroom over-issues and paper other than news, containing not more than the normal percentage of rotogravure and colored sections. This grade must be tare-free, and no prohibitive materials are allowed. Total outthrows may not exceed one fourth of 1%.

Non-Ferrous Scrap Metals (NF)- Metals, which contain no iron, such as aluminum, copper, brass and bronze.

Outthrow- Material which must be removed from paper delivered to a mill before the paper is recycled/repulped.

Paper recycling acronyms- Includes **OCC** (old corrugated containers), **WCC** (waxed corrugated containers), **ONP** (old newspapers), **OMG** (old magazines), **OTD** (old telephone directories), and **RMP** (residential mixed paper).

Paper Stock- Scrap or waste papers that have been sorted and baled into specific grades. It is commonly used interchangeably with the term waste paper.

Paperboard- General term for heavyweight grades of paper that are used for containers, boxes, cartons and packaging materials. It is divided into containerboard, boxboard and other paperboard.

Paperboard- A generic term that includes heavy classes of paper. The most common are paperboard packages, which include folding cartons for foods and medicine, set-up boxes for games and jewelry, milk and juice cartons, composite cans for frozen concentrates, and beverage carriers.

Perforator/Flattener- Equipment that perforates and flattens material, then ejects it into a receptacle or processor. Used to prevent plastic bottles from expanding after flattening. See: Twister.

Polyethylene Terephthalate (PET or PETE)- A type of plastic that is clear or colored transparent with high gloss. It is used for carbonated beverage bottles and some household cleanser containers. Often referred to as No. 1 Plastic.

Polypropylene (PP)- Plastic with a smooth surface that and is difficult to scratch. Typical uses are: battery cases, dairy tubs, jar lids, straws and syrup bottles. More frequently found in consumer goods than disposable packaging. It is hard to collect in marketable quantities for recycling and has limited uses in its recycled form. Often referred to as No. 5 Plastic.

Polystyrene (PS)- A plastic with a smooth surface that cracks easily when bent. Used for disposable packaging and utensils, styrofoam cups and shipping packing (peanuts). Also widely used in consumer products such as toys. Often referred to as No. 6 Plastic.

Polyvinyl Chloride (PVC)- An environmentally stable plastic. It is used for food wraps, blister-type packaging and containers for personal care products, plumbing, siding, toys and credit cards. Because of its chlorine content, it should not be burned. Often referred to as V-3 or No. 3 Plastic.

Positive sort- Refers to when a desired recyclable is specifically removed from the stream of materials on the sorting line either by hand picking or by a device designed for that purpose. See: Negative sort.

Post Consumer Material- Any household or commercial product, which has served its original, intended use.

Post Industrial Material- Industrial manufacturing scrap.

Prohibitive-A prohibitive is any material that, if it exceeds allowed limits, would make recycled paper unusable as the grade specified. Example- if the quantity of prohibitives in Grade #12, Double-sorted Corrugated, exceeds 1/2 of 1%, the bale might be downgraded to Grade #11, Corrugated Containers.

PSI #11, Corrugated Containers: Consists of baled corrugated containers having liners of either test liner, jute or kraft. Prohibitive materials may not exceed 1%. Total outthrows may not exceed 5%.

PSI #12, Double-Sorted Corrugated: Consists of baled, double-sorted corrugated containers generated from supermarkets and/or industrial or commercial facilities. They have liners or test liners made from jute or kraft. Materials must be sorted to eliminate boxboard, off-shore corrugated, plastic and wax. Prohibitive materials may not exceed 1%. Total outthrows may not exceed 2%. Double-sorted corrugated has more rigid specifications, especially the restriction on offshore corrugated and wax. Offshore corrugated generally applies to materials derived from areas, such as some Asian countries, that are fiber poor and produce low strength, off-color corrugated materials.

Pulp- The solution resulting from blending wood, recovered paper or, in some cases, cotton with water to break it down into individual cellulose fibers. This is the fibrous material used to make paper.

Recovered paper grades- These are the classifications of different types of recovered paper, each with its own value to manufacturers. While there are dozens of specific grades, they can be grouped into four categories- corrugated/Kraft paper, newspapers, high-grade papers and mixed papers.

Regrind- Ground up recyclable plastics. Often used to refer to manufacturing scrap returned to the manufacturing process.

Resource Recovery- Any process of obtaining matter or energy from materials formerly discarded. A **Resource Recovery Facility** is usually used to refer to a waste-to-energy facility with a front-end system for recovering some recyclable materials.

Soft mixed paper- Typically includes magazines and newspapers—or papers with shorter fibers. Paperboard packaging may also be included.

Sorted office paper- A mix of papers collected for recycling that includes white and pastel copy and writing paper; white, green-bar and multi-stripe computer paper; letterhead and envelopes; notepads; advertising booklets, and fliers.

Source-Separation (source-separated) – (1) The separation of recyclables from the waste stream by the generator with the intent of recovering them for economic use. (2) The sorting of specific recyclables by type prior to their collection or deposition into a collection container. May also refer to recyclables sorted at the curb by collection personnel (curb-sort).

Special Wastes- Any waste requiring special handling such as scrap tires, used motor oil, hospital wastes or household hazardous wastes.

Steel (Tin) Can- A rigid container made exclusively or primarily of steel. When used for food, it will often have a thin layer of tin. It is 100% recyclable.

Stickies- Paper contaminants, which includes adhesives, thermal plastics, hot melts or other substances, which are not water-soluble.

Test Linerboard- Linerboard that is made exclusively out of recycled materials such as double-lined kraft cuttings and old corrugated containers.

Transfer Station- A facility where waste is taken by small collection vehicles and loaded into larger vehicles for transport to a landfill or incinerator.

Trommel- A rotary cylindrical screen that is typically inclined at a downward angle that, combined with the tumbling action of the trommel, separates materials of different density. Trommel screens are used by material recovery facilities to separate paper from glass and other contaminants. Smaller trommels have been used to separate labels and caps from crushed glass. Some trommels are designed to let paper pass through the screen while diverting heavier materials to re-crushing or a landfill. Other applications require multi-stage trommel screens, which have meshes or plates of different aperture sizes. These screens may be used for the separation of commingled materials with components of various sizes.

Twister- An alternative to a flattener/perforator, it is an auger/extruder device used to compact plastic bottles by twisting them. The manufacturer claims the plastic's memory is overcome and the bottles do not re-expand.

UBC- An acronym for Used Beverage Containers. More often used to refer to used aluminum beverage cans.

White office paper (White ledger)-A mix of paper collected for recycling that includes white copy paper and writing paper; white, green-bar and multi-stripe computer print-out; and white envelopes without plastic windows or labels.

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