CHAPTER

7

WASTE HANDLING AND SEPARATION, STORAGE, AND PROCESSING AT THE SOURCE

The handling and separation, storage, and processing of solid wastes at the source before they are collected is the second of the six functional elements in the solid waste management system. Because this element can have a significant effect on the characteristics of the waste, on subsequent functional elements, on public health, and on public attitudes concerning the operation of the waste management system, it is important to understand what this element involves. This chapter includes a description and discussion of the handling and separation, storage, and processing of waste materials at the source, with particular emphasis on residential sources of waste generation. Processing at the source may take place at any time before collection (before, during, or after storage) and is, therefore, discussed as appropriate throughout the chapter. (The handling and storage of hazardous wastes at the source was discussed in Chapter 5.)

7-1 HANDLING AND SEPARATION OF SOLID WASTE AT THE SOURCE

The handling and separation of solid wastes at the source before they are collected is a critical step in the management of residential solid waste. Because waste diversion has been mandated by law in a number of states, the separation of waste components at the source has also become an important element of solid waste management programs.

Waste Handling

In general, handling refers to the activities associated with managing solid wastes until they are placed in the containers used for their storage before collection or return to drop-off and recycling centers. The specific activities associated with handling waste materials at the source of generation will vary depending on the types of waste materials that are separated for reuse and recycling and the extent to which these materials are separated from the waste stream. Depending on the type of collection service, handling may also be required to move the loaded containers to the collection point and to return the empty containers to the point where they are stored between collections. Waste handling and separation methods used at residential and commercial sources are described and discussed in the following two sections.

Separation for Recycling

The separation of solid waste components including wastepaper, cardboard, aluminum cans, glass, and plastic containers at the source of generation is one of the most positive and effective ways to achieve the recovery and reuse of materials. Once the waste component is separated, the question facing the homeowner is what to do with the wastes until they are collected or taken to a local buy-back or recycling center. Some homeowners store the separated components within the home, periodically transferring the accumulated wastes to larger containers used for the storage of these materials between collections. Other homeowners prefer to take separated waste components and place them directly in the containers used for the storage of these materials. Waste separation is considered in greater detail in the following two sections.

7-2 WASTE HANDLING AND SEPARATION AT RESIDENTIAL DWELLINGS

While residential dwellings and building types can be classified in various ways, a classification based on the number of stories is adequate for the purpose of discussing the handling and separation of wastes at residential dwellings. The three classifications most often used, and adopted for this text, are these: low-rise—under four stories; medium-rise—from four to seven stories; and high-rise—over seven stories. In the discussion of handling and separation, low-rise residential dwellings are further subdivided into the following categories: single-family detached; single-family attached—such as row or town houses; and multifamily. Because of the significant differences in the solid waste handling operations for low-rise dwellings and medium- and high-rise apartments, each is considered separately in the following discussion. Kitchen waste food grinders and home waste compactors are used in all types of residential units. The use of these processing units is considered further in Section 7-5.

At Low-Rise Detached Dwellings

The residents or tenants of low-rise detached dwellings are responsible for placing the solid wastes and recyclable materials that are generated and accumulated in and around their dwellings in storage containers (see Table 7-1). The types of storage containers used depend on whether waste separation is mandated. In many communities, the decision has been made not to require the residents to separate their wastes, but rather to reach the mandated separation goals using materials recovery facilities (MRFs). In some collection systems, mixed wastes are placed in a variety of storage containers with little or no standardization (see Fig. 7-1). In other systems, mixed wastes are placed in large 90-gal containers equipped with wheels (see Fig. 7-2). In both of these systems, the homeowner or tenants

TABLE 7-1
Persons responsible for and auxiliary equipment used in the handling and separation of solid waste at the source

Source	Persons responsible	Auxiliary equipment and facilities
Residential		
Low-rise	Residents, tenants	Household compactors, large-wheeled containers, small-wheeled handcarts
Medium-rise	Tenants, building maintenance crews, janitorial services, unit managers	Gravity chutes, service elevators, collection carts, pneumatic conveyors
High-rise	Tenants, building maintenance crews, janitorial services	Gravity chutes, service elevators, collection carts, pneumatic conveyors
Commercial	Employees, janitorial services	Wheeled or castered collection carts, container trains, burlap drop cloths, service elevators, conveyors, pneumatic conveyors
Industrial	Employees, janitorial services	Wheeled or castered collection carts, container trains, service elevators, conveyors
Open areas	Owners, park officers, municipal employees	Vandalproof containers
Treatment plant sites	Plant operators	Various conveyors and other manually operated equipment and facilities
Agricultural	Owners, workers	Varies with the individual commodity

FIGURE 7-1
Curb collection service with no standardization of container sizes.

FIGURE 7-2
Typical storage containers (90-gal capacity), equipped with wheels for ease of movement, which are emptied into the collection vehicle mechanically.

are responsible for transporting the containers filled with wastes to the street curb for collection.

In systems in which the waste components are separated, the solid wastes remaining after the recyclable materials have been separated are placed in one or more large containers. The separated wastes are placed in special containers or bags. In some residences, waste compactors are being used to reduce the volume of wastes to be collected. Compacted wastes are usually placed in waste containers or in sealed plastic bags. The homeowner or tenants are responsible for transporting the containers used for the storage of the solid wastes remaining after the recyclable materials have been separated, along with the containers used for the recyclable materials, to the street curb for collection. A number of different collection systems, with and without recycling, are delineated in Table 7-2. Two residential waste separation systems are compared in Example 7-1.

TABLE 7-2
Typical options used for the collection of residential MSW from detached dwellings without and with separation of waste components at the source

Options	Remarks
1. *Without separation of waste components at the source*	
a. One 60- to 90-gal container with curbside collection; separate collection of garden trimmings	Separation of components occurs at a materials recovery facility (MRF)
b. All types of containers; unlimited curbside collection service; separate collection of garden trimmings	Separation of waste components occurs at a MRF
2. *With separation of waste components at the source*	
a. Unlimited curbside collection service; separated newspaper placed in bundles; separate collection of garden trimmings	Regular collection vehicles equipped with bins for newspaper; newspaper unloaded separately at a MRF or paper recovery facility
b. Unlimited curbside collection service; separated waste components placed in three specially designed plastic bins; separate collection of garden trimmings	One bin is for newspaper, one is for glass and plastic, and one is for aluminum and tin cans; glass, plastic, aluminum, and tin cans separated at a MRF
c. Curbside collection with four containers for separated waste components. (This option is best suited to communities with limited amounts of garden trimmings such as San Francisco, CA.)	One container is for all types of uncontaminated paper and cardboard, one is for recyclable materials including plastic containers, glass, aluminum and tin cans, one is for garden trimmings, and one is for the leftover materials; individual components separated at a MRF
d. Curbside collection with one 90-gal container and two heavy-duty plastic bags; separate collection of garden trimmings. Plastic bags are placed in the 90-gal container for collection (see Fig. 7-2); separate collection of garden trimmings	One plastic bag, colored or clear, is for all types of uncontaminated paper, cardboard, magazines, junk mail, and all other paper; the clear plastic bag is for other recyclable materials including plastic bottles and containers, glass bottles and jars, aluminum and tin cans; other materials are placed in 90-gal container; individual components separated at a MRF. It should be noted that see-through bags may be considered a violation of privacy.
e. Curbside collection with three see-through or coated heavy-duty plastic bags and one container; separate collection of garden trimmings. Plastic bags and other waste are collected with the same collection vehicle; separate collection of garden trimmings	One plastic bag is for all types of uncontaminated paper and cardboard, one is for recyclable materials including plastic containers, glass, aluminum and tin cans, one is for garden trimmings; leftover materials are placed in the container; individual components separated at a MRF (one option that has been proposed is to use prisoners to do the sorting)
f. Any of options 2a through 2e but with garden trimmings placed in plastic bags and collected in the same collection vehicle with other wastes	Bagged garden trimmings are placed to one side of the collection vehicle hopper and then separated by hand at the unloading point. It should be noted that this option has limited application, primarily to rear-loaded collection vehicles used in conjunction with appropriate unloading points

Example 7-1 Comparison of residential waste separation programs. The effectiveness of residential waste separation programs depends on the type of system used for the collection of separated wastes. A number of communities use a collection system in which three containers are used for recycled materials in addition to one or more containers for non-recyclable materials. In the three-container system (system 1), newspaper is placed in one container. Aluminum cans, glass, and plastics are placed in the second container. The remaining wastes are placed in the third container. The separated materials, placed in special containers, are collected at the curb. In another system (system 2), four containers are used. All paper and cardboard materials are placed in one container. All plastic, glass, tin cans, aluminum, and any other metals are placed in a second container. Garden wastes are placed in the third container, and all remaining waste materials are placed in the fourth container. Compare these two systems. Assume newspaper represents 25 percent of the total amount of paper.

Solution. Determine realistically how much of the waste stream can be separated for recycling using the two systems described above. Assume 80 percent of the available material is separated and the participation rate is 100 percent. An estimate of the amount of solid waste that can be separated using the above systems is presented in the following table.

	Percent by weight			
	Recycling system 1		Recycling system 2	
Component	As generated[a,b]	Separated for recycle[c]	As generated[a,b]	Separated for recycle[d]
Organic				
Food wastes	9.0 (3)[e]		9.0 (4)[e]	
Paper	**34.0** (1)	6.8[f]	**34.0** (1)	27.2
Cardboard	6.0 (3)		**6.0** (1)	4.8
Plastics	**7.0** (2)	5.6	**7.0** (2)	5.6
Textiles	2.0 (3)		2.0 (4)	
Rubber	0.5 (3)		0.5 (4)	
Leather	0.5 (3)		0.5 (4)	
Yard wastes	18.5 (3)		**18.5** (3)	14.8
Wood	2.0 (3)		2.0 (4)	
Misc. organics	—	—	—	
Inorganic				
Glass	**8.0** (2)	6.4	**8.0** (2)	6.4
Tin cans	6.0 (3)		**6.0** (2)	4.8
Aluminum	**0.5** (2)	0.4	**0.5** (2)	0.4
Other metal	3.0 (3)		**3.0** (2)	2.4
Dirt, ash, etc.	3.0 (3)		3.0 (4)	
Total	100.0	19.2	100.0	66.4

[a] From Table 3-4.

[b] Waste components that are to be recycled are shown in bold.

[c] Based on 80 percent recovery with 100 percent participation. If only 50 percent of the homes participate, the recycling rate drops to about 9.6 percent.

[d] Based on 80 percent recovery with 100 percent participation. If only 50 percent of the homes participate, the recycling rate drops to about 33.2 percent.

[e] Container number.

[f] $6.8 = 34.0 \times 0.25 \times 0.8$

Comment. As shown in above computation table, the amount of material separated for recycling with system 1 is 19.2 percent versus 66.4 percent for system 2. If the participation rate were to drop to 50 percent, the corresponding amounts are 9.6 versus 33.2 percent. Using system 1, it will be difficult to achieve the 25 percent recycling goal without a high degree of homeowner participation. Additional separation, possibly at a MRF, will be required to reach the 50 percent goal by the year 2000. Using system 2, both the 25 and 50 percent diversion goals are achievable with a reasonable amount of homeowner participation.

At Low- and Medium-Rise Apartments

Handling methods in most low- and medium-rise apartment buildings resemble those used for low-rise dwellings, but methods may vary somewhat depending on the waste storage location and collection method. Typical solid waste storage locations include basement storage, outdoor storage, and, occasionally, compactor storage. (The use of compactors is considered in the discussion of waste handling in high-rise apartments.) Different types of nonrecycling and recycling waste handling and separation systems for low- and medium-rise apartment buildings are delineated in Table 7-3. The recycling of wastes from apartments is considered in detail in Ref. 1.

Basement Storage/Curbside Collection. Curbside collection service is common for most low- and medium-rise apartments. Where curbside collection is used, the building owner provides a basement storage room or area for the storage of solid waste. Typically, the containers used for recycling are located within or next to the solid waste storage area. Residents carry their waste and recyclable materials to the storage area and deposit them in the appropriate containers. The maintenance staff is responsible for transporting the containers to the street for curbside collection. Alternatively, in many apartments the maintenance staff is responsible for the collection of wastes and recyclable materials left outside of the doorway to the apartment or from a utility room located on each floor.

Outdoor Storage/Mechanized Collection. In many low- and medium-rise apartments, large waste storage containers are located outdoors in special enclosures (see Fig. 7-3). The large containers are emptied mechanically using collection vehicles equipped with unloading mechanisms. The containers used for recycling are often located within the outdoor storage area or next to the waste storage area. Residents carry their waste and recyclable materials to the storage area and deposit them in the appropriate containers. If needed, the maintenance staff is responsible for moving the containers to the collection point. As noted above, in some apartments the maintenance staff is responsible for the collection of wastes and recyclable materials left outside of the doorway to the apartment or from a utility room located on each floor.

TABLE 7-3
Typical options used for the collection of residential MSW from low-, medium-, and high-rise residential apartments without and with separation of waste components at the source

Options	Remarks
1. *Without separation of waste components at the source*	
a. Standard-size (20- to 30-gal capacity) containers stored in service area or in outdoor enclosed storage areas; curbside collection; separate collection of yard wastes (Low-rise apartments)	Apartment owners, tenants, or building maintenace crews transport wastes to street curb for collection; separation of materials occurs at a MRF
b. Large (up to 300-gal capacity) mechanically unloaded containers located in basement service areas or in outdoor enclosed storage areas; separate collection of landscape wastes by grounds maintenance contractor (Low- and medium-rise apartments)	If needed, apartment maintenance crews move containers for unloading; separation of materials occurs at a MRF
c. Wastes placed outside of individual apartments or in service areas located on each floor; waste chutes used in newer high-rise apartments; large containers and processing equipment (e.g., waste balers) stored in service areas until collection, usually in the basement of high-rise apartments; separate collection of landscape wastes by grounds maintenance contractor (Medium- and high-rise apartments)	If needed, apartment maintenance crews move containers for unloading; separation of materials occurs at a MRF
2. *With separation of waste components at the source*	
a. 1a and 1b from above; separated waste components placed in conventional or specially designed containers located in the basement or in outdoor enclosed storage areas	Residents or maintenance crews move containers to the designated locations for emptying; individual components separated at a MRF
b. 1c from above; separated materials put outside individual apartments for collection, taken to service areas located on each floor, placed in separate chutes, or taken to service area and placed in separate containers	Separate chutes are normally installed in new construction where required by local building codes; separated wastes collected by building crews stored in service areas; individual components separated at a MRF

FIGURE 7-3
Typical large (4 to 8 yd^3) container used for the storage of commingled wastes and smaller (90 gal) containers used for the storage of source-separated materials (glass and aluminum cans, paper, and plastic) at low-rise apartments.

At High-Rise Apartments

In high-rise apartment buildings the most common methods of handling solid wastes involve one or more of the following: (1) wastes are picked up by building maintenance personnel or porters from the various floors and taken to the basement or service area; (2) wastes are taken to the basement or service area by tenants; or (3) wastes, usually bagged, are placed by the tenants in specially designed vertical chutes (usually circular) with openings located on each floor (see Fig. 7-4). Wastes discharged in chutes are collected in large containers, compacted into large containers, or baled directly. Recyclable materials may be put outside in the hall or entry way for pickup, or they may be taken by the tenants to the service area located on each floor for pickup. The entrance to the waste chute is usually located in the service area. Bulky items are usually taken to the service area by

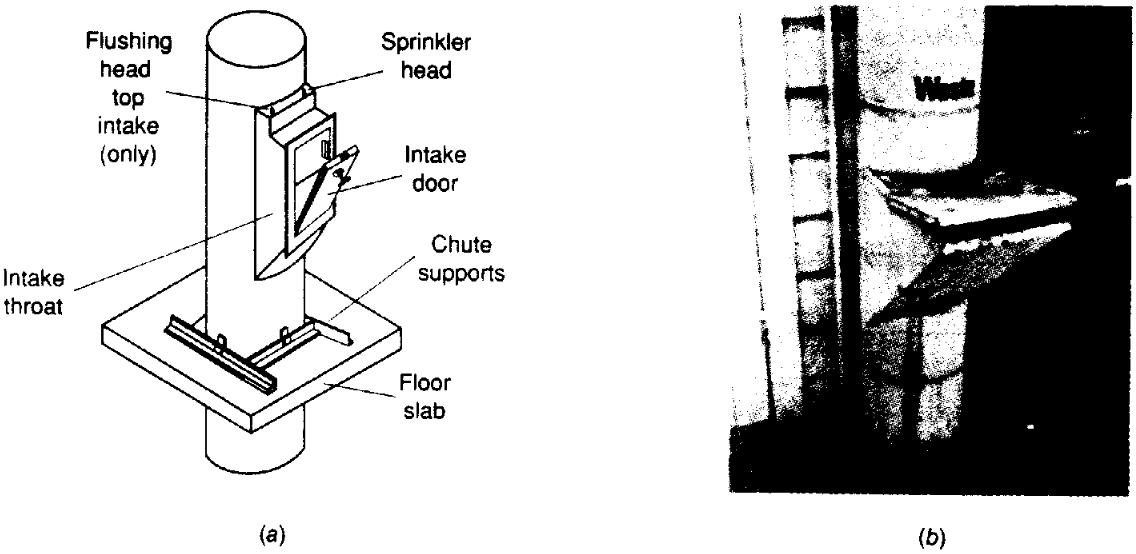


FIGURE 7-4
Typical chute openings for the discharge of waste materials in high-rise apartment buildings: (*a*) isometric view of waste chute opening on individual floor (courtesy of Cutler Manufacturing Corp.) and (*b*) outdoor type used in some older high-rise apartment buildings.

the tenants or the building maintenance crew. The latter are responsible for handling or processing the wastes accumulated in the service areas. In many high-rise apartments, solid waste chutes are used in conjunction with large compactors. The building maintenance personnel are responsible for handling the compressed wastes and any other waste or recyclable materials that tenants bring to the service areas.

Chutes for use in apartment buildings are available in diameters from 12 to 36 in. The most common chute diameter is 24 in. All the available chutes can be furnished with suitable intake doors, either side- or bottom-hinged, for installation on various floor levels (see Fig. 7-4). Draft baffles at the intake doors, door locks, sprinklers, disinfection systems, sound insulation, and roof vents are among the many accessories that are available. The use of a disinfecting and sanitizing unit is recommended because the cleanliness of the chute and the absence of odors generally depend to a large extent on their use. In designing chutes for high-rise buildings, one must consider variations in the rate at which solid wastes are discharged. Typical discharge rates in apartments with chutes are shown in Fig. 7-5. In sizing chutes it is common to assume that (1) the bulk specific weight of the solid wastes equals 175 lb/yd^3, (2) all the daily wastes will be discharged within a 4-h period, and (3) between 1 and 2 lb of wastes will be generated by each tenant each day.

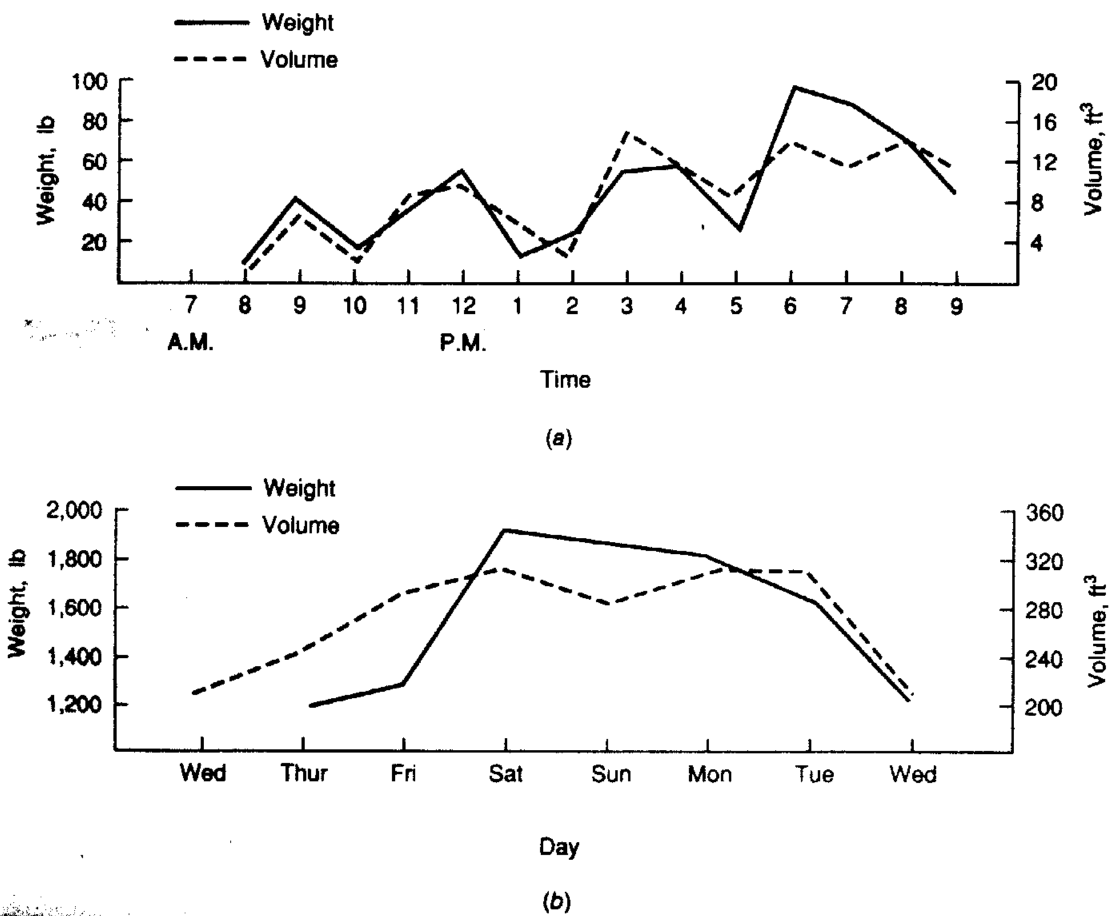
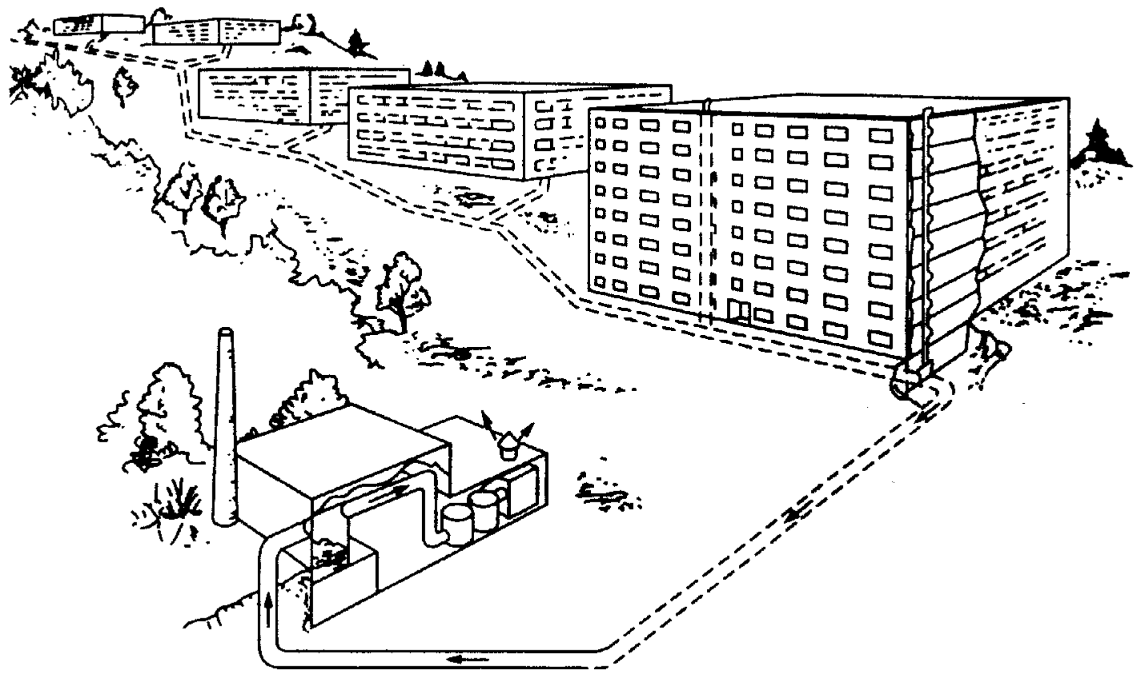


FIGURE 7-5
Typical waste discharge rates in apartments with waste chutes: (a) hourly and (b) daily.

In some of the more recently constructed apartment buildings, underground pneumatic transport systems have been used in conjunction with individual apartment chutes (see Fig. 7-6). The underground pneumatic systems transport wastes from the chute discharge points to centralized processing facilities. Both air pressure and vacuum transport systems have been used in this application.



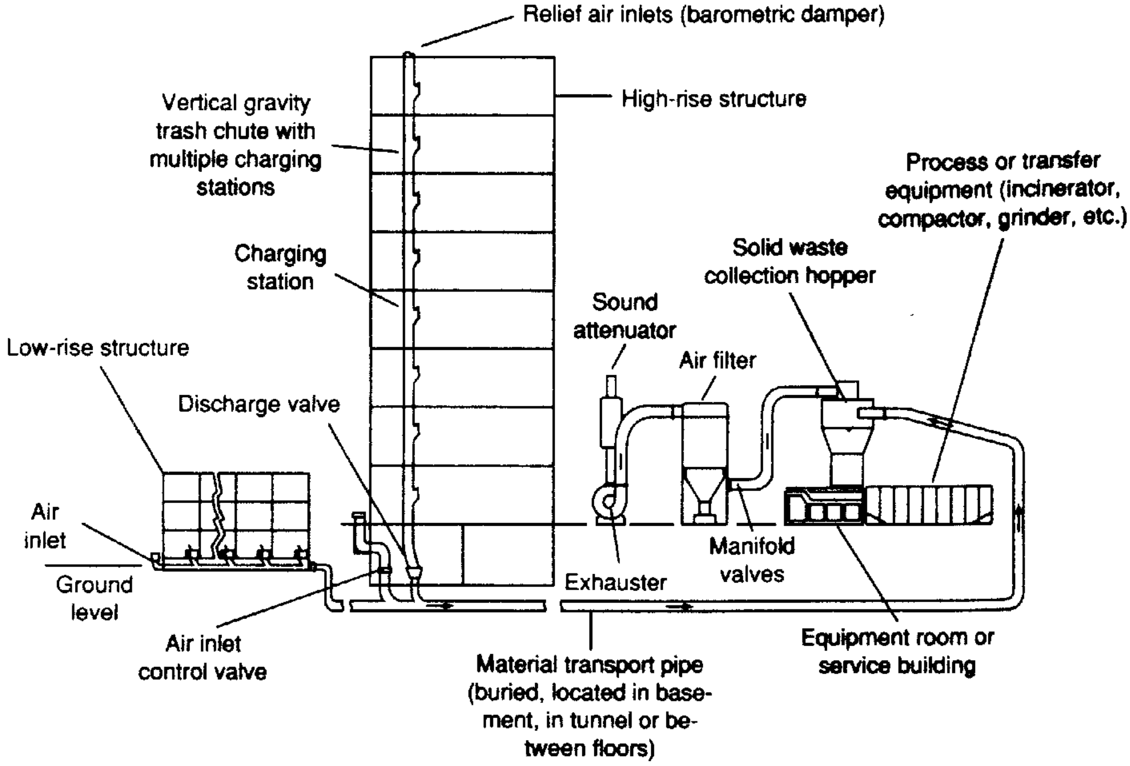


FIGURE 7-6
Typical underground pneumatic waste transport system for high-rise apartment buildings.

7-3 WASTE HANDLING AND SEPARATION AT COMMERCIAL AND INDUSTRIAL FACILITIES

The handling of solid wastes and the recycling of waste materials at commercial and industrial facilities is considered in the following discussion.

Commercial Facilities

In most office and commercial buildings, solid wastes that accumulate in individual offices or work locations are collected in relatively large containers mounted on rollers. Once filled, these containers are removed by means of the service elevator, if there is one, and emptied into (1) large storage containers, (2) compactors used in conjunction with the storage containers, (3) stationary compactors that can compress the material into bales or into specially designed containers, or (4) other processing equipment. Because many older large office and commercial buildings were designed without adequate provision for onsite storage of solid wastes and recyclable materials, the storage and processing equipment now used is often inadequate due to space limitations and tends to create handling problems.

In many office and commercial buildings, all of the office paper is now collected for recycling. The facilities used for collecting waste material for recycling are essentially the same as those used for the collection of other wastes as described above. The wastes to be recycled are stored in separate containers. In large commercial facilities baling equipment is used for the paper and can crushers are used for the aluminum cans.

Industrial Facilities

The handling and separation of nonindustrial solid wastes at industrial facilities is essentially the same as for commercial facilities. Because the handling of industrial wastes is industry- and site-specific, few generalizations are possible.

7-4 STORAGE OF SOLID WASTES AT THE SOURCE

Factors that must be considered in the onsite storage of solid wastes include (1) the effects of storage on the waste components (2) the type of container to be used, (3) the container location, and (4) public health and aesthetics.

Effects of Storage on Waste Components

An important consideration in the onsite storage of wastes are the effects of storage itself on the characteristics of the wastes being stored. These effects of storing wastes include (1) biological decomposition, (2) the absorption of fluids, and (3) the contamination of waste components.

Microbiological Decomposition. Food and other wastes placed in onsite storage containers will almost immediately start to undergo microbiological decomposition (often called *putrefaction*) as a result of the growth of bacteria and fungi. As discussed in Chapter 3, if wastes are allowed to remain in storage containers for extended periods of time, flies can start to breed and odorous compounds can develop.

Absorption of Fluids. Because the components that comprise solid wastes have differing initial moisture contents (see Table 3-7), re-equilibration takes place as wastes are stored onsite in containers. Where mixed wastes are stored together, paper will absorb moisture from food wastes and fresh garden trimmings. The degree of absorption that takes place depends on the length of time the wastes are stored until collection. If wastes are allowed to sit for more than a week in enclosed containers, the moisture will become distributed throughout the wastes. If watertight container lids are not used, wastes can also absorb water from rainfall that enters partially covered containers. Saturation of wastes to their field capacity is a common occurrence in tropical regions where it rains on most days.

Contamination of Waste Components. Perhaps the most serious effect of onsite storage of wastes is the contamination that occurs. The major waste components may be contaminated by small amounts of wastes such as motor oils, household cleaners, and paints. The effect of this contamination is to reduce the value of the individual components for recycling. While the contamination that occurs during onsite storage decreases the value of the individual waste components, one can also argue that this contamination is beneficial with respect to the disposal of these wastes in a landfill. That is, the concentrations of the individual contaminants are reduced considerably when the contaminated waste components are spread out and compacted for landfilling.

Types of Containers

To a large extent, the types and capacities of the containers used depend on the characteristics and types of solid wastes to be collected, the type of collection system in use, the collection frequency, and the space available for the placement of containers. The types and capacities of containers now commonly used for on-site storage of commingled MSW and separated waste components are summarized in Table 7-4. Typical container applications and limitations are presented in Table 7-5. Some of the more common types of containers are shown in Figs. 7-1 and 7-2.

Low-Rise Dwellings with Manual Curbside Waste Collection Service. Because solid wastes are collected manually at curbside for most low-rise detached residential dwellings, the containers should be light enough to be handled easily by one collector when they are full. Injuries to collectors have resulted from handling containers that were loaded too heavily. In general, the upper weight limit should

TABLE 7-4
Data on the types and sizes of containers used for onsite storage of solid wastes

	Capacity			Dimensions[a]	
Type	Unit	Range	Typical	Unit	Typical
Small					
Container, plastic or galvanized metal	gal	20–40	30	in	20D × 26H (30 gal)
Barrel, plastic, aluminum, or fiber	gal	20–65	30	in	20D × 26H (30 gal)
Disposable paper bags					
Standard	gal	20–55	30	in	15W × 12d × 43H (30 gal)
Leak-resistant	gal	20–55	30	in	as above
Leakproof	gal	20–55	30	in	as above
Disposable plastic bag				in	18W × 15d × 40H (30 gal)
				in	30W × 40H (30 gal)
Medium					
Container	yd^3	1–10	4	in	72W × 42d × 65H (4 yd^3)
Large					
Container					
Open top, roll off (also called debris boxes)	yd^3	12–50	—[b]	ft	8W × 6H × 20L (35 yd^3)
Used with stationary compactor	yd^3	20–40	—[b]	ft	8W × 6H × 18L (30 yd^3)
Equipped with self-contained compaction mechanism	yd^3	20–40	—[b]	ft	8W × 8H × 22L (30 yd^3)
Container, trailer-mounted					
Open top	yd^3	20–50	—[b]	ft	8W × 12H × 20L (35 yd^3)
Enclosed, equipped with self-contained compaction mechanism	yd^3	20–40	—[b]	ft	8W × 12H × 24L (35 yd^3)

[a]D = diameter, H = height, L = length, W = width, d = depth.

[b]Size varies with waste characteristics and local site conditions.

Note: gal × 0.003785 = m^3
in × 2.54 = cm
yd^3 × 0.7646 = m^3
ft × 0.3048 = m

ft × 0.3048 = m

TABLE 7-5
Typical applications and limitations of containers used for the onsite storage of solid wastes

Container type	Typical applications	Limitations
Small		
Container, plastic or galvanized metal	Very low-volume waste sources, such as individual homes, walkways in parks, and small isolated commercial establishments; low-rise residential areas with setout collection service	Containers are damaged over time and degraded in appearance and capacity; containers add extra weight that must be lifted during collection operations; containers are not large enough to hold bulky wastes.
Disposable paper bags	Individual homes with setout collection service; can be used alone or as a liner inside a household container; low- and medium-rise residential areas	Bag storage is more costly; if bags are set out on streets or curbside, dogs or other animals tear them and spread their contents; paper bags themselves add to the waste load.
Disposable plastic bags	Individual homes with setout collection service; can be used alone or as a liner inside household and storage containers; useful in holding wet food wastes inside household containers as well as in commercial containers; low-, medium-, and high-rise residential areas; commercial areas and industrial areas	Bag storage is more costly; bags tear easily, causing litter and unsightly conditions; bags become brittle in very cold weather, causing breakage; plastic lightness and durability causes later disposal problems. Bags stretch and break in warm climates.
Medium		
Container	Medium-volume waste sources that might also have bulky wastes; location should be selected for direct-collection truck access; high-density residential areas; commercial areas; industrial areas	Snow inside the containers forms ice and lowers capacity while increasing weight; containers are difficult to get to after heavy snows.
Large		
Container, open top	High-volume commercial areas; bulky wastes in industrial areas; low-density rural residential areas; location should be within a covered area but with direct-collection truck access	Initial cost is high; snow inside containers lowers capacity.
Container, used with stationery compactor	Very high-volume commercial areas; location should be outside buildings with direct-collection truck access	Initial cost is high; if container is compacted too much, it is difficult to unload at the disposal site.

be between 40 and 65 lb. The 30-gal galvanized metal or plastic container has proved to be the least expensive means of storage for low-rise dwellings.

The choice of container materials depends on the preferences of the homeowner. Galvanized metal containers tend to be noisy when being emptied and, in time, can be damaged so that a proper lid seal cannot be achieved. Although less noisy in handling, some containers constructed of plastic materials tend to crack under exposure to the ultraviolet rays of the sun and to freezing temperatures, but the more expensive plastic containers apparently do not present these problems.

Temporary and disposable containers such as paper bags, cardboard boxes, plastic containers and bags, and wooden boxes are routinely used as temporary and disposable containers of accumulated wastes (see Fig. 7-7). Under normal circumstances, temporary containers are removed along with the wastes. The principal problem in the use of temporary containers is the difficulty involved in loading them. Paper and cardboard containers tend to disintegrate because of the leakage of liquids. Where disposable plastic bags are used for lawn trimmings, plastic containers frequently stretch or break at the seams when the collector lifts the loaded bag. Such breakage is potentially hazardous and may lead to injuries to the collector because of the presence of broken glass or other dangerous items in the wastes.

With the widespread availability of paper and plastic products, the use of container liners is now common. All types of thicknesses and grades of material are available. In most areas, the homeowner decides what type of liner to use, if any. A disadvantage in the use of liners is that if the wastes are to be separated by component, or if they are to be combusted, it is necessary to break up the liner bags in a preprocessing step. Thus, although their use may be a convenience for the homeowner, liners may not be ideal from the standpoint of materials recovery and recycling.

Low-Rise Dwellings with Mechanized Curbside Waste Collection Service. Over the past 10 years, there has been a significant increase in the use of mechanical collection systems for residential service. This increase is expected

FIGURE 7-7
Temporary and disposable containers used for the storage and collection of wastes from the curb.

FIGURE 7-8
Typical containers used for the storage of commingled wastes. Containers are designed for curbside collection with mechanized collection vehicles.

to continue, especially as labor and insurance premium costs rise. Where mechanized collection systems are used, the container used for the onsite storage of wastes is an integral part of the collection system. The containers are designed specifically to work with the container-unloading mechanism attached to the collection vehicle. Typical examples are shown in Fig. 7-8. The containers used for residential service with most mechanized systems vary in size from about 75 to 120 gals, with 90 gal being the most common. Although the containers shown in Fig. 7-8 appear bulky and difficult to manage, they are designed so that they can be tilted back and moved quite easily by residents.

Low- and Medium-Rise Apartments. In low-rise apartment complexes, a number of different storage containers have been used [1]. The two most common types are (1) individual plastic or galvanized metal containers and (2) large portable or fixed containers. Where apartments are grouped in close proximity, containers assigned to the individual apartments are often located in a common area. Although individual containers are used in some low-rise apartment buildings, the most common practice is to use one or more large containers for a group of apartments. Typically, these containers are kept in enclosed areas with easy access to a nearby street (see Fig. 7-9). Often, the container enclosures are covered. In most locations the containers are equipped with casters or rollers so that they can be moved easily for emptying into collection vehicles or onsite processing equipment. The containers used for recyclable materials depend on the types of wastes that are separated and the type of waste collection systems used.

High-Rise Apartments. Where solid waste chutes are available, separate storage containers are not used. In some older medium- and high-rise apartments without chutes, wastes are stored in containers on the premises between collections. The most common means of storage for wastes accumulated from the individual apartments include: (1) enclosed storage containers or disposable bags used in conjunction with compaction equipment; (2) large open-top containers for

FIGURE 7-9
Typical containers used for the storage of commingled wastes and recyclable materials at apartment buildings.

uncompacted waste, bulky items, and white goods; and (3) large open-top containers for recycled materials.

Commercial Facilities. The types of containers used for commercial facilities will depend, to a large extent, on the methods used for collecting the wastes produced at various locations within the facility and on the available space (see Fig. 7-10).

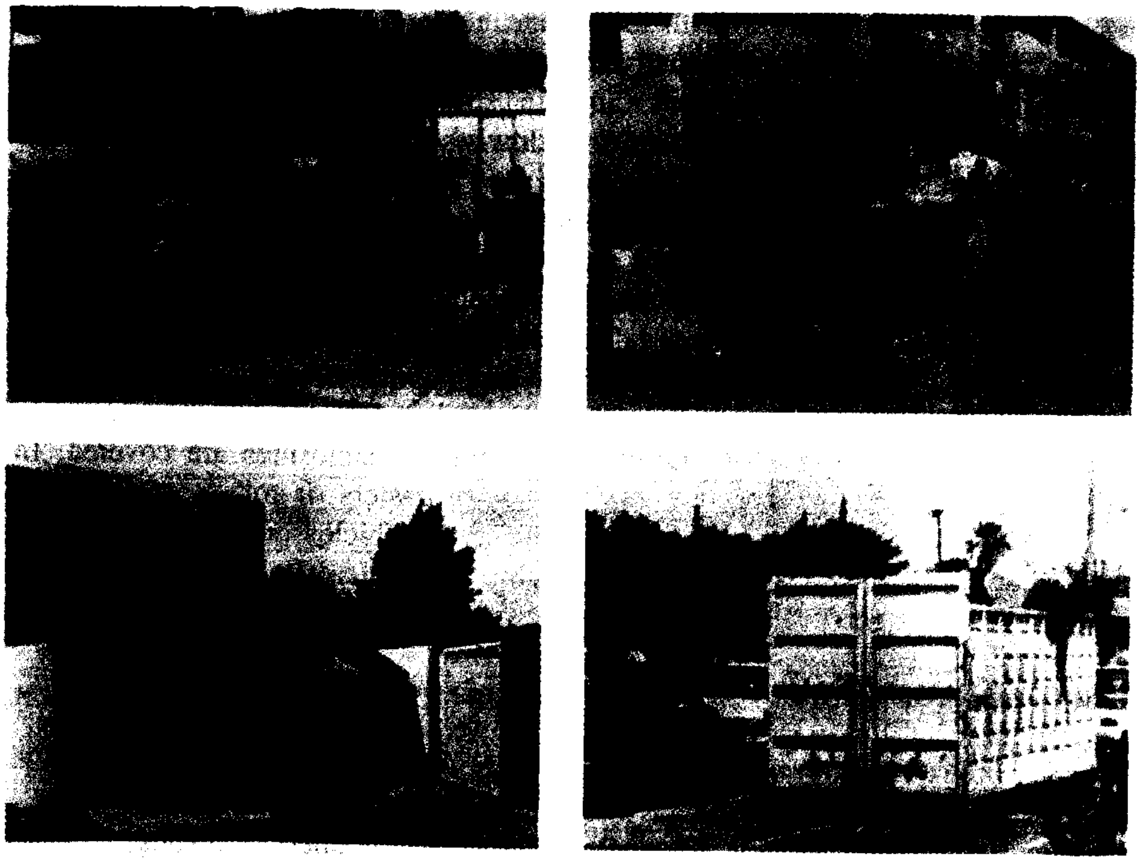
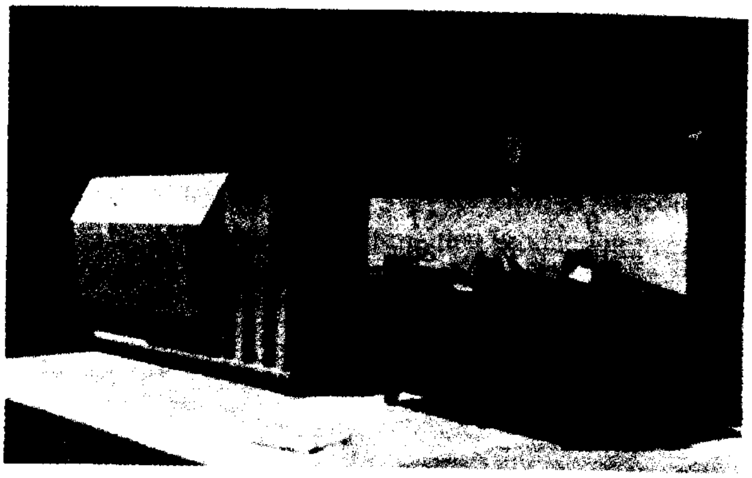
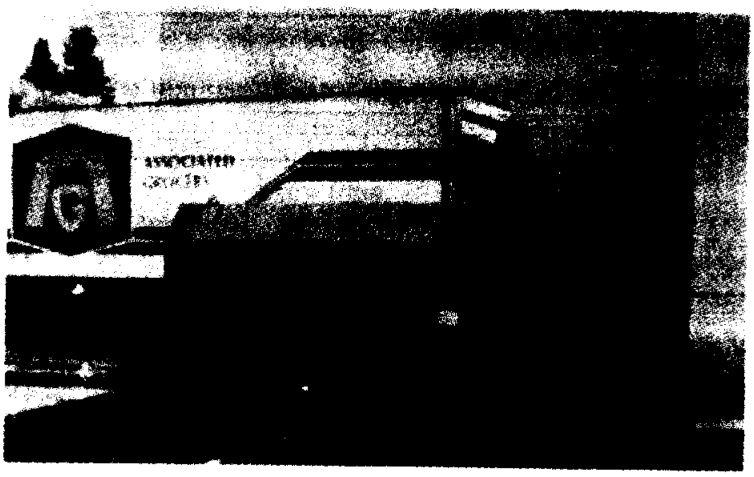


FIGURE 7-10
Typical container-storage locations for containers used at commercial facilities.



(a)



(b)

FIGURE 7-11
Typical compaction facilities used for waste management in commercial establishments: (a) large container equipped with internal compaction mechanism and (b) compactor used in conjunction with stationary compactor.

Typically, large open-top containers are used for unseparated wastes. The use of containers equipped with compaction mechanisms or in conjunction with stationary compactors is increasing (see Fig. 7-11). Where a considerable amount of recoverable materials is generated, special onsite processing equipment may also be used. Selection of a container size for a commercial facility is illustrated in Example 7-2.

Example 7-2 Selection of container size for use at a commercial facility. A commercial facility produced the following quantities of solid waste each week for a calendar quarter of operation. Using these waste production data, determine the size of container at which it becomes more cost effective to make extra pickup trips, on call, instead of using a larger-sized container. Assume the data given below are applicable.

1. Waste production data

Week no.	Waste, yd³/wk	Week no.	Waste, yd³/wk
1	41	8	27
2	30	9	37
3	35	10	36
4	34	11	33
5	39	12	28
6	25	13	31
7	32		

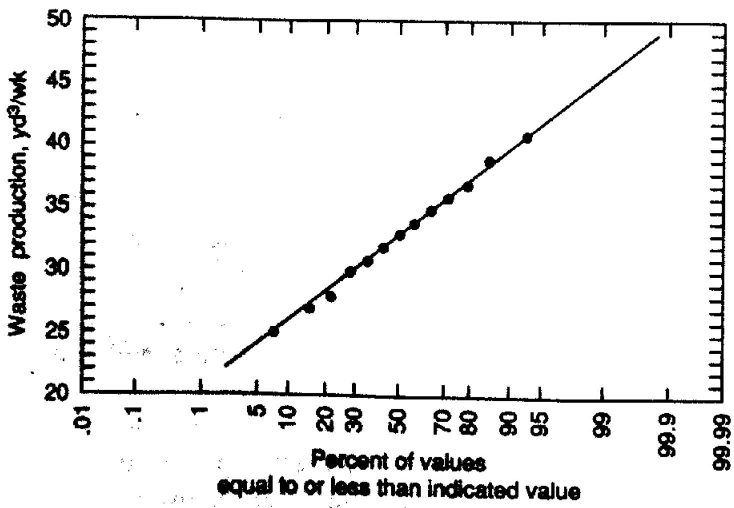
2. Collection system data
   (*a*) The capital cost of containers and annual operation and maintenance (O & M) costs

Capacity, yd³	Capital cost, $	Annual O & M cost, $/yr
30	3000	150
35	3500	175
40	4000	225
45	4900	300
50	6100	400

   (*b*) Cost per trip = $50.00/trip
   (*c*) Useful life of containers = 10 yr
   (*d*) Discount rate = 10%
   (*e*) Capital recovery factor (i = 10%, n = 10 yr) = 0.16275

Solution

1. Plot the waste production data on arithmetic probability graph paper. If the data are not normally distributed, it may be necessary to plot them on log-probability paper. The data



are plotted on the accompanying graph using the techniques outlined in Appendix D (see also Example 6-2). Because a straight line can be fitted to the plotted points, it can be assumed, for all practical purposes, that the waste production data are distributed normally.

2. From the probability plot prepared in Step 1, determine the number of additional trips that would be required per year for each of the container sizes.

   (*a*) The percentage of the time that production rates of 30, 35, 40, 45, and 50 yd^3/wk will be exceeded is as follows:

yd^3/wk	Percent
30	70.0
35	35.0
40	10.0
45	1.6
50	0.1

   (*b*) The number of extra trips required is

yd^3/wk	Extra trips, trip/yr[a]
30	36.4 (37)
35	18.2 (19)
40	5.2 (6)
45	0.8 (1)
50	0.05 (1)

[a] Percent from 2(*a*) × 52

3. Determine the annual cost of providing collection service to the commercial facility as a function of the container size.

   (*a*) Determine the annual capital cost. The annual capital cost for a 30 yd^3 container is computed as follows:

$$\text{Annual capital cost} = \text{capital cost} \times \text{capital recovery factor}$$

$$= \$3000 \times 0.16275 = \$488.25$$

   (*b*) The cost for the regular collection trips is calculated as follows:

$$\text{Regular collection cost} = 52 \text{ trip/yr} \times \$50.00/\text{trip} = \$2600.00$$

   (*c*) The cost for the extra collection trips if a 30 yd^3 container is used is computed as follows:

$$\text{Extra collection cost} = 37 \text{ trip/yr} \times \$50.00/\text{trip} = \$1850.00$$

   (*d*) Summarize the costs for each container size. The required cost summary is presented in the following table:

	Cost, dollars				
	Container size, yd^3				
Cost item	30	35	40	45	50
Annual capital cost	488.25	569.62	651.00	797.48	992.78
Annual maintenance cost	150.00	175.00	225.00	300.00	400.00
Regular haul trips	2600.00	2600.00	2600.00	2600.00	2600.00
Extra haul trips	1850.00	950.00	300.00	50.00	50.00
Total	5085.25	4294.62	3776.00	3747.48	4042.78

4. From the preceding analysis it can be concluded that a container size of 45 yd^3 will result in the lowest cost.

Comment. The approach delineated in this example is applicable to a variety of problems in solid waste management where choices must be made between the expenditure of capital cost versus an increase in operational costs.

Container Storage Locations

Container storage locations depend on the type of dwelling or commercial and industrial facilities, the available space, and access to collection services.

Residential Dwellings. Between collections, containers used in low-rise detached dwellings usually are placed (1) at the sides or rear of the house (see Fig. 7-12), (2) in alleys, where alley collection is used, (3) in or next to the garage/carport or, where available, some common location specifically designated for that purpose. When two or more dwellings are located in close proximity, a concrete pad may be constructed at some convenient location between them. The pad may be either open or surrounded by a wooden enclosure. Unless enclosed

FIGURE 7-12
Typical storage locations for containers between collections at residential dwellings.

pads are supervised properly, however, unsightly and unsanitary conditions may develop.

Typical solid waste container storage locations for low- and medium-rise apartment buildings include basement storage and outdoor storage. In large high-rise apartments, the waste storage and processing equipment is located in the basement of the building.

Commercial and Industrial Facilities. The siting of containers at existing commercial and industrial facilities depends on both the location of available space and service-access conditions (see Fig. 7-11). In many of the newer designs, specific service areas are included for this purpose. Often, because the containers are not owned by the commercial or industrial activity, the locations and types of containers to be used for onsite storage must be worked out jointly between the building owners and the public or private collection agency.

Public Health and Aesthetics

Although residential solid wastes account for a relatively small proportion of the total wastes generated in the United States (10 to 15 percent), they are perhaps the most important because they are generated in areas with limited storage space. As a result, they can have significant public health and aesthetic impacts.

Public health concerns are related primarily to the infestation of areas used for the storage of solid wastes with vermin and insects that often serve as potential disease vectors. By far the most effective control measure for both rats and flies is proper sanitation. Typically, proper sanitation involves the use of containers with tight lids, the periodic washing of the containers as well as of the storage areas, and the periodic removal of biodegradable materials (usually within less than 8 days), which is especially important in areas with warm climates. An excellent description of solid waste–disease relationships may be found in Ref. 2.

Aesthetic considerations are related to the production of odors and the unsightly conditions that can develop when adequate attention is not given to the maintenance of sanitary conditions. Most odors can be controlled through the use of containers with tight lids and with the maintenance of a reasonable collection frequency. If odors persist, the contents of the container can be sprayed with a masking deodorant as a temporary expedient. To maintain aesthetic conditions, the container should be scrubbed and washed periodically.

7-5 PROCESSING OF SOLID WASTES AT RESIDENTIAL DWELLINGS

Waste processing is used to (1) reduce the volume, (2) recover usable materials, or (3) alter the physical form of the solid wastes. The most common onsite processing operations used at low-rise detached residential dwellings include food waste grinding, component separation, compaction, incineration (in fireplaces), and composting. Backyard incineration, once a common processing technique used to reduce the volume of waste, is no longer allowed in most urban areas. Processing operations used at low-, medium-, and high-rise apartments include food waste grinding, component separation, and compaction. Typical onsite processing operations and facilities are listed by source in Table 7-6.

Grinding of Food Wastes

In the past 20 years, the use of kitchen food waste grinders has gained such wide acceptance that, in some areas, nearly all new homes are equipped with them and retrofitting of older homes is common. Food waste grinders are used primarily for wastes from the preparation, cooking, and serving of foods. Most grinders sold for home use cannot be used for large bones or other bulky items.

Functionally, grinders render the material that passes through them suitable for transport through the sewer system. Because the organic material added to the wastewater has resulted in overloading many treatment facilities, it has been necessary in some communities to forbid the installation of waste food grinders in new developments until additional treatment capacity becomes available.

Where food waste grinders are used extensively, the weight of waste collected per person will tend to be lower (see Example 6-4). In terms of the col-

TABLE 7-6
Typical operations and facilities used for the processing of solid waste at the source of generation

Source	Persons responsible	Operations and facilities
Residential dwellings		
Low-rise detached	Residents, tenants	Grinding, component separation, compaction, composting
Low- and medium-rise	Tenants	Grinding, component separation, compaction, combustion (fireplace)
	Building maintenance crews, contract services	Compaction, component separation, composting
High-rise	Tenants	Grinding, component separation, compaction, combustion (fireplace)
	Building maintenance crews, contract services	Compaction, component separation, combustion, shredding, hydropulping
Commercial	Janitorial services	Component separation, compaction, shredding, combustion, hydropulping
Industrial	Janitorial services	Component separation, compaction, shredding, combustion, hydropulping
Open areas	Owners, park operators	Compaction, separation of waste components
Treatment plant sites	Plant operators	Dewatering facilities
Agricultural	Owner, workers	Varies with individual commodity

lection operation, the use of home grinders does not have a significant impact on the volume of solid wastes collected. Even the weight difference is not major. In some cases where grinders are used, it has been possible to increase the time period between collection pickups because wastes that might readily decay are not stored.

Separation of Wastes

As noted earlier, the separation of solid waste components at the source of generation is one of the most effective ways to achieve the recovery and reuse of materials. Where the remaining wastes are to be combusted, the question that must be answered is, what is the energy content of residual solid waste? The effect of home separation on the energy content of the residential MSW is considered in Example 7-3.

Example 7-3 Effect of home separation of waste on energy content of *as-collected* residential MSW. Using the computation table prepared in Example 4-3 (reproduced below), estimate the energy content in Btu/lb of the remaining solid wastes if 60 percent of the paper and 90 percent of the cardboard are separated by the homeowner.

Component	Solid wastes,[a] lb	Energy,[b] Btu/lb	Total energy, Btu
Organic			
Food wastes	9.0	2,000	18,000
Paper	34.0	7,200	244,800
Cardboard	6.0	7,000	42,000
Plastics	7.0	14,000	98,000
Textiles	2.0	7,500	15,000
Rubber	0.5	10,000	5,000
Leather	0.5	7,500	3,750
Yard wastes	18.5	2,800	51,800
Wood	2.0	8,000	16,000
Inorganic			
Glass	8.0	60	480
Tin cans	6.0	300	1,800
Aluminum	0.5	—	—
Other metal	3.0	300	900
Dirt, ash, etc.	3.0	3,000	9,000
Total	100.0		506,530

[a] From Table 3-4.
[b] From Table 4-5.

Solution

1. The total energy content of 100 lb of solid waste, with the composition given in Table 3-4, is equal to 506,530 Btu.

2. Determine the energy content and weight of 60 percent of the paper in the original sample.
   (*a*) Energy content, 60% paper

$$0.60 \times 244{,}800 \text{ Btu} = 146{,}880 \text{ Btu}$$

   (*b*) Weight, 60% paper

$$0.60 \times 34 \text{ lb} = 20.4 \text{ lb}$$

3. Determine the energy content and weight of 90 percent of the cardboard in the original sample.
   (*a*) Energy content, 90% cardboard

$$0.90 \times 42{,}000 \text{ Btu} = 37{,}800 \text{ Btu}$$

   (*b*) Weight, 90% cardboard

$$0.90 \times 6 \text{ lb} = 5.4 \text{ lb}$$

4. Determine the total energy content, weight, and energy content per pound of the original sample after paper and cardboard have been separated.
   (*a*) Total energy after recovery

$$(506{,}530 - 146{,}880 - 37{,}800) = 321{,}850 \text{ Btu}$$

   (*b*) Total weight after recovery

$$(100 - 20.4 - 5.4) \text{ lb} = 74.2 \text{ lb}$$

   (*c*) Energy content of waste per lb after separation

$$\frac{321{,}850 \text{ Btu}}{74.2 \text{ lb}} = 4338 \text{ Btu/lb } (10{,}090 \text{ kJ/kg}) \text{ versus } 5065 \text{ Btu/lb } (11{,}781 \text{ kJ/kg})$$

   in original sample

Comment. In this example, the removal by weight of approximately 26 percent of the wastes reduced the per-pound energy content of the original sample by approximately 14 percent.

Compaction

The two principal types of compactors used for the processing of wastes at residential dwellings are (1) small (individual) home and apartment compaction units and (2) large compactors used to compact wastes from a large number of apartments.

Home and Apartment Compaction Units. In the past few years, a number of small compactors designed for home use have appeared on the market. Manufacturers' claims for these units in terms of the compaction ratio usually are based on the compaction of loose paper and corrugated paper. Although compactors can reduce the original volume of wastes placed in them by up to 70 percent, they can be used for only a small proportion of the solid wastes generated. The effect of the use of home compactors on the volume of wastes collected is illustrated in Example 7-4.

Example 7-4 Effect of home compactors on volume of collected solid wastes. Assume that home compaction units are to be installed in a residential area. Estimate the volume reduction that could be achieved in the solid wastes collected if the compacted specific weight is equal to 540 lb/yd^3 and the data given in Tables 3-4 and 4-1 are applicable.

Solution

1. Set up a computation table to determine the volume of wastes as discarded in containers, using the data given in Tables 3-4 and 4-1.

Component	Weight,[a] lb	Specific weight,[b] lb/yd^3	Volume, yd^3 $\times 10^{-2}$
Organic			
Food wastes	9.0	490	1.84
Paper	34.0	150	22.67
Cardboard	6.0	167[c]	3.59
Plastics	7.0	110	6.36
Textiles	2.0	110	1.82
Rubber	0.5	220	0.23
Leather	0.5	270	0.19
Yard wastes	18.5[d]	170	10.88[d]
Wood	2.0[d]	400	0.50[d]
Inorganic			
Glass	8.0	330	2.42
Tin cans	6.0	150	4.00
Aluminum	0.5	270	0.19
Other metal	3.0[d]	540	0.56[d]
Dirt, ash, etc.	3.0[d]	810	0.37[d]
Total	100.0		55.62
			43.31[e]

[a] Data from Table 3-4.
[b] Data from Table 4-1.
[c] Cardboard partially compressed by hand before being placed in waste compactor.
[d] Components not usually placed in home waste compactors.
[e] Total excluding components not usually placed in home waste compactors.

2. Determine the volume of compacted wastes, excluding yard wastes; wood; metals other than aluminum and tin cans; and dirt, ashes, etc.

$$\text{Compacted volume} = \frac{(100 - 18.5 - 2 - 3 - 3)\text{ lb}}{540\text{ lb/yd}^3}$$

$$= \frac{73.5\text{ lb}}{540\text{ lb/yd}^3} = 0.136\text{ yd}^3$$

3. Determine the volume reduction for the compressible material.

$$\text{Volume reduction} = \left(\frac{(0.433 - 0.136)\ \text{yd}^3}{0.433\ \text{yd}^3}\right) \times 100$$

$$= 69\%$$

4. Determine the overall volume reduction achieved with a home compactor, taking into account garden trimmings; wood; metals other than aluminum and tin cans; dirt, ashes, etc.

Overall volume reduction

$$= \left(\frac{0.556\ \text{yd}^3 - (0.136 + 0.109 + 0.005 + 0.006 + 0.004)\ \text{yd}^3}{0.556\ \text{yd}^3}\right) \times 100$$

$$= \left(\frac{0.556 - 0.260}{0.556}\right) \times 100$$

$$= 53\%$$

Comment. When the overall volume reduction is assessed, the significance of a home compactor is reduced. This finding is especially true as the percentages of the components not compacted, such as garden trimmings, increase.

The use of home compactors may also be counterproductive from the standpoint of subsequent processing operations. For example, if the wastes are to be separated mechanically into components at a MRF, the compacted wastes will have to be broken up again before sorting. Also by compacting, the wastes may become so saturated with the liquids present in the food wastes that the recovery of paper or other components may not be feasible because product specifications may not be met.

Compactors for Large Apartment Buildings. To reduce the volume of solid wastes that must be handled, compaction units commonly are installed in large apartment buildings. Typically, a compactor is installed at the bottom of a solid waste chute (see Fig. 7-13). Wastes falling through the chute activate the compactor by means of photoelectric cells or limit switches. Once these switches are activated, the wastes are compressed. Depending on the design of the compactor, the compressed wastes may be formed into bales or extruded and loaded automatically into metal containers or paper bags.

When a bale has been formed or a container or bag is filled, the compactor shuts down automatically and a warning light turns on. The operator must then tie and remove the bale from the compactor, or remove the full bag and replace it with an empty one. In some applications the use of completely automatic equipment may be warranted. In sizing compaction equipment for use in conjunction with solid waste chutes in apartments, it is common to use the same assumptions used in sizing the chutes (see Section 7-2).

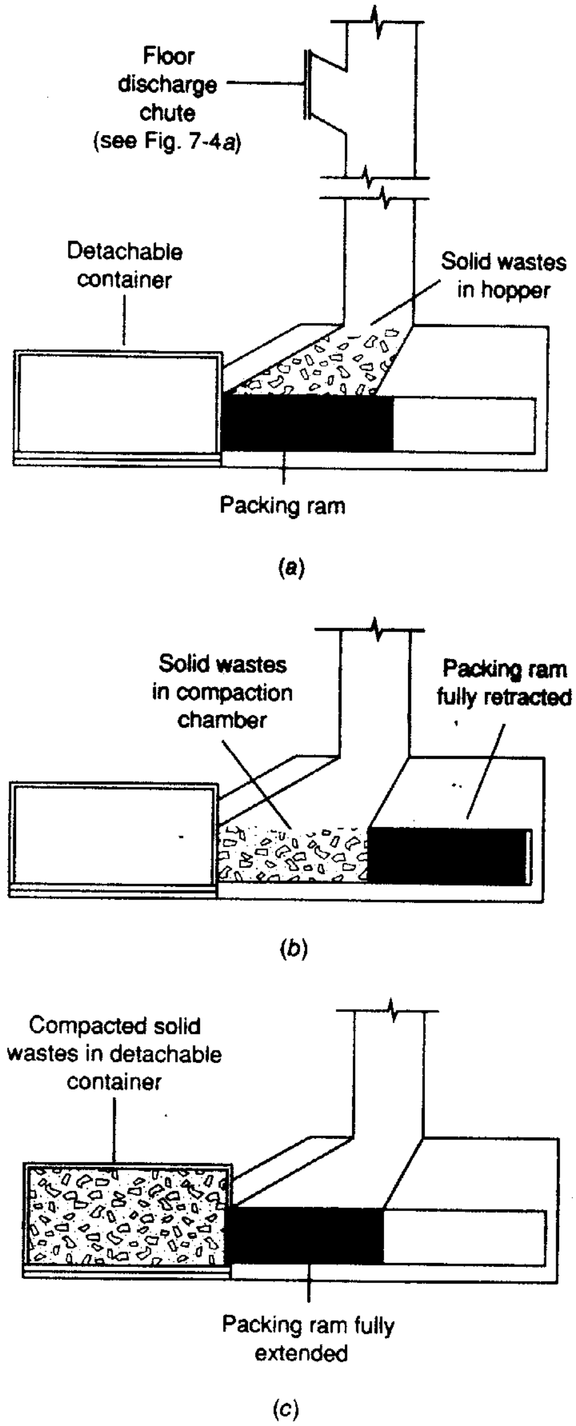


FIGURE 7-13
Typical compactor used in conjunction with waste chutes in large apartment buildings: (*a*) start of compaction cycle; (*b*) loading of compaction chamber; and (*c*) compaction into container.

While the use of compactors reduces the bulk volume of the wastes to be handled, the weight of course remains the same. Typically, the compacted volume will vary from 20 to 60 percent or less of the original volume. Unless baled solid wastes are broken up, it is impossible to recover individual components from compacted wastes. Where solid waste incinerators are used, the compacted wastes must be broken up to avoid delayed combustion in the furnace and high losses of unburned combustible materials. All these factors must be considered when the use of onsite compactors is being evaluated.

Composting

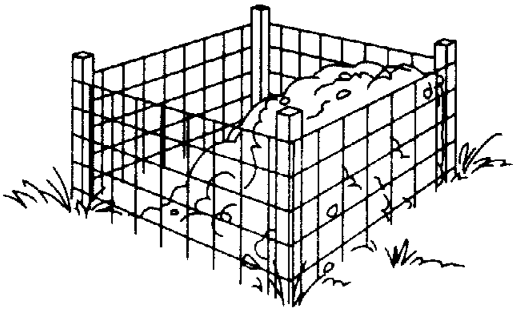
In the 1970s home composting as a means of recycling organic materials increased in popularity [4, 5]. It is an effective way of reducing the volume and altering the physical composition of solid wastes while at the same time producing a useful by-product. A variety of methods are used, depending on the amount of space available and the wastes to be composted. In some states, the composting of leaves by individual homeowners is now required by law. In terms of the overall waste management problems facing most cities, the impact of home composting on the volume of solid wastes to be handled is relatively small. Nevertheless, the composting of leaves can be a significant factor in the computation to determine the quantity of waste diverted from landfills. The large-scale composting of MSW is considered further in Chapters 9 and 14.

Backyard Composting. Backyard composting requires that the individual homeowner develop some method of composting yard wastes, principally leaves and grass clippings [3]. If they are chipped, brush, stumps, and wood are also compostable. The simplest backyard composting method involves placement of the material to be composted in a pile and occasionally watering and turning it to provide moisture and oxygen to the microorganisms within the pile. During the composting period, which can take up to year, the material placed in the pile will undergo bacterial and fungal decompostion until only a humus material known as *compost* remains. The composted material, which is biologically stabilized, can be used as a soil amendment or as a mulching material. Examples of composting units that can be built by homeowners are illustrated in Fig. 7-14. Many homeowners prefer a more organized approach to composting, using one of the many prefabricated composting units now available (see Fig. 7-15). A number of additives are also available to enhance the composting process. Other imaginative backyard compost systems are being developed even as you read this discussion.

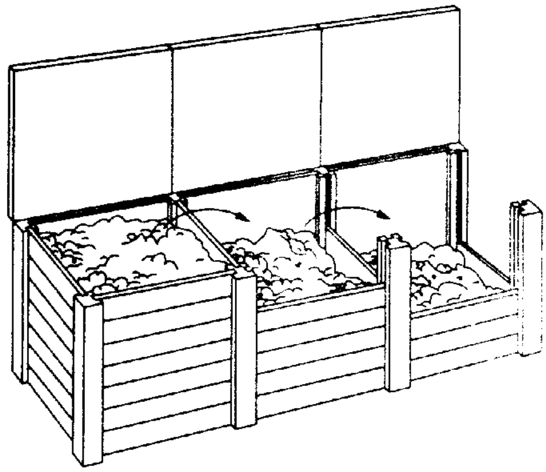
Lawn Mulching. Another type of composting involves leaving grass clippings from a newly mowed lawn where they were cut. If the grass clippings are short enough they will fall through the upright grass to the humus layer on the ground surface. In time, the grass clippings will be composted and incorporated into the humus. Allowing the grass clippings to remain on the lawn not only reduces the amount of waste generated at the source, but also allows for the the recycling of nutrients.

Combustion

In the past, the burning of combustible materials in fireplaces and the burning of rubbish in backyard incinerators was common practice. Backyard incineration is now banned in most parts of the country. The impact of burning combustible wastes in home fireplaces on the amount of waste collected depends on the location and the length of the burning season. Elimination of backyard burning significantly



(a)



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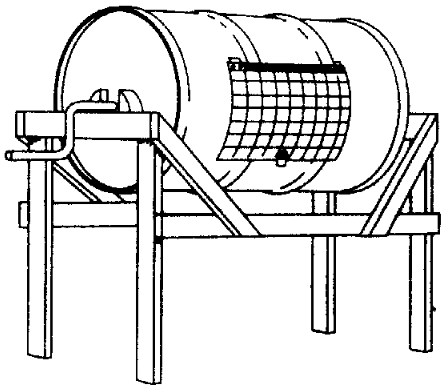

(c)

FIGURE 7-14
Composting units that can be built by homeowners: (a) simple fenced enclosure, (b) three-bin system used to accelerate the compost process, and (c) composter constructed from 55-gal drum. (Courtesy of Minnesota Pollution Control Agency.)

FIGURE 7-15
Commercial composting unit used for the production of compost at residences.

increased the quantity of paper, cardboard, and yard wastes collected. Although little used in the United States, waste combustion is still used in many parts of the world.

The choice between the two types of combusters (commonly known as incinerators) used for high-rise apartments depends on the method of charging: flue-fed and chute-fed. In the flue-fed type, wastes are charged through doors on each floor directly into the refractory flue, the bottom of which opens directly into the top of the furnace combustion chamber. In the chute-fed type, wastes are charged through hopper doors on each floor into a metal chute, and they collect in a basement hopper. The wastes are then either manually or mechanically transferred into the furnace.

7-6 PROCESSING OF SOLID WASTES AT COMMERCIAL AND INDUSTRIAL FACILITIES

Onsite processing operations carried out at commercial-industrial facilities are generally similar to those described for residential sources. However, compaction is very important in commercial facilities. Other differences occur primarily in industrial facilities. Because most of the processes tend to be industry-specific, no attempt has been made to document the various processes that have been used.

Compaction

The baling of waste cardboard at markets and other commercial establishments is quite common. The bales vary in size, but typically are about 36 × 48 × 60 in. Baled cardboard is reprocessed for the production of packing materials or shipped overseas for remanufacture into a variety of products.

Shredding and Hydropulping

Shredding and pulping are alternative processing operations that have been used, both in conjunction with the previous methods and by themselves, for reducing the volume of wastes that must be handled. Shredding is used most commonly in commercial establishments and by governmental agencies to destroy sensitive documents that are no longer of value. In some cases, the volume of wastes has been observed to increase after shredding.

Although hydropulping systems work well, they are expensive and typically involve discharge to the local wastewater collection system. Because the discharge of pulped material increases the organic loading on local treatment facilities, the use of pulverizers may be restricted if treatment capacity is limited.

7-7 DISCUSSION TOPICS AND PROBLEMS

7-1. Tour your community and make a brief survey of the different types of containers now used for the collection of solid waste.

7-2. Estimate the maximum amount (by weight) of material that could be separated for recycling from residential MSW using a two-container system. What should be the size of the two containers? Use the waste composition given in Table 3-4, and assume that there are 3.1 residents per residence.

7-3. Obtain a component distribution of the solid wastes generated in your community, and determine the percentage reduction that could be achieved if home compactors were installed. Assume the specific weight of the compacted wastes to be 20 lb/ft^3. Compare your answer with that derived in Example 7-4.

7-4. List the advantages and disadvantages associated with the separation of solid wastes in high-rise apartment buildings.

7-5. Assuming that the quantities of solid wastes generated daily at a commercial facility are distributed normally (see Appendix D), with a mean value of 10 yd^3 and a standard deviation of 7 yd^3, what size container would you recommend for this facility? What are the important tradeoffs in the selection of container size?

7-6. Using the data presented in Fig. 7-5, estimate the size of a container to be used with a gravity chute for a 24-story apartment building with 192 individual living units if the container will be emptied daily. Assume that the average occupancy rate for each living unit is 3.1 persons.

7-7. What compactor volume displacement (e.g., capacity), expressed in terms of cubic yards per hour, would you recommend for use in the 24-story apartment building of Problem 7-6?

7-8. As a consulting engineer, you have been commissioned to develop a comprehensive solid waste system for a community interested in achieving a greater recovery and reuse of its solid wastes. Two of the possible alternatives are separation at the home or separation at a materials recovery facility. What important factors must be considered in evaluating these two alternatives?

7-9. Find out what is now being done in your community with respect to the collection of household hazardous wastes. Do you believe the program is effective? What can you suggest to improve the effectiveness of the program?

7-8 REFERENCES

1. Bergen County Utilities Authority: *Bergen County Apartment Recycling Manual,* Little Ferry, NJ, 1988.
2. Hanks, T. G.: *Solid Waste/Disease Relationships,* U.S. Department of Health, Education, and Welfare, Solid Wastes Program, Publication SW–1c, Cincinnati, OH, 1967.
3. Strom, P. and M. Finstein: *Leaf Composting Manual for New Jersey Municipalities,* New Jersey Department of Environmental Protection, Division of Solid Waste Management, Office of Recycling, Trenton, NJ, 1986.
4. *The BioCycle Guide to Composting Municipal Wastes,* BioCycle, Emmaus, PA, 1989.
5. U.S. Environmental Protection Agency: *Decision-Makers Guide to Solid Waste Management,* EPA/530-SW89-072, Washington, DC, November 1989.