Designation: D 5231 – 92 (Reapproved 1998)

# Standard Test Method for Determination of the Composition of Unprocessed Municipal Solid Waste[1]

This standard is issued under the fixed designation D 5231; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

## 1. Scope

1.1 This test method describes procedures for measuring the composition of unprocessed municipal solid waste (MSW) by employing manual sorting. This test method applies to determination of the mean composition of MSW based on the collection and manual sorting of a number of samples of waste over a selected time period covering a minimum of one week.

1.2 This test method includes procedures for the collection of a representative sorting sample of unprocessed waste, manual sorting of the waste into individual waste components, data reduction, and reporting of the results.

1.3 This test method may be applied at landfill sites, waste processing and conversion facilities, and transfer stations.

1.4 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

1.5 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For specific hazard statements, see Section 6.

## 2. Terminology

2.1 *Definitions:*

2.1.1 *composite item*—an object in the waste composed of multiple waste components or dissimilar materials, such as disposable diapers, bi-metal beverage containers, electrical conductors composed of metallic wire encased in plastic insulation, etc.

2.1.2 *solid waste composition or waste composition*—the characterization of solid waste as represented by a breakdown of the mixture into specified waste components on the basis of mass fraction or of weight percent.

2.1.3 *sorting sample*—a 200 to 300-lb (91 to 136-kg) portion deemed to represent the characteristics of a vehicle load of MSW.

2.1.4 *unprocessed municipal solid waste*—solid waste in its discarded form, that is, waste that has not been size reduced or otherwise processed.

2.1.5 *waste component*—a category of solid waste, composed of materials of similar physical properties and chemical composition, which is used to define the composition of solid waste, for example, ferrous, glass, newsprint, yard waste, aluminum, etc.

## 3. Summary of Test Method

3.1 The number of samples to be sorted is calculated based on statistical criteria selected by the investigators.

3.2 Vehicle loads of waste are designated for sampling, and a sorting sample is collected from the discharged vehicle load.

3.3 The sample is sorted manually into waste components. The weight fraction of each component in the sorting sample is calculated from the weights of the components.

3.4 The mean waste composition is calculated using the results of the composition of each of the sorting samples.

## 4. Significance and Use

4.1 Waste composition information has widespread applications and can be used for activities such as solid waste planning, designing waste management facilities, and establishing a reference waste composition for use as a baseline standard in both facility contracts and acceptance test plans.

4.2 The method can be used to define and report the composition of MSW through the selection and manual sorting of waste samples. Where applicable, care should be taken to consider the source and seasonal variation of waste.

4.3 After performing a waste composition analysis, laboratory analyses may be performed on representative samples of waste components, or mixtures of waste components, for purposes related to the planning, management, design, testing, and operation of resource recovery facilities.

## 5. Apparatus

5.1 *Metal, Plastic, or Fiber Containers*, sufficient for storing and weighing each waste component, labeled accordingly. For components that will have a substantial moisture content (for example, food waste), metal or plastic containers are recommended in order to avoid absorption of moisture by the container and thus the need for a substantial number of weighings to maintain an accurate tare weight for the container.

5.2 *Mechanical or Electronic Weigh Scale*, with a capacity of at least 200 lb (91 kg) and precision of at least 0.1 lb (0.045 kg).

[1] This test method is under the jurisdiction of ASTM Committee D34 on Waste Disposal and is the direct responsibility of Subcommittee D34.01.06 on Analytical Methods.

Current edition approved July 31, 1992. Published September 1992.

5.3 *Heavy-Duty Tarps, Shovels, Rakes, Push Brooms, Dust Pans, Hand Brooms, Magnets, Sorting Table, First Aid Kit, Miscellaneous Small Tools, Traffic Cones, Traffic Vests, Leather Gloves, Hardhats, Safety Glasses, and Leather Boots.*

## 6. Hazards

6.1 Review the hazards and procedures with the operating and sorting personnel prior to conducting the field activities.

6.2 Sharp objects, such as nails, razor blades, hypodermic needles, and pieces of glass, are present in solid waste. Personnel should be instructed of this danger, and they should brush waste particles aside while sorting rather than projecting their hands with force into the mixture. Personnel handling and sorting solid waste should wear appropriate protection, such as heavy leather gloves, dust masks, hardhats, safety glasses, and safety boots.

6.3 During the processes of unloading waste from collection vehicles and handling waste with heavy equipment, projectiles may issue from the mass of waste. The projectiles can include flying glass particles from breaking glass containers and metal lids from plastic and metal containers that burst under pressure when run over by heavy equipment. The problem is particularly severe when the waste handling surface is of high compressive strength, for example, concrete. Personnel should be informed of this danger and wear eye and head protection if in the vicinity of either the collection vehicle unloading point or heavy equipment, or both.

6.4 Select a location for the discharge of designated loads, manual sorting activities, and weighing operations that is flat, level, and away from the normal waste handling and processing areas.

6.5 Weigh storage containers each day, or more frequently, if necessary, in order to maintain an accounting of the tare weight.

6.6 Loss of mass from the sorting sample can occur through the evaporation of water. Samples should thus be sorted as soon as possible after collection.

6.7 Containers of liquids or other potentially dangerous wastes shall be put aside and handled by the crew chief.

## 7. Calibration

7.1 All weigh scale equipment shall be calibrated according to the manufacturer's instructions. Take appropriate corrective action if the readings are different from those of the calibration weights.

## 8. Procedure

8.1 Secure a flat and level area for discharge of the vehicle load. The surface should be swept clean or covered with a clean, durable tarp prior to discharge of the load.

8.2 Position the scale on a clean, flat, level surface and adjust the level of the scale if necessary. Determine the accuracy and operation of the scale with a known (that is, reference) weight.

8.3 Weigh all empty storage containers and record the tare weights.

8.4 Determine the number of samples to be sorted. The determination is a function of the waste components to be sorted and the desired precision as applied to each component. Weights of 200 to 300 lb (91 to 136 kg) for sorting samples of unprocessed solid waste are recommended. The number of samples is determined using the calculational method described in 9.1.

8.5 A comprehensive list of waste components for sorting is given in Table 1. A description of some of the waste component categories is given in Table 2. Other waste components can be defined and sorted, depending on the purpose of the waste composition determination. The list in Table 1 is comprised of those components most commonly used to define and report the composition of solid waste. It is recommended that, at a minimum, the complement of left-justified categories in Table 1 be sorted. Similar breakdowns of solid waste composition are therefore available for purposes of comparison, if desired. Label the storage containers accordingly.

8.6 Vehicles for sampling shall be selected at random during each day of the one-week sampling period, or so as to be representative of the waste stream as agreed upon by the affected parties. With respect to the random selection of vehicles, any method is acceptable that does not introduce a bias into the selection. An acceptable method is the use of a random number generator. For a weekly sampling period of $k$ days, the number of vehicles sampled each day shall be approximately $n/k$, where $n$ is the total number of vehicle loads to be selected for the determination of waste composition. A weekly period is defined as 5 to 7 days.

8.7 Direct the designated vehicle containing the load of waste to the area secured for discharge of the load and collection of the sorting sample.

8.8 Collect any required information from the vehicle operator before the vehicle leaves the discharge area. Direct the vehicle operator to discharge the load onto the clean surface in one contiguous pile, that is, to avoid gaps in the discharged load in order to facilitate collection of the samples.

8.9 Using a front-end loader with at least a 1-yd $^3$(0.765-m$^3$) bucket, remove the material longitudinally along one entire side of the discharged load in order to obtain a representative cross-section of the material. The mass of material shall be sufficient to form a mass of material which, on a visual basis, is at least four times the desired weight of the sorting sample (that is, approximately 1000 lb (454 kg)). Mix, cone, and quarter the material, and select one quarter to be the sorting sample, using a random method of selection or a sequence agreed by all affected parties, for the purpose of eliminating or minimizing biasing of the sample. If an oversize item (for

TABLE 1 List of Waste Component Categories

| | |
|---|---|
| Mixed paper | Other organics |
| High-grade paper | Ferrous |
| Computer printout | Cans |
| Other office paper | Other ferrous |
| Newsprint | Aluminum |
| Corrugated | Cans |
| Plastic | Foil |
| PET bottles | Other aluminum |
| HDPE bottles | Glass |
| Film | Clear |
| Other plastic | Brown |
| Yard waste | Green |
| Food waste | Other inorganics |
| Wood | |

**TABLE 2 Descriptions of Some Waste Component Categories**

| Category | Description |
|---|---|
| Mixed paper | Office paper, computer paper, magazines, glossy paper, waxed paper, and other paper not fitting the categories of newsprint and corrugated |
| Newsprint | Newspaper |
| Corrugated | Corrugated medium, corrugated boxes or cartons, and brown (kraft) paper (that is, corrugated) bags |
| Plastic | All plastics |
| Yard waste | Branches, twigs, leaves, grass, and other plant material |
| Food waste | All food waste except bones |
| Wood | Lumber, wood products, pallets, and furniture |
| Other organics/ combustibles | Textiles, rubber, leather, and other primarily burnable materials not included in the above component categories |
| Ferrous | Iron, steel, tin cans, and bi-metal cans |
| Aluminum | Aluminum, aluminum cans, and aluminum foil |
| Glass | All glass |
| Other inorganics/ non-combustibles | Rock, sand, dirt, ceramics, plaster, non-ferrous non-aluminum metals (copper, brass, etc.), and bones |

example, water heater) composes a large weight percent of the sorting sample, add a notation on the data sheet and weigh it, if possible. Unprocessed solid waste is a heterogeneous mixture of materials. Care must thus be taken during application of the procedures for sample collection in order to obtain a representative sample.

8.10 One sorting sample is selected from each collection vehicle load designated for sampling. All handling and manipulation of the discharged load and longitudinal and sorting samples shall be conducted on previously cleaned surfaces. If necessary, remove the sorting sample to a secured manual sorting area. The sorting sample may be placed on a clean table for sorting for the convenience of the sorting personnel. The sorting area shall be a previously cleaned, flat, level surface.

8.11 Position the storage containers around the sorting sample. Empty all containers from the sorting sample, such as capped jars, paper bags, and plastic bags of their contents. Segregate each waste item and place it in the appropriate storage container.

8.12 In the case of composite items found in the waste, separate the individual materials where practical, and place the individual materials into the appropriate storage containers. Where impractical, segregate the composite items for classification by the crew chief according to the following order:

8.12.1 If there are many identical composite items (for example, plastic-sheathed aluminum electrical conductor), place them into the waste component containers corresponding to the materials present in the item, and in the approximate proportions according to the estimated mass fraction of each material in the item.

8.12.2 If there are only a few of the identical composite item, place them in the storage container corresponding to the material that comprises, on a weight basis, the majority of the item (for example, place bi-metal beverage cans in the ferrous container).

8.12.3 If composite items represent substantial weight percents of the sorting sample, a separate category should be established, for example, composite roofing shingles.

8.12.4 If none of the above procedures is appropriate, place the item(s) (or proportion it (them)) in the storage container labeled" other non-combustible" or "other combustible," as appropriate.

8.13 Sorting continues until the maximum particle size of the remaining waste particles is approximately 0.5 in. (12.7 mm). At this point, apportion the remaining particles into the storage containers corresponding to the waste components represented in the remaining mixture. The apportionment shall be accomplished by making a visual estimate of the mass fraction of waste components represented in the remaining mixture.

8.14 Record the gross weights of the storage containers and of any waste items sorted but not stored in containers. The data sheet shown in Fig. 1 can be used to record both gross and tare weights.

8.15 After recording the gross weights, empty the storage containers and weigh them again, if appropriate. Re-weighing

Waste Composition Data Sheet

Day/Date: ____________ Collection Company: ____________
Site: ____________ Vehicle Type: ____________
Weather: ____________ Route No: ____________
Recorded by: ____________

| Component | Weight in Pounds | | | Percent of Total |
|---|---|---|---|---|
| | Gross | Tare | | |
| Mixed Paper | | | | |
| High Grade Paper | | | | |
| Computer Printout | | | | |
| Other Office Paper | | | | |
| Newsprint | | | | |
| Corrugated | | | | |
| Plastic | | | | |
| PET bottles | | | | |
| HDPE bottles | | | | |
| Film | | | | |
| Other Plastic | | | | |
| Food Waste | | | | |
| Wood | | | | |
| Other Organics | | | | |
| Ferrous | | | | |
| Cans | | | | |
| Other Ferrous | | | | |
| Aluminum | | | | |
| Cans | | | | |
| Foil | | | | |
| Other Aluminum | | | | |
| Glass | | | | |
| Clear | | | | |
| Brown | | | | |
| Green | | | | |
| Other Inorganics | | | | |

TOTALS ____________

NOTES: ____________

Lab sample taken? Yes ______ No ______

**FIG. 1 Waste Composition Data Sheet**

is important and necessary if the containers become moisture-laden, for example, from wet waste.

8.16 Clean the sorting site, as well as the load discharge area, of all waste materials.

## 9. Calculation

9.1 *Number of 200 to 300-lb (91 to 136-kg) Samples*:

9.1.1 The number of sorting samples (that is, vehicle loads) (*n*) required to achieve a desired level of measurement precision is a function of the component(s) under consideration and the confidence level. The governing equation for *n* is as follows:

$$n = (t^* \, s/e \cdot \bar{x})^2 \quad (1)$$

where:

$t^*$ = student *t* statistic corresponding to the desired level of confidence,
$s$ = estimated standard deviation,
$e$ = desired level of precision, and
$\bar{x}$ = estimated mean.

9.1.1.1 All numerical values for the symbols are in decimal notation. For example, a precision value (*e*) of 20 % is represented as 0.2.

9.1.1.2 One sorting sample is chosen per vehicle load.

9.1.1.3 Suggested values of *s* and of $\bar{x}$ for waste components are listed in Table 3. Values of $t^*$ are given in Table 4 for 90 and 95 % levels of confidence, respectively.

9.1.2 Estimate the number of samples ( $n'$) for the selected conditions (that is, precision and level of confidence) and components using (Eq 1). For the purposes of estimation, select from Table 4 the $t^*$ value for $n = \infty$ for the selected level of confidence. Since the required number of samples will vary among the components for a given set of conditions, a compromise will be required in terms of selecting a sample size, that is, the number of samples that will be sorted. The component that is chosen to govern the precision of the composition measurement (and therefore the number of samples required for sorting) is termed the "governing component" for the purposes of this method.

**TABLE 3 Values of Mean ( $\bar{x}$ ) and Standard Deviation(s) for Within-Week Sampling to Determine MSW Component Composition[A]**

| Component | Standard Deviation(s) | Mean ($\bar{x}$) |
|---|---|---|
| Newsprint | 0.07 | 0.10 |
| Corrugated | 0.06 | 0.14 |
| Plastic | 0.03 | 0.09 |
| Yard waste | 0.14 | 0.04 |
| Food waste | 0.03 | 0.10 |
| Wood | 0.06 | 0.06 |
| Other organics | 0.06 | 0.05 |
| Ferrous | 0.03 | 0.05 |
| Aluminum | 0.004 | 0.01 |
| Glass | 0.05 | 0.08 |
| Other inorganics | 0.03 | 0.06 |
| | | 1.00 |

[A]The tabulated mean values and standard deviations are estimates based on field test data reported for MSW sampled during weekly sampling periods at several locations around the United States.

**TABLE 4 Values of *t* Statistics ($t^*$) as a Function of Number of Samples and Confidence Interval**

| Number of Samples, *n* | 90 % | 95 % |
|---|---|---|
| 2 | 6.314 | 12.706 |
| 3 | 2.920 | 4.303 |
| 4 | 2.353 | 3.182 |
| 5 | 2.132 | 2.776 |
| 6 | 2.015 | 2.571 |
| 7 | 1.943 | 2.447 |
| 8 | 1.895 | 2.365 |
| 9 | 1.860 | 2.306 |
| 10 | 1.833 | 2.262 |
| 11 | 1.812 | 2.228 |
| 12 | 1.796 | 2.201 |
| 13 | 1.782 | 2.179 |
| 14 | 1.771 | 2.160 |
| 15 | 1.761 | 2.145 |
| 16 | 1.753 | 2.131 |
| 17 | 1.746 | 2.120 |
| 18 | 1.740 | 2.110 |
| 19 | 1.734 | 2.101 |
| 20 | 1.729 | 2.093 |
| 21 | 1.725 | 2.086 |
| 22 | 1.721 | 2.080 |
| 23 | 1.717 | 2.074 |
| 24 | 1.714 | 2.069 |
| 25 | 1.711 | 2.064 |
| 26 | 1.708 | 2.060 |
| 27 | 1.706 | 2.056 |
| 28 | 1.703 | 2.052 |
| 29 | 1.701 | 2.048 |
| 30 | 1.699 | 2.045 |
| 31 | 1.697 | 2.042 |
| 36 | 1.690 | 2.030 |
| 41 | 1.684 | 2.021 |
| 46 | 1.679 | 2.014 |
| 51 | 1.676 | 2.009 |
| 61 | 1.671 | 2.000 |
| 71 | 1.667 | 1.994 |
| 81 | 1.664 | 1.990 |
| 91 | 1.662 | 1.987 |
| 101 | 1.660 | 1.984 |
| 121 | 1.658 | 1.980 |
| 141 | 1.656 | 1.977 |
| 161 | 1.654 | 1.975 |
| 189 | 1.653 | 1.973 |
| 201 | 1.653 | 1.972 |
| ∞ | 1.645 | 1.960 |

9.1.3 After determining the governing component and its corresponding number of samples ($n_o$), return to Table 4 and select the student *t* statistic ($t^*_o$) corresponding to $n_o$. Recalculate the number of samples, that is, $n'$, using $t^*_o$.

9.1.4 Compare $n_o$ to the new estimate of *n*, that is, $n'$, which was calculated for the governing component. If the values differ by more than 10 %, repeat the calculations given in 9.1.2 and 9.1.3.

9.1.5 If the values are within 10 %, select the larger value as the number of samples to be sorted. Refer to Appendix X1 for a sample calculation of *n*.

9.2 *Component Composition*:

9.2.1 The component composition of solid waste is reported on the basis of the mass fraction (expressed as a decimal) or percent of waste component *i* in the solid waste mixture. The reporting is on the basis of wet weight, that is, the weight of materials immediately after sorting.

9.2.2 The mass fraction of component *i*, $mf_i$, is defined and computed as follows:

$$mf_i = \frac{w_i}{\sum_{i=1}^{j} w_i} \quad (2)$$

where:

$w_i$ = weight of component i and

$j$ = number of waste components.

In those cases in which a container is used to store and weigh the materials,

$$w_i = \text{gross weight} - \text{tare weight of container} \quad (3)$$

9.2.3 The percent of component $i$, $P_i$, is defined and computed as follows:

$$P_i = mf_i \times 100 \quad (4)$$

9.2.4 For the data analysis to be correct, the denominator of (Eq 2) must be unity, and

$$\sum_{i=1}^{j} P_i = 100 \quad (5)$$

9.3 The mean component composition for the one-week period is calculated using the component composition results from each of the analysis samples. The mean mass fraction of component $i$, $\overline{mf_i}$, is calculated as follows:

$$\overline{mf_i} = \frac{1}{n} \sum_{k=1}^{n} (mf_i)_k \quad (6)$$

and the mean percent of component $i$, $P_i$, is calculated as follows:

$$\bar{P}_i = \frac{1}{n} \sum_{k=1}^{n} (P_i)_k \quad (7)$$

where:

$n$ = number of samples.

## 10. Precision and Bias

10.1 A precision and bias statement cannot be made for this test method at this time. However, the committee is interested in conducting an interlaboratory test program and encourages interested parties to contact ASTM Headquarters.[2]

## 11. Keywords

11.1 composition; municipal solid waste; waste characterization

[2] ASTM Headquarters, 1916 Race Street, Philadelphia, PA 19103.

# APPENDIX

## (Nonmandatory Information)

## X1. EXAMPLE CALCULATION OF THE NUMBER OF SAMPLES FOR ANALYSIS

X1.1 *Example Assumptions:*

X1.1.1 Corrugated is selected as the governing component.

X1.1.2 A 90 % confidence level is selected.

X1.1.3 A precision of 10 % is desired.

X1.1.4 Therefore:

$s$ = 0.06 (from Table 3),
$\bar{x}$ = 0.14 (from Table 3),
$e$ = 0.10, and
$t^*(n = \infty)$ = 1.645 (from Table 4).

Using (Eq 1):

$$n = [t^* s/(e \cdot \bar{x})]^2 = \left[\frac{1.645\ (0.06)}{0.1\ (0.14)}\right]^2 = 50 = n_o \quad (X1.1)$$

Referring again to Table 4, for $n = 50$,

$$t^*_{90}\ (n = 50) = 1.677 \quad (X1.2)$$

and,

$$n = \left[\frac{1.677\ (0.06)}{0.1\ (0.14)}\right]^2 = 52 = n' \quad (X1.3)$$

Since 52 (that is, $n'$) is within 10 % of 50 (that is, $n_o$), 52 samples should be selected for analysis.