Designation: D 6003 – 96

Standard Test Method for Determining Weight Loss From Plastic Materials Exposed to Simulated Municipal Solid-Waste (MSW) Aerobic Compost Environment [1]

This standard is issued under the fixed designation D 6003; 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 is used to determine the degree and rate of aerobic biodegradation of plastic materials exposed to a controlled composting environment. Aerobic composting takes place in an environment where temperature, aeration, and humidity are closely monitored and controlled.

1.2 The test is designed to determine the biodegradability of plastic materials, relative to that of a standard material, in an aerobic environment. Aeration of the test reactors is maintained at a constant rate throughout the test and reactor vessels of a size no greater than 4-L volume are used to ensure that the temperature of the vessels is approximately the same as that of the controlled environment chamber.

1.3 Biodegradability of the plastic is assessed by determining the amount of weight loss from samples exposed to a biologically active compost relative to the weight loss from samples exposed to a "poisoned" control.

1.4 The test is designed to be applicable to all plastic materials that are not inhibitory to the bacteria and fungi present in the simulated Municipal Solid Waste (MSW).

1.5 The values stated in SI units are to be regarded as the standard.

1.6 *This standard does not purport to address all of the safety concerns, 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.*

NOTE 1—There is no similar or equivalent ISO method.

2. Referenced Documents

2.1 *ASTM Standards:*

D 618 Practice for Conditioning of Plastics and Electrical Insulating Materials for Testing[2]

D 883 Terminology Relating to Plastics[2]

D 1193 Specification for Reagent Water[3]

D 1898 Practice for Sampling of Plastics[2]

D 2973 Test Method for Total Nitrogen in Peat Materials[4]

D 2974 Test Methods for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils[4]

D 2976 Test Method for pH of Peat Materials[4]

D 2980 Test Method for Volume Weights, Water-Holding Capacity, and Air Capacity of Water-Saturated Peat Materials[4]

D 3593 Molecular Weight Averages and Molecular Weight Distribution of Certain Polymers by Liquid Size Exclusion Chromatography (Gel Permeation Chromatography)[5]

D 4129 Test Method for Total and Organic Carbon in Water by High-Temperature Oxidation and Coulometric Detection[6]

D 5338 Test Method for Determining Aerobic Biodegradation of Plastic Materials under Controlled Composting Conditions[7]

D 5509 Practice for Exposing Plastics to a Simulated Compost Environment[7]

D 5512 Practice for Exposing Plastics to a Simulated Compost Environment Using an Externally Heated Reactor[7]

2.2 *APHA-AWWA-WPCF Standards:*

2540 G Total, Fixed, and Volatile Solids in Solid and Semi-Solid Samples

3. Terminology

3.1 *Definitions*—Definitions of terms applying to this test method appear in Terminology D 883 and Practice D 5509.

4. Summary of Test Method

4.1 The test method consists of the following:

4.1.1 Selecting plastic materials for exposure in a controlled aerobic composting environment;

4.1.2 Preparing and characterizing a simulated compost with the proper C:N ratio, pH, water holding capacity, porosity, and inoculum to establish and maintain a high biological activity;

[1] This test method is under the jurisdiction of ASTM Committee D-20 on Plastics and is the direct responsibility of Subcommittee D20.96 on Environmentally Degradable Plastics.

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[2] *Annual Book of ASTM Standards*, Vol 08.01.

[3] *Annual Book of ASTM Standards*, Vol 11.01.

[4] *Annual Book of ASTM Standards*, Vol 04.08.

[5] *Discontinued, 1993*. Replaced by Test Method D 5296.

[6] *Annual Book of ASTM Standards*, Vol 11.02.

[7] *Annual Book of ASTM Standards*, Vol 08.03.

4.1.3 Exposing the test materials to the compost under controlled, aerobic conditions;

4.1.4 Removing the test specimens for cleaning; and

4.1.5 Assessing the degradability of the plastics by measuring weight loss from the test specimens.

5. Significance and Use

5.1 Aerobic composting represents an attractive alternative to the disposal of solid wastes in landfills. Composting by biologically mediated oxidative decomposition produces highly stable organic matter that may be used for land applications or horticulture. However, the degradation of plastics within a compost can affect the decomposition of materials enclosed by the plastic, other non-plastic materials in the compost, and the resulting composition and appearance of the composted material. This test is intended to help assess the environmental degradability of plastics under standard composting conditions. Characterization of the ability of a plastic to degrade under controlled, environmentally relevant conditions is essential when developing products with a programmed lifetime.

5.2 Considering the diversity of materials that may be introduced into a particular compost, as well as the variety of designs of composting facilities, it is important to recognize that no single test can adequately simulate all the conditions which may occur during composting. Consequently, this test is intended to provide a uniform, standardized environment simulating a representative MSW compost operating at near-optimum conditions.

5.3 Because a specimen degrades to the point where it can not be distinguished from the other materials within the compost does not mean that it has become fully mineralized. Determination of a plastic's degradation products and their potential toxicity requires further testing. Mineralization of the plastic material (that is, conversion of polymer-C to CO_2) should be investigated using Test Method D 5338.

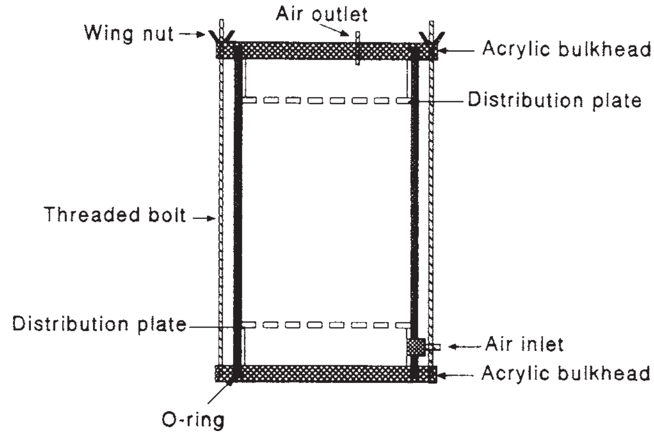
5.4 Predicting long-term environmental fate and effects of a plastic from the results of short-term exposure to a simulated waste disposal environment is difficult. Thus, caution should be exercised when extrapolating the results obtained from this or any other controlled-environment test to disposal in the natural environment.

6. Apparatus

6.1 *Composting Apparatus*:

6.1.1 A suitable bioreactor vessel (see Fig. 1) consists of a 127-mm (i.d.) by 300-mm long acrylic cylinder; two acrylic bulkhead plates (150 mm × 150 mm); two acrylic distribution plates, positioned 25 mm from the bulkhead plates; and four all-thread bolts with wing nuts. Air enters the bioreactor through an inlet (6.4-mm i.d.) positioned about 25 mm above the bottom bulkhead, and exits the bioreactor through an outlet (6.4-mm i.d.) in the top bulkhead.

NOTE 2—The size of the reactor may be changed as long as there is sufficient volume to allow for the even distribution of the MSW and test materials. However, the internal volume of the reaction vessel should not exceed 4 L; this will allow adequate control of the internal temperature of the compost via the exchange of heat between the contents of the reaction vessel and the environment chamber.



NOTE 1—Bioreactor = acrylic cylinder; 127-mm (ID) × 300 mm long.
Air exit port = 6.4 mm diameter.
Air inlet port = 6.4 mm diameter; 25 mm above the acrylic bulkhead.
Perforated distribution plate: positioned 50 mm above the acrylic bulkhead.

FIG. 1 Schematic Drawing of the Aerobic Bioreactor

6.1.2 The bioreactors are connected to a filtered air supply capable of providing water-saturated air at a rate of 100 to 200 mL min^{-1}. The air supply to each bioreactor is humidified by passing through a fritted-glass air dispersion tube immersed in distilled water (300 mL in a 500-mL Erlenmeyer flask) and regulated via a flow meter (see Fig. 2). Water in the humidifier flask must be maintained at the temperature of the environment chamber.

6.1.3 A controlled-environment chamber capable of maintaining a temperature of 30 (±2) to 70 (±2) °C.

6.2 *Analytical Equipment*:

6.2.1 *Analytical Balance*, to weigh test materials, (±0.1 mg).

6.2.2 *Top Loading Balance*, to weigh MSW samples for determining water content, (±0.01 g).

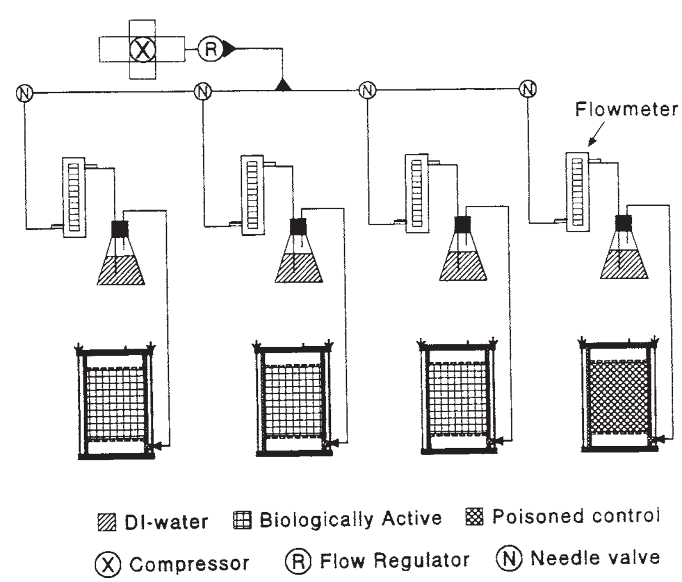


FIG. 2 Schematic of the Film Weight-Loss Bioreactor System