Designation: ~~D5526 – 12~~ D5526 – 18

Standard Test Method for Determining Anaerobic Biodegradation of Plastic Materials Under Accelerated Landfill Conditions[1]

This standard is issued under the fixed designation D5526; 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 covers determination of the degree and rate of anaerobic biodegradation of plastic materials in an accelerated-landfill test environment. This test method is also designed to produce mixtures of household waste and plastic materials after different degrees of decomposition under conditions that resemble landfill conditions. The test materials are mixed with pretreated household waste and exposed to a methanogenic inoculum derived from anaerobic digesters operating only on pretreated household waste. The anaerobic decomposition occurs under dry (more than 30 % total solids) and static nonmixed conditions. The mixtures obtained after this test method can be used to assess the environmental and health risks of plastic materials that are degraded in a landfill.

1.2 This test method is designed to yield a percentage of conversion of carbon in the sample to carbon in the gaseous form under conditions that resemble landfill conditions. It is possible that this test method will not simulate all conditions found in landfills, especially biologically inactive landfills. This test method more closely resembles those types of landfills in which the gas generated is recovered or even actively promoted, or both, for example, by inoculation (codeposition of anaerobic sewage sludge and anaerobic leachate recirculation), moisture control in the landfill (leachate recirculation), and temperature control (short-term injection of oxygen and heating of recirculated leachate) (**1-7**).[2]

1.3 This test method is designed to produce partially degraded mixtures of municipal solid waste and plastics that can be used to assess the ecotoxicological risks associated with the anaerobic degradation of plastics after various stages of anaerobic biodegradation in a landfill.

1.4 Claims of performance shall be limited to the numerical result obtained in the test and not be used for unqualified "biodegradable" claims. Reports shall clearly state the percentage of net gaseous carbon generation for both the test and reference samples at the completion of the test. Furthermore, results shall not be extrapolated past the actual duration of the test.

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~~ safety, health, and ~~health~~environmental practices and determine the applicability of regulatory limitations prior to use.* Specific hazards statements are given in Section 8.

NOTE 1—There is no known ISO equivalent to this standard.

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

D618 Practice for Conditioning Plastics for Testing

D883 Terminology Relating to Plastics

D1293 Test Methods for pH of Water

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

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[2] The boldface numbers in parentheses refer to the list of references at the end of this standard.

[3] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

D1888 Methods Of Test for Particulate and Dissolved Matter in Water (Withdrawn 1989)[4]
D2908 Practice for Measuring Volatile Organic Matter in Water by Aqueous-Injection Gas Chromatography
D3590 Test Methods for Total Kjeldahl Nitrogen in Water
D4129 Test Method for Total and Organic Carbon in Water by High Temperature Oxidation and by Coulometric Detection
E260 Practice for Packed Column Gas Chromatography
E355 Practice for Gas Chromatography Terms and Relationships

2.2 *APHA-AWWA-WPCF Standards:*[5]
2540D Total Suspended Solids Dried at 103°–105°C
2540E Fixed and Volatile Solids Ignited at 550°C
212 Nitrogen Ammonia

3. Terminology

3.1 *Definitions*—For definitions of terms used in this test method see Terminology D883.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *methanogenic inoculum*—anaerobically digested organic waste containing a high concentration of anaerobic methane-producing microorganisms.

4. Summary of Test Method

4.1 This test method described consists of the following: (*1*) selecting and analyzing material for testing; (*2*) obtaining a pretreated municipal-solid-waste fraction and a concentrated anaerobic inoculum from an anaerobic digester; (*3*) exposing the material to an anaerobic static batch fermentation at more than 30 % solids; (*4*) measuring total carbon in the gas (CO_2 and CH_4) evolved as a function of time; (*5*) removing the specimens for cleaning (optional), conditioning, testing, and reporting; (*6*) assessing the degree of biodegradability; and (*7*) assessing the degree of biodegradability under less than optimum conditions.

4.2 The percentage of biodegradability is obtained by determining the percent of conversion of carbon from the test material to carbon in the gaseous phase (CH_4 and CO_2). This percentage of biodegradability will not include the amount of carbon from the test substance that is converted to cell biomass and that is not, in turn, metabolized to CO_2 and CH_4.

5. Significance and Use

5.1 Decomposition of a plastic within a landfill involves biological processes that will affect the decomposition of other materials enclosed by, or in close proximity to, the plastic. Rapid degradation of the plastic has the ability to increase the economic feasibility of landfill-gas recovery, minimize the duration of after-care of the landfill, and make possible the recovery of the volume reduction of the waste due to biodegradation during the active life of the landfill. This procedure has been developed to permit determination of the anaerobic biodegradability of plastic products when placed in biologically active environments simulating landfill conditions.

5.2 As degradation occurs inevitably in a landfill, it is of immediate concern that the plastic materials do not produce toxic metabolites or end products under the various conditions that have the potential to occur in a landfill. The mixtures remaining after completion of the test method, containing fully or partially degraded plastic materials or extracts, can be submitted subsequently to ecotoxicity testing in order to assess the environmental hazards posed by the breakdown of plastics to varying degrees in landfills. This test method has been designed to assess biodegradation under optimum and less-than-optimum conditions.

5.3 *Limitations*—Because a wide variation exists in the construction and operation of landfills, and because regulatory requirements for landfills vary greatly, this procedure is not intended to simulate the environment of all landfills. However, it is expected to closely resemble the environment of a biologically active landfill. More specifically, the procedure is intended to create a standard laboratory environment that permits rapid and reproducible determination of the anaerobic biodegradability under accelerated landfill conditions, while at the same time producing reproducible mixtures of fully and partially decomposed household waste with plastic materials for ecotoxicological assessment.

6. Apparatus

6.1 *Pressure-Resistant Glass Vessels*—Twenty-seven, each with a volume of 4 to 6 L, which can be closed airtight and capable of withstanding an overpressure of two atmospheres. The lids of the reactors are equipped with an overpressure valve (to prevent the overpressure from becoming higher than 2 bars), a manometer that provides a rough indication of the overpressure, a septum that allows one to take gas samples and measure the exact overpressure, and, finally, a valve to release the overpressure (Fig. 1).

6.2 *Incubators,* sufficient to store the vessels in the dark at 35 ± 2°C for the duration of the test.

[4] The last approved version of this historical standard is referenced on www.astm.org.
[5] *Standard Methods for the Examination of Water and Wastewater*, 20th ed., 1999, available from American Public Health Association, 800 I Street, NW, Washington, D.C. 20001-3710, or http://www.standardmethods.org.

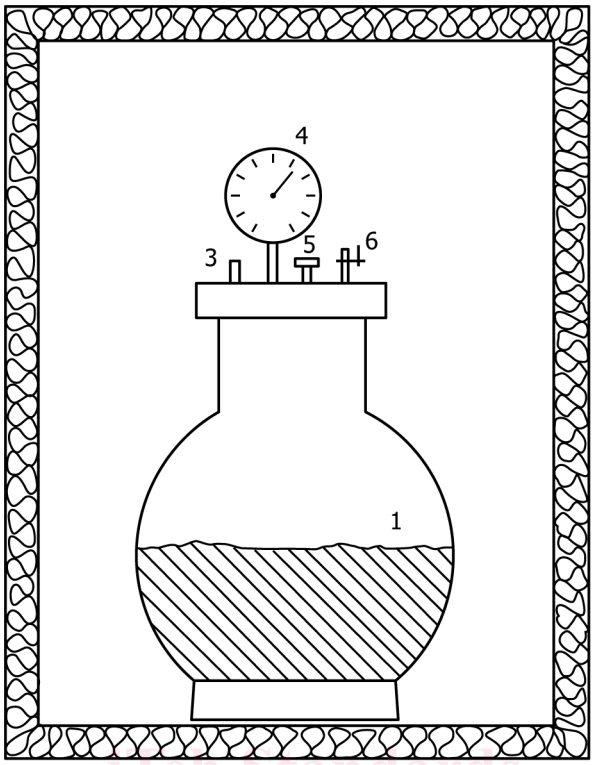

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FIG. 1 Setup of Accelerated Landfill

6.3 *Pressure Transducer,* connected to a syringe needle to measure the headspace pressure in the test vessel.

6.4 *Gas Chromatograph,* or other apparatus, equipped with a suitable detector and column(s) for measuring methane and carbon dioxide concentrations in the evolved gases.

6.5 *pH Meter,* precision balance (±0.1 g), analytical balance (±0.1 mg), thermometer, and barometer.

6.6 *Suitable Devices,* for determining volatile fatty acids by aqueous-injection chromatography, total Kjeldahl nitrogen, ammonia nitrogen, dry solids (105°C), and volatile solids (550°C) concentrations.

7. Reagents and Materials

7.1 *Pretreated-Household Waste*, derived from mixed municipal solid waste or the organic fraction thereof, after homogenizing, screening over a screen with holes of a diameter of 40 to 80 mm, and aerobically stabilized over a period of 2 to 4 weeks by blowing air into the material and maintaining a dry-matter content of 50 ± 5 % and a temperature of 55 ± 10°C. (Optional: the pretreated household waste can be replaced by a similarly pretreated simulated solid waste.)

7.2 *Anaerobic Inoculum,* derived from a properly operating anaerobic digester with pretreated household waste as a sole substrate or a digester that treats predominantly household waste.

7.3 *Cellulose, Analytical-Grade,* for thin-layer chromatography as a positive control.[6]

[6] Avicel®, available from EM Chemicals, Inc., Hawthorne, NY, was used for development of this test method.