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# Standard Guide for Assessing the Compostability of Environmentally Degradable Plastics[1]

This standard is issued under the fixed designation D 6002; 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.

ε[1] NOTE—Added Note 1 and Summary of Changes section in March 2002.

## 1. Scope *

1.1 This guide covers suggested criteria, procedures, and a general approach to establish the compostability of environmentally degradable plastics.

1.2 *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 standard.

## 2. Referenced Documents

2.1 *ASTM Standards:*

D 638 Test Method for Tensile Properties of Plastics[2]

D 882 Test Methods for Tensile Properties of Thin Plastic Sheeting[2]

D 883 Terminology Relating to Plastics[2]

D 3593 Test Method for Molecular Weight Averages/ Distribution of Certain Polymers by Liquid Size-Exclusion Chromatography (Gel Permeation Chromatography (GPC)) Using Universal Calibration[3]

D 5152 Practice for Water Extraction of Residual Solids from Degraded Plastics for Toxicity Testing[4]

D 5209 Test Method for Determining the Aerobic Biodegradation of Plastic Materials in the Presence of Municipal Sewer Sludge[5]

D 5247 Test Method for Determining the Aerobic Biodegradability of Degradable Plastics by Specific Microorganisms[6]

D 5338 Test Method for Determining Aerobic Biodegradation of Plastic Materials Under Controlled Composting Conditions[6]

D 5509 Practice for Exposing Plastics to a Simulated Compost Environment[6]

D 5512 Practice for Exposing Plastics to a Simulated Compost Environment Using an Externally Heated Reactor[6]

D 5951 Practice for Preparing Residual Solids Obtained After Biodegradability Standard Methods for Plastics in Solid Waste for Toxicity and Compost Quality Testing[6]

D 5988 Test Method for Determining the Aerobic Biodegradation in Soil of Plastic Materials or Residual Plastic Materials after Composting[6]

E 1440 Guide for an Acute Toxicity Test with the Rotifer Brachionus[7]

E 1720 Test Method for Determining Ready, Ultimate, Biodegradability of Organic Chemicals in a Sealed Vessel $CO_2$ Production Test[7]

G 22 Practice for Determining Resistance of Plastics to Bacteria[8]

2.2 *ORCA Document:*

Guidelines for the Evaluation of Feedstock for Source Separated Biowaste Composting and Biogasification[9]

2.3 *OECD Guidelines:*[10]

OECD Guideline 207 Earthworm, Acute Toxicity Tests

OECD Guideline 208 Terrestrial Plants, Growth Test

## 3. Terminology

3.1 *Definitions:*

3.1.1 *biodegradable plastic*—a degradable plastic in which the degradation results from the action of naturally occurring microorganisms such as bacteria, fungi, and algae. **D 883**

3.1.2 *compostable*—capable of undergoing biological decomposition in a compost site as part of an available program, such that the material is not visually distinguishable and breaks down into carbon dioxide, water, inorganic compounds, and biomass, at a rate consistent with known compostable materials.

[1] This guide is under the jurisdiction of ASTM Committee D20 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] *Discontinued*—See 1992 *Annual Book of ASTM Standards*, Vol 08.03.

[4] Discontinued; see *1998 Annual Book of ASTM Standards*, Vol 08.03.

[5] Discontinued; see *1992 Annual Book of ASTM Standards*, Vol 08.03.

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

[7] *Annual Book of ASTM Standards*, Vol 11.05.

[8] Discontinued; see *2001 Annual Book of ASTM Standards*, Vol 14.04.

[9] Available from Organic Reclamation and Composting Association, Avenue E. Mounier 83, Box 1, B-1200 Brussels, Belgium.

[10] Available from Organization for Economic Development, Director of Information, 2 rue Andre' Pascal, 75775 Paris Cedex 16, France.

***A Summary of Changes section appears at the end of this standard.**

3.1.3 *composting*—a managed process that controls the biological decomposition and transformation of biodegradable material into a humus-like substance called compost; the aerobic mesophilic and thermophilic degradation of organic matter to make compost; the transformation of biologically decomposable material through a controlled process of bio-oxidation that proceeds through mesophilic and thermophilic phases and results in the production of carbon dioxide, water, minerals, and stabilized organic matter (compost or humus). Composting uses a natural process to stabilize mixed decomposable organic material recovered from municipal solid waste, yard trimmings, biosolids (digested sewage sludge), certain industrial residues, and commercial residues **(1)**.[11]

3.1.4 *degradable plastic*—a plastic designed to undergo a significant change in its chemical structure under specific environmental conditions, resulting in a loss of some properties that may be measured by standard methods appropriate to the plastic and the application in a period of time that determines its classification. **D 883**

3.1.5 *mesophilic phase*—the phase of composting that occurs between 20 and 45°C (68 and 113°F) **(1)**.

3.1.6 *plastic*—a material that contains as an essential ingredient one or more organic polymeric substances of large molecular weight, is solid in its finished state, and, at some stage in its manufacture or processing into finished articles, can be shaped by flow. **D 883**

3.1.7 *polymer*—a substance consisting of molecules characterized by the repetition (neglecting ends, branch junctions, and other minor irregularities) of one or more types of monomeric units. **D 883**

3.1.8 *thermophilic phase*—the phase in the composting process that occurs between 45 and 75°C (113 and 167°F); it is associated with specific colonies of microorganisms that accomplish a high rate of decomposition **(1)**.

## 4. Summary of Guide

4.1 This guide uses a tiered criteria-based approach to assess the compostability of environmentally degradable plastic products (processed material containing polymeric materials, processing additives, and other additives required to meet performance requirements).

4.1.1 This guide includes methods that simulate mesophilic and thermophilic conditions that are representative of composting processes and compost end use.

4.1.2 The tiers progress from rapid screening of polymeric materials and other organic components to relatively longterm, more complex/higher cost evaluations. This guide will allow one to focus the correct level of resources on materials of greatest interest and potential.

4.1.3 Each tier in this guide includes objectives and a summary that presents potential test methods, method principles, test duration, implication of results, and suggested priority.

NOTE 2—The availability of other test methods appropriate for this guide is acknowledged.

NOTE 3—See Fig. 1 for a description of this guide in flow-chart form.

## 5. Significance and Use

5.1 Plastics that are designed to degrade after use have been developed. These materials are intended to enhance existing solid waste landfill diversion programs by allowing difficult to recycle materials to be collected and processed in alternative solid waste disposal systems. Composting has emerged as a viable approach to process these materials and the organic fraction of municipal solid waste (MSW). A comprehensive testing program is needed to establish the compostability (for example, fragmentation rate, biodegradation rate, and safety) of these materials.

5.2 This guide can be adapted to generate product-specific evidence for the substantiation of compostable claims to obtain classification as a compostable product.

NOTE 4—State and local regulations should also be considered.

## 6. Tier 1: Rapid Screening Tests

6.1 In this tier, rapid screening level studies are performed, under mesophilic conditions, to obtain information unavailable from literature review. The objectives are as follows:

6.1.1 To determine whether biodegradation of polymeric materials and other organic components in the plastic product can occur. Biodegradation is based on carbon dioxide production.

6.1.2 To expand understanding of the degradation mechanism.

NOTE 5—A positive result in Tier 1 tests is not required to demonstrate the compostability of product components. Components which fail Tier 1 tests might prove successful in Tier 2 composting tests. If a component fails Tier 1, but is still considered promising, it should advance to Tier 2. Likewise, a promising component could enter the test strategy directly at Tier 2.

NOTE 6—Chemical analysis, (for example, regulated heavy metals) of product component may be appropriate prior to initiation of testing.

6.2 The following test methods are suggested for initial screening of polymeric materials, monomeric subunits of the polymer, and other organic components.

6.2.1 *Test Method D 5209 (Sturm Test)*—This aqueous test method uses a fresh sample of activated sewage sludge that has been aerated, homogenized, and settled. The supernatant is used as the inoculum. It contains primarily a mixed bacterial population that promotes rapid biodegradation under mesophilic conditions. The metabolism of test materials produces $CO_2$, which is trapped in alkali solution and quantitated by titration. The test length is typically 30 days, but it can be extended if the medium is reinoculated. A positive result (recovery of 60 % + of theoretical $CO_2$) usually indicates that the material will also biodegrade in a composting environment. A negative result should be confirmed by a laboratory thermophilic composting test such as Test Method D 5338. The contribution of nonmicrobial degradation can be quantified by including sterile or poison controls and comparing changes in molecular weight or mass.

6.2.2 *Soil Contact Test (Test Method D 5988)*—This static test uses a defined sand/soil/mature compost matrix to provide a consortium of mesophilic and thermophilic bacteria and fungi. Biodegradation is measured in a manner similar to the

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