



Designation: D 5929 – 96

Standard Test Method for Determining Biodegradability of Materials Exposed to Municipal Solid Waste Composting Conditions by Compost Respirometry¹

This standard is issued under the fixed designation D 5929; 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 the biodegradation properties of a material by reproducibly exposing materials to conditions typical of municipal solid waste (MSW) composting. A material is composted under controlled conditions using a synthetic compost matrix and determining the acclimation time, cumulative oxygen uptake, cumulative carbon dioxide production, and percent of theoretical biodegradation over the period of the test. This test method does not establish the suitability of the composted product for any use.

1.2 The values stated in both inch-pound and SI units are to be regarded separately as the standard. The values given in parentheses are for information only.

1.3 *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.*

2. Referenced Documents

2.1 ASTM Standards:

D 513 Test Methods for Total and Dissolved Carbon Dioxide in Water²

D 1129 Terminology Relating to Water²

D 1293 Test Methods for pH of Water²

D 2908 Practice for Measuring Volatile Organic Matter in Water by Aqueous-Injection Chromatography³

2.2 APHA-AWWA-WEF Standard Methods:

2540G Total, Fixed, and Volatile Solids in Solid and Semi-solid Samples⁴

¹ This test method is under the jurisdiction of ASTM Committee D34 on Waste Management and is the direct responsibility of Subcommittee D34.07 on Municipal Solid Waste.

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² Annual Book of ASTM Standards, Vol 11.01.

³ Annual Book of ASTM Standards, Vol 11.02.

⁴ Available from American Public Health Assoc., 1015 15th Street, NW, Washington, DC 20005, Standard Methods for the Examination of Water and Waste Water, 18th ed., 1992.

3. Terminology

3.1 *Definitions*—Definitions of terms applying to this test method appear in Terminology D 1129.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *acclimation time, n*—the time required for the oxygen uptake to reach 10 % of the total measured cumulative oxygen uptake.⁵

3.2.2 *oxygen uptake, n*—the cumulative oxygen consumed by the organisms during the test.

3.2.3 *theoretical carbon dioxide production (ThCDP), n*—the maximum carbon dioxide that can be produced by a material as calculated by the carbon content of the material.

3.2.4 *theoretical oxygen uptake (ThOU), n*—the maximum oxygen consumption required to fully oxidize a material based on the elemental content of the material.

3.2.5 *virgin newsprint*—nonprinted newspaper roll stock.

4. Summary of Test Method

4.1 This test method consists of the following:

4.1.1 The samples are prepared by cutting or forming the material into the form it would most likely be seen in the waste stream. A theoretical maximum carbon dioxide production and oxygen uptake are determined from an elemental analysis.

4.1.2 An inoculum is obtained from a municipal MSW or yard waste compost facility. It is procured from a static pile that has been composting for at least two months.

4.1.3 The synthetic MSW is prepared from virgin newsprint, pine bark or wood chips, corn starch, corn oil, bovine casein, and urea. A buffer/dilution water is prepared from magnesium, calcium, iron and a phosphate buffer.

4.1.4 The test material, synthetic compost, inoculum, and dilution water are combined and placed in a highly insulated reactor which monitors oxygen consumption and temperature and captures all evolved carbon dioxide.

⁵ Tabak, Henry H. and Lewis, Ronald F., *CEC/OECD Ring Test of Respiration Method for Determination of Biodegradability*, U. S. Environmental Protection Agency, pp. 1–3.

4.1.5 The system is monitored, and oxygen uptake rates, temperature profiles, and total carbon dioxide produced are recorded.

4.1.6 The total oxygen uptake and carbon dioxide produced are compared with the theoretical values obtained from the elemental analysis, and a percent of biodegradation is generated. Possible negative effects of the material are evaluated by observing the acclimation time of the synthetic MSW and evaluating the oxygen uptake rate.

5. Significance and Use

5.1 As the crisis in solid waste continues to grow, MSW composting is increasingly being considered as one component in the overall solid waste management strategy. The volume reduction achieved by composting, combined with the production of a usable end product, is resulting in increasing numbers of municipalities analyzing and selecting MSW composting as an alternative to incineration or to reduce reliance on landfill disposal. This test method will help determine the effect of materials on the compost process and establish if the material can be properly disposed through solid waste composting facilities.⁶

5.2 This test method attempts to provide a simulation of the overall compost process while maintaining reproducibility. Exposing the test material with several other types of materials that are typically in MSW provides an environment which provides the key characteristics of composting: material not in a sole carbon source environment which allows co-metabolism, compost system is self heating, and provides a direct measurement of organism respiration.

6. Apparatus

6.1 *Compost Respirometry Apparatus* (see Fig. 1):

6.1.1 A minimum of six reactors, 2 to 6-L volume, with the test material in triplicate and the controls in triplicate. The reactors should be surrounded with efficient insulation to minimize heat loss and be gastight. Insulation should be 8 cm of urethane foam or equivalent.

6.1.2 *Tubing*, with high resistance to gas permeation.

6.1.3 *Peristaltic Pump*, to control and maintain gas flow through each reactor.

6.1.4 *4-L Scrubber Vessel*, for each reactor fitted with a scrubber solution sampling port.

6.1.5 *Differential Pressure Switch*, for each reactor that actuates between 2 and 5 in. (51 and 127 mm) of water.

6.1.6 *Solenoid and Mass Flowmeter*, to control and measure the addition of pure (99.997 +) oxygen to system.

6.1.7 *Temperature Probe*, situated in the middle of the compost.

6.1.8 *Data Acquisition and Control System*, for the measurement of temperature and the control and measurement of the oxygen addition.

6.2 *Miscellaneous*:

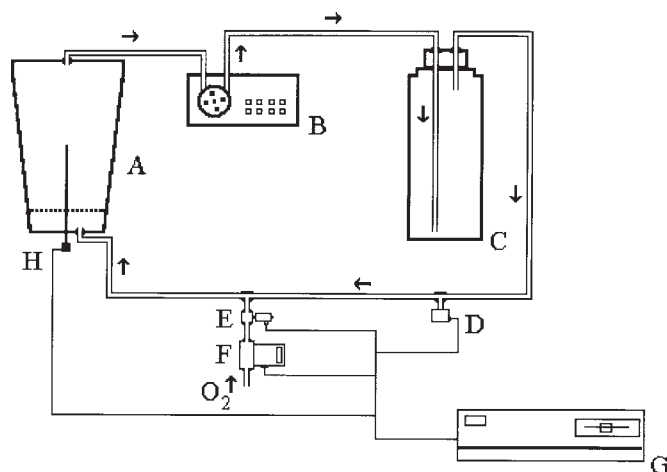
6.2.1 *Temperature Control Room*, or hood to maintain the external temperature of the apparatus at 40°C.

6.2.2 *Flow Meter*, to measure recirculation flow in each reactor (optional).

6.2.3 *Computer Control of Peristaltic Pump*, for automatic recirculation flow control (optional).

6.3 Suitable devices for the measurement of pH, dry solids (105°C), elemental analysis of material, carbon dioxide content of scrubbers, weight, and volume of the final compost material.

7. Test Materials



NOTE 1—The compost respirometer features a 4-L reactor vessel (A) insulated with 8 cm of urethane foam. The atmosphere is drawn through the reactor by a peristaltic pump (B) to maintain aeration. The effluent gases are passed through a 4-L scrubber vessel (C) containing 1.5 L of 5 M NaOH to remove any carbon dioxide from the effluent gas stream. Samples are drawn from this scrubber solution during the evaluation to determine the carbon dioxide released by the compost. As the microorganisms consume the oxygen in the system, a pressure drop occurs and is detected by a highly sensitive pressure switch (D). This signals the data acquisition and control system (G) and the oxygen is replaced with pure bottled oxygen by a solenoid (E) and the amount added is measured by a mass flowmeter (F). The gasses are then returned to the reactor. A thermocouple (H) is centered in the test reactor to monitor the temperature of the compost. The system is sealed to prevent interference from barometric fluctuations.

FIG. 1 Compost Respirometer Functional Diagram

7.1 The test materials can be in any form as long as its dimensions do not exceed 3 by 3 by 12 cm. The test materials should be in the form that they would be seen in the waste stream. A representative sample must be obtained by using appropriate ASTM methods or other documented method.

7.2 Analyze the test materials for carbon, hydrogen, nitrogen, oxygen, phosphorus, sulfur, and any other elements that are suspected to be present at a level to effect oxygen uptake. The ThOU must be calculated for each material.

7.3 Calculate the ThCDP from the carbon content of the test material.

7.4 The nitrogen content of the synthetic MSW should be adjusted if the C/N ratio is greater than 40:1. This is accomplished by adjusting the urea content of the synthetic MSW. The synthetic MSW has adequate nitrogen to support the addition of up to 35 g of carbon before the ratio exceeds 40:1.

⁶ Biocycle: Journal of Waste Recycling Staff, eds., *The Biocycle Guide to Composting Municipal Wastes*, JG Press, Inc., 1989.