



Designation: D5271 – 02

Standard Test Method for Determining the Aerobic Biodegradation of Plastic Materials in an Activated-Sludge-Wastewater-Treatment System¹

This standard is issued under the fixed designation D5271; 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 designed to index plastic materials which are more or less biodegradable relative to a standard in aerobic activated-sludge-treatment systems.

1.2 This test method is designed to be applicable to all plastic materials that are not inhibitory to the bacteria present in the activated sludge. Compounds with toxic properties may delay or inhibit the degradation process.

1.3 This test method measures the degree and rate of aerobic biodegradation of plastic materials (including formulation additives which may be biodegradable) on exposure to activated-sludge biomass in the concentration range from 0.1 to 2.5 g/L mixed-liquor volatile suspended solids (MLVSS) under laboratory conditions.

1.4 The high MLVSS concentration relative to other biodegradation tests has the advantage of improved repeatability and increased likelihood of more rapid adaptation or acclimation of the biomass.

1.5 This test method allows for the determination of biological nitrification and the oxidation of other non-carbon components of the plastic.

1.6 This test method does not purport to determine whether or not a plastic material will pass through primary treatment to the aeration basin of an activated-sludge wastewater-treatment plant. The size or density of the plastic material may exclude it from the secondary-treatment stage of a treatment facility.

1.7 This test method is equivalent to [ISO 14851](#).

1.8 *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 a specific hazards statement, see Section 8.

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.

Current edition approved March 10, 2002. Published May 2002. Originally published as D5271 – 92. Last previous edition D5271 – 93. DOI: 10.1520/D5271-02.

2. Referenced Documents

2.1 ASTM Standards:²

[D883](#) Terminology Relating to Plastics

[D1193](#) Specification for Reagent Water

[D1898](#) Practice for Sampling of Plastics³

[D2579](#) Test Method for Total Organic Carbon in Water³

[D3593](#) Test Method for Molecular Weight Averages and Molecular Weight Distribution of Certain Polymers by Liquid Size-Exclusion Chromatography (Gel Permeation Chromatography GPC) Using Universal Calibration³

[D5209](#) Test Method for Determining the Aerobic Biodegradation of Plastic Materials in the Presence of Municipal Sewage Sludge³

2.2 APHA-AWWA-WPCF Standards:⁴

[2540D](#) Total Suspended Solids Dried at 103°–105°C

[2540E](#) Fixed and Volatile Solids Ignited at 550°C

2.3 ISO Standard:

[ISO 14851](#) Determination of the Ultimate Aerobic Biodegradability of Plastic Materials in an Aqueous Medium - Method by Measuring the Oxygen Demand in a Closed Respirometer⁵

3. Terminology

3.1 Definitions:

3.1.1 Definitions of terms applying to this test method appear in Terminology [D883](#).

3.1.2 *biological nitrification*—the process by which organic nitrogen or ammonia salts are oxidized to nitrite (NO₂) or nitrate (NO₃), or both, by means of the metabolic pathways of microorganisms.

² 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.

³ Withdrawn. The last approved version of this historical standard is referenced on www.astm.org.

⁴ *Standard Methods for the Examination of Water and Wastewater*, American Public Health Association-American Water Works Association-Water Pollution Control Federation, 17th Edition, 1989.

⁵ Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *mixed liquid volatile suspended solids (MLVSS)*—the VSS in a completely mixed activated sludge reactor.

3.2.2 *soluble organic carbon (SOC)*—the TOC that is capable of passing through a 0.45- μ m pore-size filter.

3.2.3 *theoretical biochemical oxygen demand (BOD_T)*—the amount of oxygen required for complete biochemical oxidation of a compound.

3.2.4 *total organic carbon (TOC)*—the concentration expressed in milligrams per litre of carbon atoms in solution as determined by Test Methods D2579.

3.2.5 *volatile suspended solids (VSS)*—the concentration of solids expressed in milligrams per litre in solution as defined by APHA-AWWA-WPCF Standard Method 2540D.

3.3 Abbreviations:Abbreviation:

3.3.1 TSS—total suspended solids.

4. Summary of Test Method

4.1 This test method consists of (1) selection of plastic material for the determination of aerobic biodegradability, (2) obtaining activated sludge from a wastewater-treatment plant and preparing inoculum, (3) exposing plastic material to the aerated inoculum, (4) measuring oxygen consumed as a result of metabolism of the substrate, soluble organic carbon (SOC) consumption, nitrate and nitrite determinations (when applicable) and residual-polymer weight, and (5) assessing the degree of biodegradability.

4.2 Report the percent of theoretical aerobic biodegradation based on measured or calculated carbon, hydrogen, oxygen, nitrogen, phosphorus, and sulfur content with respect to time and the ultimate amount of biodegradation obtained.

5. Significance and Use

5.1 The degree and rate of aerobic biodegradability of a plastic material in the environment determines to what extent and in what time period that plastic may be eliminated from certain environments. With increasing use of plastics, disposal is becoming a major issue. This procedure estimates the degree and time required to biodegrade plastics in an activated-sludge-wastewater-treatment aeration basin. This test method determines the degree of aerobic biodegradation by measuring the consumption of oxygen due to respiration of the microbial population, as a function of time when the plastic is exposed to an inoculum of activated sewer sludge in the concentration range from 30 mg/L to 1000 mg/L MLVSS. This test method is designed to measure the oxidation of plastics containing carbon, hydrogen, oxygen, nitrogen, phosphorus, sulfur, chlorine, and sodium. Changes in the molecular weight and physical characteristics of the polymer after exposure to activated-sludge inoculum can be assessed by other ASTM test methods, such as Test Method D5209.

5.2 Activated sludge from a sewage treatment plant that treats principally municipal waste is considered to be an acceptable active aerobic inoculum available over a wide geographical area in which to test a broad range of plastic materials. When biodegradation in a specific activated-sludge-wastewater-treatment system is to be determined seed should be collected from that environment. Alternatively, soil or compost suspensions, or both can be used for inoculation,

because with some plastic materials the activity of fungi is important for biodegradation.

6. Apparatus

6.1 *Respirometry Apparatus* (see Figs. 1 and 2).

6.1.1 *Cylindrical Glass Vessels*, with a volume of 0.5 to 4.0 L, capable of forming an airtight seal.

6.1.2 *Oxygen-Supply or Generation Device*, that forms an airtight seal with the cylindrical glass vessel. This may be an electrolytic cell that generates oxygen by hydrolysis, or a gaseous-oxygen supply in the form of pure oxygen.

6.1.3 *Carbon Dioxide-(CO₂) Absorbing Material*, placed in the headspace of the sealed cylindrical glass vessel. This may be KOH pellets or a KOH solution sufficient to adsorb all CO₂ generated due to substrate conversion and endogenous respiration. The CO₂ produced by 0.1 g of carbon will be adsorbed by approximately 1 g of KOH. One drop of phenolphthalein solution may be added as an indicator (the KOH solution will turn from pink to clear when the KOH is consumed). If the KOH is consumed prior to the end of the test, the test should be repeated with either a smaller sample size or additional carbon dioxide-scrubbing capacity.

6.1.4 *Oxygen Sensor/Regulator*, that measures the oxygen demand in the cylindrical glass vessel and regulates the amount of oxygen supplied to the respirometer.

6.1.5 *Recorder*, that measures and records the amount of oxygen generated or supplied to the respirometer. This may be an analog- or a digital-recording device such as a strip-chart recorder or a computer.

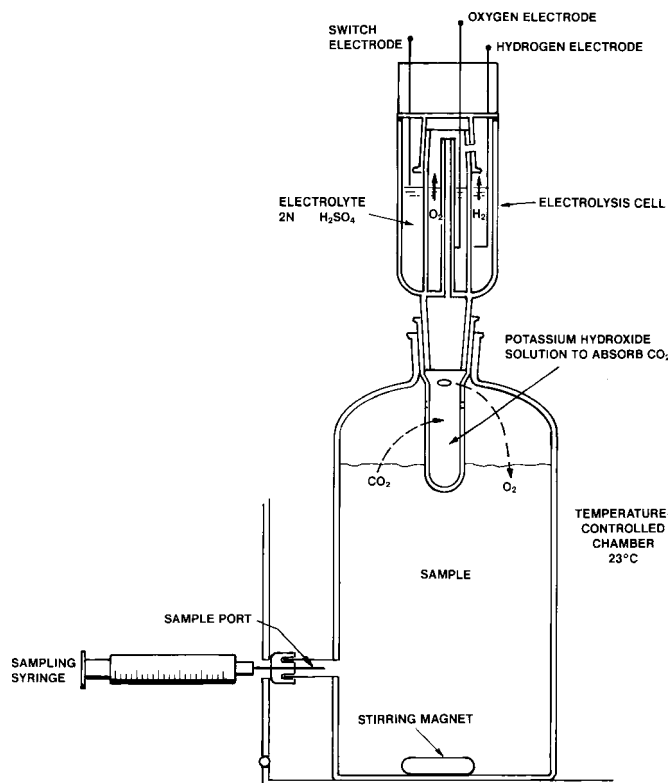


FIG. 1 Electrolytic Respirometer