GREEN SEAL

ENVIRONMENTAL STANDARD GS-35

SUMMARY BACKGROUND REPORT

AND

PROPOSED ENVIRONMENTAL STANDARD FOR

FOOD-SERVICE PACKAGING

Part B: SINGLE-USE PLATES AND BOWLS

January 18, 2002

Draft for Public Comment

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Green Seal

In collaboration with

The University of Tennessee

Center for Clean Products and Clean Technologies

Knoxville, Tennessee

Note: This proposed standard will become part B of existing GS-35, Environmental Standard for Food-Service Food Packaging

GREEN SEAL

Green Seal is a non-profit organization devoted to environmental standard setting, product certification, and public education. Green Seal helps identify environmentally responsible products in order to encourage and enable consumers to purchase such products and reduce their impacts on the Environment. Through its standard setting, certification and education programs, Green Seal:

- identifies products that are designed and manufactured in an environmentally responsible manner;
- offers scientific analyses to help consumers make educated purchasing decisions regarding environmental impacts;
- ensures consumers that any product bearing the Green Seal Certification Mark has earned the right to use it; and
- encourages manufacturers to develop new products that are significantly less damaging to the environment than their predecessors.

The intent of Green Seal's Environmental requirements is to reduce, to the extent technologically and economically feasible, the environmental impacts associated with the manufacture, use and disposal of products. Set on a category-by-category basis, Environmental Standards focus on significant opportunities to reduce a product's environmental impact.

Green Seal offers certification to all products covered by its Standards. Manufacturers may submit their products for evaluation by Green Seal. Those which comply with Green Seal's requirements may be authorized to use the Green Seal Certification Mark on products and in product advertising. Manufacturers authorized to use the Green Seal Certification Mark on their product are subject to an ongoing program of testing, inspection, and enforcement.

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INTRODUCTION

Single-use Plates and Bowls

Every year, billions of single-use plates and bowls are sold to American consumers. Approximately 29 billion disposable plates are used in the U.S. each year (U.S. EPA 2000a). These plates hold such diverse food items as a meat and potatoes dinner (including gravy), hamburgers, hot dogs, lasagna, and casseroles; disposable bowls serve to contain items such as soups, chili, stuffed potatoes, salads, french fries with chili and cheese on them, and soft-serve ice cream. Single-use plates and bowls serve many purposes, including containment, portability, sanitation, and protection. As a result, these containers are a part of everyday life.

Because single-use plates and bowls are so widespread, their use has become a serious concern both to members of the food service industry and to the environmental community. Efforts to date to reduce the environmental impacts of these food service items have primarily focused on source reduction (i.e., reducing the weight and amount of materials used). However, the majority of these plates and bowls are still disposed of in a municipal solid waste landfill. An estimated 910,000 tons of waste plastic plates and cups were generated in 1999, representing 0.4% of total municipal solid waste (MSW) in the U.S. This includes plates, cups, bowls, and other food service products. In addition, an estimated 930,000 tons (0.4% of total MSW generation) of waste paper plates, cups, bowls, and other food service products were generated in 1999 (U.S. EPA, 2000a).

Through this environmental standard, Green Seal seeks to identify opportunities for reduction or elimination of significant environmental impacts over the life-cycle of single-use plates and bowls through review of manufacturing, use and disposal issues. In addition the performance of the plate or bowl with respect to grease and moisture resistance is considered. By recognizing environmentally responsible single-use plates and bowls that perform well, Green Seal can assist foodservice users and consumers in maintaining all of the benefits of these types of food containers while reducing some of the environmental impacts associated with their manufacture, use, and disposal.

PART I: PROPOSED STANDARD FOR CERTIFICATION OF SINGLE-USE PLATES AND BOWLS

FOREWORD

A. Certification. This Environmental Standard Document contains the basic requirements for certain products (as defined in the Scope section below) to be certified by Green Seal and for their manufacturers to receive authorization to use the Green Seal Certification Mark on products and their packaging, and in product advertising. The requirements are based on an assessment of the environmental impacts of product manufacture, use, and disposal and reflect information and advice obtained from industry, trade associations, users, government officials, environmental and other public interest organizations, and others with relevant expertise. These requirements are subject to revision as further experience and investigation may show is necessary or desirable. Green Seal solicits information and advice on issues associated with this Standard.

B. Compliance with the Standard. Compliance with the Standard is one of the conditions of certification of a product or service by Green Seal.

C. Compliance with Government Rules. In order to be authorized to use the Green Seal Certification Mark, the manufacturer of the certified product must disclose all governmental allegations or determinations of violation of federal, state, or local environmental laws or regulations with respect to facilities in which the product is manufactured. Certification will be denied any product manufactured in violation of environmental laws or regulations if, in Green Seal's judgment, such violations indicate that the environmental impacts of the product significantly exceed those contemplated in the setting of the standard.

D. Limitations on Purpose of Standard. Green Seal's Standards provide basic criteria to promote environmental quality. Provisions for product safety have not been included in this Standard Document because government agencies and other national standard-setting organizations establish and enforce safety requirements.

E. Substantially Equivalent Products. Products that are substantially similar to those covered by this standard in terms of function and environmental impact may be evaluated and certified by Green Seal against the intent of the requirements of this Standard.

F. Unanticipated Environmental Impacts. A product which complies with this Standard Document will not necessarily be certified by Green Seal if, when examined and tested, it is found to have other features which significantly increase its impact on the environment. In such a situation, Green Seal will ordinarily amend its standards to account for the unanticipated environmental impacts.

G. Certification Agreement and Green Seal Rules. In order to be authorized to apply the Green Seal to a product or its packaging, or to use the Green Seal in product advertising, the manufacturer of the product must (1) undergo an initial product evaluation to determine that the product complies with Green Seal's requirements, (2) sign a Green Seal Certification Agreement that, among other things, defines how and where the Green Seal may be used, (3) pay fees to cover the costs of testing and monitoring, (4) agree to an ongoing program of factory inspections and product testing, and (5) comply with the requirements found in the most recent version of "Rules Governing the Use of the Green Seal Certification Mark."

H. Disclaimer of Liability. Green Seal, in performing its functions in accordance with its objectives, does not assume or undertake to discharge any responsibility of the manufacturer or any other party. Green Seal shall not incur any obligations or liability for damages, including consequential damages, arising out of or in connection with the interpretation of, reliance upon, or any other use of this Standard.

I. Care in Testing. Many tests required by Green Seal's Standards involve safety considerations. Adequate safeguards for personnel and property should be employed in conducting such tests.

J. Referenced Standards. Standards referenced in this document may have been superseded by a later edition, and it is intended that the most recent edition of all referenced standards be used in determining compliance of a product with this Standard Document.

K. Labeling Requirements. This Standard Document neither modifies nor supersedes government labeling requirements. Labeling language which varies in form from the requirements of this section may be used with the written approval of Green Seal.

ENVIRONMENTAL STANDARD

1.0 Scope

This proposed environmental standard establishes environmental requirements for *Single-Use Plates and Bowls*.

The scope of this proposed standard is for single-use plates and bowls used by quick-serve restaurants (QSRs), catering services, and other food service venues whether the food is to be eaten in the venue or taken to a different location (take-out). This standard includes typical single-use plates that are characterized by lips to prevent spillage and also includes compartmented plates, but excludes plate-type containers that have attached lids (e.g., hinged take-out containers). This standard includes soup-type bowls, but excludes clamshell-type containers that have attached lids.

2.0 Definitions

2.1 Compostable: A characteristic of a product, packaging or associated component that allows it to biodegrade, generating a relatively homogeneous and stable humus-like substance.

2.2 Recycled Content: A material that has been recovered or otherwise diverted from the solid waste stream, either during the manufacturing process (pre-consumer), or after consumer use (post-consumer).

3.0 Product-Specific Performance Requirements

3.1 Grease Resistance: The plate or bowl material must not permit grease to penetrate for a minimum of thirty minutes, as tested with ISO 5634 Paper and Board - Determination of Grease Resistance (Attachment A).

3.2 Water and Moisture Resistance: The plate or bowl material must not permit moisture or small amounts of water to penetrate for a minimum of thirty minutes, as tested with modified ISO 5634 Paper and Board - Determination of Grease Resistance. The modification is described in Attachment B.

4.0 Product-Specific Health and Environmental Requirements

4.1 Recycled Content: The plate or bowl shall have a minimum recycled content of 45% by weight. The manufacturer must demonstrate that any pre-consumer material used to meet the recycled content requirement would otherwise have entered the solid waste stream. All recycled materials used in the plate or bowl must meet U.S. Food and Drug Administration regulations and standards for use of recycled materials in food service.

4.2 Fiber Bleaching: Any fiber used in the product, including but not limited to wood, paper, bamboo, sugarcane, kenaf, and reed fiber, shall not be bleached with chlorine or chlorine compounds (such as hypochlorite and chlorine dioxide). For post-consumer recycled fiber, this requirement applies to the recycling process and not to the original process of producing the fiber prior to first use by the consumer.

4.3 Compostability: The material shall be compostable in accordance with ASTM D6400-99, Standard Specification for Compostable Plastics.

4.4 Toxics in Packaging and Inks: Plates and bowls must not contain inks, dyes, stabilizers, or any other additives to which any lead, cadmium, mercury, or hexavalent chromium has been intentionally introduced. The sum of the concentration levels of lead, cadmium, mercury, and hexavalent chromium present in any plate or bowl must not exceed 100 parts per million by weight.

5.0 Labeling Requirements for Certification by Green Seal

Unless otherwise approved in writing by Green Seal, the following requirements shall apply:

1. The Green Seal Certification Mark may appear on the product.

2. Whenever the Green Seal Certification Mark appears, it shall be accompanied by a description of the basis of certification. This description shall be in a location, style, and typeface that are easily readable by the consumer. The description shall read as follows:

   "This product meets Green Seal's standards for single-use plates and bowls based on its recycled content, use of unbleached or non-chlorine bleached fiber (where wood, paper or other plant fiber is used), and compostability in centralized composting facilities where they are available."

PART II: SUMMARY BACKGROUND REPORT

1.0 SINGLE-USE PLATE AND BOWL MATERIALS

Currently, in the foodservice industry, the most commonly used single-use plate or bowl material is expanded polystyrene (also called "styrofoam") (FPI, 2002). Alternatives to these include, but are not limited to, paper, crystalline polystyrene, and starch and limestone-based composites. These materials and their production processes are described below.

1.1 Expanded and Crystalline Polystyrene

Polystyrene is used to manufacture food service containers of several different types, including plates, bowls, drinking cups, and clamshell-type hinged containers.

1.1.1 Manufacturing: Polystyrene is a product of polymerization of the styrene monomer, which is made from ethylbenzene. The two compounds required to make ethylbenzene are benzene and ethylene. Benzene is a product of petroleum processing, and ethylene is produced either from petroleum or natural gas.

The two common forms of polystyrene are crystalline and foam. To make expanded polystyrene (EPS), a hydrocarbon (such as pentane) is introduced into the finished polystyrene resin, subsequently vaporizing to form EPS resin, which is then molded into a form. For crystalline polystyrene, the plastic itself is simply molded into the plate or bowl mold. Both EPS and crystalline polystyrene are used to manufacture cups, bowls, plates, and clamshell containers.

1.1.2 Raw Materials Extraction and Processing: Crude oils are complex mixtures of hydrocarbons that vary in composition depending on origin. The main components are alkanes, cycloalkanes, and a small fraction of aromatics. The physical and chemical processes, by which petroleum is refined, are carried out on a large scale and cover a broad range of unit operations. In the United States, approximately 11% of the total petroleum consumed becomes a petrochemical feedstock (API, 2002).

Aromatic hydrocarbons are manufactured by catalytic reforming of cycloalkanes. This process produces mixed aromatics in the form of benzene, toluene, and xylene. The high demand for benzene in chemical applications exceeds the ratio of aromatics produced by catalytic reforming. As a result, toluene is often converted to benzene by hydrodealkylation and disproportionation (McKetta, 1997). The major uses of benzene are in the production of ethylbenzene (55% of total benzene), cumene (24%), and cyclohexane (12%) (ATSDR, 1997).

1.2 Paper

Paper production requires wood chips, limestone, recycled paper, sodium chloride, sulfur, oxygen, cornstarch, talc, and other materials. The paper used in paper plate or bowl manufacturing process is either created using traditional paperboard production technologies (e.g., Dixie) or is pulp-molded (e.g., Chinet). In the former process, a paperboard product is produced and then printed (if necessary), coated with an inside protective coating (polyethylene was used as the coating in the product analyzed in this study), and then stamped into plates on a plate-forming machine (same process for bowls). In the pulp molding process, mostly processed paper pulp is fed directly into forming machines that mold, heat and cut the plates to the final shape. As necessary, printing is done after molding.

Bleached (white) paper is typically used for production of single-use plates and bowls. Traditionally, wood fibers are bleached in a series of three to five stages of chemical bleaching and water washing. The number of cycles depends on the desired whiteness of the product, the color of the initial pulp, and the design of the plant. The most common bleaching agents are sodium hydroxide, elemental chlorine and chlorine dioxide (U.S. EPA, 1995a). The use of chlorine dioxide in bleaching processes has increased steadily compared to elemental chlorine use because of chlorine dioxide's lower formation of chlorinated organics, including dioxins and furans, in bleach-plant wastewater and lower bleach-plant chemical consumption. Bleaching processes have been developed that are chlorine free, including processes employing ozone, oxygen, and peroxide. Currently, the commercial use of these processes is limited (U.S. EPA, 1995a).

1.3 Starch and Limestone Composite

Plates and bowls can be made from composite material using starch, calcium carbonate (limestone), and cellulose fiber. Potato starch is often used as the binder. A typical product uses a fiber matrix for reinforcement that is about 10% of the product weight, which is composed of recycled post-consumer paper and virgin softwood fiber. Coatings are used inside (top) and outside (bottom); a biodegradable paraffin wax can be used for the outside coating and one of several compostable materials can be used for the inside coating. Other miscellaneous materials used in manufacturing include guar gum, ink, and water.

The fabrication process involves blending the ingredients in a mixer, transferring the mixture into molds, and then heating the molds for about a minute, during which the water evaporates. After the plates and bowls are removed from the mold coatings are applied and the printing done.

1.4 Quick-Serve Restaurant (QSR) and Supermarket Plate and Bowl Survey

A survey of quick-serve restaurants and supermarkets in the Knoxville, Tennessee area was performed in November 2001, to develop a snapshot of the types of single-use products that are in use in the foodservice and direct-to-consumer market for single-use plates and bowls. The survey included twelve national or local chain quick-serve restaurants and two supermarkets. Twenty-two out of the thirty-four different samples of plates and bowls that were obtained met the general size, shape, and unit-of-service included in this standard. The foods offered in the plates and bowls ranged from burgers and sandwiches (e.g., McDonald's, Arby's) to chicken (e.g., KFC) to seafood (e.g., Captain D's) to Italian (Fazoli's).

A spreadsheet summarizing the results of the survey can be found in Attachment C. Some of the major findings include:

- EPS was the most often used material for single-use plates and bowls [also confirmed by the FPI (FPI, 2002)].

- A wide variety of sizes and shapes of plates and bowls are used to serve everything from sandwiches to chili to baked potatoes to burritos.
- Out of the original thirty-four different samples obtained, twenty-three were plastic and eight were paper or paper-based.
- Thirteen of the twenty-three plastic samples were marked for identification of the plastic resin.

2.0 ENVIRONMENTAL EVALUATION

The human health and environmental criteria in this standard are based on a life-cycle evaluation of four single-use plate and bowl materials: EPS, crystalline polystyrene, paper, and a starch and limestone composite. Environmental issues of concern include:

- use of material resources (and associated extraction and processing impacts),
- toxic substances releases in manufacturing,
- air emissions during manufacturing, and
- solid waste generation.

Each of these is discussed in the sections 2.1 through 2.4. A summary of the evaluation is presented in section 2.5.

2.1 Use of Material Resources

The use of material resources encompasses the issues of renewable versus non-renewable resources, associated impacts of raw material extraction/production and processing, and the use of recycled materials.

Agricultural products are renewable resources, and petroleum, coal, and mineral resources are non-renewable. The most widely used single-use plates and bowls (EPS) are produced from petroleum and natural gas resources, both non-renewable. The starch-limestone composite utilizes a combination of renewable (starch, wood fiber) and non-renewable resources (limestone), and the paper plates and bowls use mostly renewable resources (wood fiber).

The impacts of extraction or production of raw materials can be significant. Petroleum and natural gas extraction create waste drilling fluids, water pollution, and air emissions. Growing and harvesting trees for paper production can cause loss of biodiversity and sedimentation of streams. Cultivating and harvesting crops for starch production typically requires the use of fertilizer and pesticides, which can cause water pollution, as well as water and fuel use.

Because of the impacts of growing and harvesting trees or cultivated crops for production of single-use plates and bowls, the use of these renewable resources does not always present a clear advantage in the extraction/production and processing stage over the use of non-renewable resources, such as petroleum. Furthermore, the amount of petroleum resources utilized for production of single-use plates and bowls is relatively insignificant in comparison to that used for production of fuels.

The use of recycled materials, however, can reduce the impacts of using virgin material resources, both renewable and non-renewable. Recycled content is important for several reasons. The use of recycled material:

- conserves the material itself (as a natural resource),
- typically results in reduced life-cycle energy requirements,
- results in reduced life-cycle impacts from raw materials extraction and processing, and
- encourages recycling, creating market incentive for further recycling, and thereby diverting wastes from landfills.

Recycled content is either pre-consumer or post-consumer waste material used in the product. Both are diverted from the solid waste stream and can significantly reduce impacts associated with extraction, production, and processing of raw materials, depending, of course, on the impacts associated with the recycling process. The use of recycled content can also reduce the impacts of manufacturing processes, including toxic substances releases, energy use, air emissions, and greenhouse gases, as discussed below.

Based on the plates and bowls currently in the marketplace, recycled content can range from 0% to almost 100%, depending on the type of coatings that are used on the products and the way that certain wastes would be disposed of if they were not used in the plates or bowls. Using recycled content can significantly reduce the extraction and materials processing impacts, including raw material use, energy consumption, air emission, and solid waste impacts.

A criterion is recommended for this area of concern. The recycled content criterion is that at least 45% (by weight) of the product being produced is recycled content (either pre-consumer or post-consumer). For any recycled content that is pre-consumer waste, it must be shown that the waste would have otherwise been placed in a landfill.

2.2 Toxic Substances Releases from Manufacturing

The refining of petroleum and natural gas and the bleaching of wood fibers are major sources of toxic substances released in material processing and product manufacturing of single-use plates and bowls. The sections below discuss these processes and their toxics releases. These releases can generally be reduced through the substitution of recycled content for virgin materials, as recommended in Section 2.1. Other specific recommendations for reducing impacts are presented.

2.2.1 Petroleum and Natural Gas Refining: For petroleum-based feedstocks, the principal pollutants are hydrocarbon air emissions, oil and dissolved-solids water discharges, and a small amount of solid waste. Petroleum refineries release a number of hazardous air pollutants, including aldehydes, ammonia, benzo(a)pyrene, biphenyl, carbon monoxide, ethylbenzene, formaldehyde, benzene, ethylene oxide, and propylene oxide (U.S. EPA, 1995b). Benzene, ethylene oxide, and propylene oxide are all listed as carcinogens by the NTP (NTP, 2001). For the natural gas components, the principal pollutants are hydrocarbon air emissions and water discharges that include oil, grease, and dissolved solids (Pittinger et al., 1991). The air emissions from petroleum and natural gas processing also contribute significantly to the VOC loading in the lower atmosphere, which contributes to photochemical smog. Additionally, both contribute significant amounts of greenhouse gases to the atmosphere; however, the manufacturing processes contribute much less to the atmosphere than the combustion of those fuels (U.S. EPA, 1995a and 2000b).

2.2.2 Bleaching Plant and Paper Pulp Fibers: The bleaching process in paper and wood fiber production, where chlorine or chlorine compounds are used, generates toxic chlorinated compounds in wastewater and sludge. Over 300 different organochlorines have been identified in the discharges of pulp mills, including dioxins, furans, chlorinated phenols, acids, and benzenes. Many of the chlorinated compounds tend to settle or adsorb to the wastewater sludge. Wastewater sludge is one of the largest solid waste streams generated by the pulp and paper industry. An EPA study of 104 pulp and paper mills reported that sludge generation ranked from 14 to 140 kg sludge per ton of pulp. This study also found dioxins and furans in the sludge of the pulp and paper mills (U.S. EPA, 1998).

Organochlorines resist natural breakdown processes and build up in the environment and animals over time. Organochlorines concentrate in the tissues of living things and are magnified as they move up the foodchain. Chlorinated dioxins are among the most potent carcinogens ever tested. Several studies during the nineties have revealed that the general human population now has levels of dioxin in their tissues high enough to be at risk of adverse health effects due to dioxin exposures (Thornton, 1997; Birnbaum, 1993).

Other bleaching processes, such as hydrogen peroxide and ozone, use energy and chemicals and result in wastewater discharges, albeit less toxic. Based on these issues, a criterion requiring wood fiber or other plant fiber to be either unbleached or bleached without the use of chlorine or chlorine compounds or other fiber is recommended. Unbleached fiber is preferred, but it may not always be available.

2.3 Air Emissions During Manufacturing

In this section, three categories of air emissions are discussed that result from the production of single-used plates and bowls: acidification gases, urban smog forming gases, and greenhouse gases (GHG, also called global warming gases). These emissions result from materials used in manufacturing processes and from electrical energy and fuels utilized in manufacturing. In the United States, the majority of electricity is generated from fossil fuel combustion (67%) (EIA, 1997). Coal is the most widely used fossil fuel, accounting for 84% of fossil fuel electricity generation, while natural gas and oil account for 13% and 3%, respectively. These manufacturing and fuel emissions are also reduced through the use of recycled content for production of the plates and bowls.

2.3.1 Acidification Gases: The release of certain chemicals contributes to the formation of acid precipitation. Acid precipitation is best known for the damage it causes to forests and lakes. Less well known are the many ways it damages ecosystems, soils, and even ancient historical monuments, or the groundwater contamination that can result from the heavy metals these acids leach into groundwater (EEA, 2001). The primary acid gases are sulfur dioxide and nitrogen oxides, which are mainly emitted by burning fossil fuels. They are also released during petroleum refining and paper production.

2.3.2 Hydrocarbon Emissions and Urban Smog Formation: The combination of nitrogen oxides and hydrocarbons in the presence of sunlight causes urban smog, which is also know as "ground-level ozone" or "photochemical smog." The major source of nitrogen oxides in much of the United States is combustion of coal for electricity generation, although motor vehicle exhaust is also a major source. Hydrocarbon releases result from automobile exhaust, petroleum refining and other industrial emissions, and the evaporation of chemical solvents.

With regard to human health, repeated exposure to ozone pollution may cause permanent damage to the lungs. Even when ozone is present at low levels, inhaling it triggers a variety of health problems including chest pains, coughing, nausea, throat irritation, and congestion. It also can worsen bronchitis, heart disease, emphysema, and asthma, and reduce lung capacity. Healthy people also experience difficulty in breathing when exposed to ozone pollution. Because ozone pollution usually forms in hot weather, anyone who spends time outdoors in the summer may be affected, particularly children, the elderly, outdoor workers, and people exercising. Millions of Americans live in areas where the national ozone health standards are exceeded.

Ground-level ozone damages plant life and is responsible for 500 million dollars in reduced crop production in the United States each year. It interferes with the ability of plants to produce and store food, making them more susceptible to disease, insects, other pollutants, and harsh weather. "Bad" ozone damages the foliage of trees and other plants, ruining the landscape of cities, national parks and forests, and recreational areas.

Ozone concentrations can vary from year to year. Changing weather patterns (especially the number of hot, sunny days), periods of air stagnation, and other factors that contribute to ozone formation make long-term predictions difficult (U.S. EPA, 2001a).

2.3.3 Greenhouse Gases: Global warming refers to the build up of carbon dioxide and other gases in the atmosphere that are associated with a "greenhouse effect" of rising temperature and climate change. The primary greenhouse gases are carbon dioxide, methane, and nitrous oxide. Fossil fuel combustion for electricity generation is responsible for 35% of the United State's emissions of carbon dioxide (EIA, 1998). Other more potent greenhouse gases include hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride. Increased agriculture, deforestation, landfills, industrial production, and mining also contribute a significant share of emissions. In 1997, the United States emitted about one-fifth of total global greenhouse gases (U.S. EPA, 2001b).

The petroleum refining and pulp and paper industries depend heavily on fossil fuel production and paper production by-products, respectively, for their total energy demand. Combustion of these by-products contributes significant amounts of global-warming gases to the atmosphere. Petroleum refineries utilize "refinery gas" (44% of total energy needs in 1996), and pulp and paper mills consume waste wood, wood chips, and spent liquor wastes (almost 55% in 1990), all of which contribute GHG emissions, especially carbon dioxide (U.S. EPA, 2000b).

Furthermore, the petroleum refining industry's approximate 10% dependence on electricity for its energy-intensive needs pushes its contribution to global warming even higher.

2.4 Solid Waste Disposal

An estimated 910,000 tons of waste plastic plates and cups were generated in 1999, representing 0.4% of total municipal solid waste (MSW) in the U.S. This includes plates, cups, bowls, and other food service products. In addition, an estimated 930,000 tons (0.4% of total MSW generation) of waste paper plates, cups, bowls, and other food service products were generated in 1999 (U.S. EPA, 2000b).

2.4.1 Compostability: Although disposal of quick-serve plates and bowls is still typically in a municipal solid waste landfill, degradable packaging would alleviate problems with litter and resulting hazards to wildlife. Compostable plates and bowls are beneficial in two ways. Disposal in home compost would alleviate the solid waste capacity problem, and suitability for municipal composting would decrease overall solid waste landfill use.

To speak specifically about the products, polystyrene is virtually nonbiodegradable (and thus noncompostable). Paper products, especially paper plates, are generally compostable and degradable in the environment, although degradation rates would vary depending on environmental conditions and any coating on the paper. Some analysis has been done on Chinet plates in composting systems, with positive results. Rodale Inc., the parent company of the Website OrganicGardening.com, has been composting used Chinet paper plates from their cafeteria since 1992. They found an optimum mix of about 25% Chinet plates and 75% mixed yard waste (leaves and grass clippings) created a high quality compost. However, the Chinet plates don't have a coating, which definitely speeds up the process. As a local public works coordinator where Rodale, Inc. is located stated, "We once made a 10 inch high stack of 10" plates and inserted it into the center of our yard waste mix, and the plates were gone six weeks later... the stuff breaks down very quickly. But paper that's coated may take a lot longer" (McGrath, 2000).

The starch and limestone composite plates and bowls have also had some composting analysis completed, with positive results. The Department of the Interior (DOI) conducted a pilot study for one year that was started on Earth Day 1999. The DOI utilized the starch and limestone composite plates and bowls, in lieu of the polystyrene plates and bowls that had been used previously, in its headquarters cafeteria in Washington, D.C. "Source separation areas in the cafeteria were redesigned so that patrons could easily divert biodegradable food service ware, unbleached recycled content paper napkins, any leftover organics, and the 100% recycled content carry-out trays into specially marked containers lined with biodegradable trash bags." The trash was hauled to USDA's Agricultural Research Center in Belstville, Maryland, where it was mixed with grass clippings and partially decomposted leaves to achieve a proper carbon to nitrogen mix. After mixing, three different methods of composting were used, all of which were methods the DOI would consider in a future expansion of the composting program. The best results came from using a mixing auger, and resulted in only small traces of the plates and bowls and bags after four weeks. "By six months, virtually all traces of the biodegradables were gone in all the composts [using all the composting methods]" (Olawski, 2001).

Based on the available information, the recommended criterion is that the material shall be compostable. The test method best suited for compostability testing is ASTM D6400-99: Standard Specification for Compostable Plastics (Attachment D).

2.4.2 Recyclability: Recycling could reduce the life-cycle impacts of plates and bowls by conserving natural resources and reducing solid waste. Although the various materials currently being scrutinized here are potentially recyclable, at issue is whether recycling of used plates and bowls is a practical option. For used plates and bowls, the presence of food waste is a contaminant to the recycling process and poses a problem for collection sites by attracting nuisance animals or disease vectors. At this time, used single-use plates and bowls are not being recycled to any appreciable extent (U.S. EPA, 2000b), and there is no indication that they will be in the near future. Recycling programs available to consumers would need to be developed if this is to be an option. Therefore, no criterion based on the recyclability of a material is recommended.

2.5 Summary of Environmental Evaluation

Table 1 presents a summary of the evaluation of EPS, crystalline polystyrene, paper, and the starch and limestone composite.

Table 1. Summary of Environmental Evaluation

	Crystalline Polystyrene	EPS	Paper	Starch and limestone composite
Use of material resources and recycled content	- -	-	+	+
Toxic substances from manufacturing	-	-	- / + [a]	+
Acidification	-	-	-	+
Urban smog	- -	- -	-	+
Greenhouse gas emissions	-	-	-	+
Solid waste disposal (compostability)	- -	- -	+	+

Key: + = better; - = worse; - - = much worse.
[a] Depends to a large extent on bleaching process and recycled content.

2.6 Other Environmental Standards

A survey was made of other existing environmental standards. Few standards were found pertaining to food packaging, and no standards were found addressing single-use plates and bowls. An overview of the criteria for the more relevant standards is provided below.

2.6.1 Green Seal (U.S.): GS-35 is an environmental standard for food-service packaging, with part A addressing rigid containers, including hinged and two-part containers. This standard (Green Seal, 2000) includes criteria for

- grease resistance,
- water and moisture resistance,

- compression resistance,
- recycled content,
- unbleached wood fiber, or nonchlorine-based bleaching,
- a minimum volume-to-weight ratio (30 cm3 per gram),
- compostability, and
- toxics in packaging and inks.

Also from Green Seal, GS-9 is an environmental standard for paper towels and paper napkins. This standard (Green Seal, 1993) includes criteria for

- recycled content (100% recovered material and at least 40% post-consumer material by weight),
- restricted process chemicals, and
- packaging.

2.6.2 Nordic Ecolabeling: Grease proof paper is used in baking paper, sandwich wraps, and wrapping paper for other foods. The criteria document for Grease proof paper includes criteria for

- emission during manufacture of wood pulp and paper and migration of chemicals from the paper products to food. This includes a list of restricted or prohibited process chemicals, and assesses effluents for adsorbable organic halogens (AOX), phosphorus, sulfur, and chemical oxygen demand (COD).

No criteria are set regarding forest management "until relevant, controllable, international standards are available."

2.6.3 Environmental Choice Program (Canada): ECP-62 is for table napkins. This Final Guideline (ECP, 1995) includes criteria for

- resource and energy consumption,
- chemical oxygen demand (COD) in effluent,
- sublethal toxicity emission factor (TEF_{sub}; based on no-observed effects concentration to aquatic organisms) of waste water effluent, and
- net solid waste, assessed as total load points.

It also requires that

- there be no measurable concentration of 2,3,7,8-TCDD or 2,3,7,8-TCDF in effluent, and
- pulp from primary wood fiber come from sustainably managed forests.

2.6.4 European Union (EU Ecolabel): Product groups with existing ecolabels include copying paper and tissue paper (there do not appear to be any food-related product groups currently with standards under study). These include criteria for

- air and water emissions, including COD, AOX, carbon dioxide, sulfur, and sulfur dioxide,
- sustainable forest management,
- energy consumption, and
- minimization of solid waste.

2.6.5 The Federal Trade Commission (FTC): The FTC has issued the following as a guideline for marketing claims regarding recycled content, degradability, and compostability (FTC, 1998):

- *A recycled content claim may be made only for materials that have been recovered or otherwise diverted from the solid waste stream, either during the manufacturing process (pre-consumer), or after consumer use (post-consumer). To the extent the source of recycled content includes pre-consumer material, the manufacturer or advertiser must have substantiation for concluding that the pre-consumer material would otherwise have entered the solid waste stream.*
- *Degradable, biodegradable, photodegradable: ... the entire product or package will completely break down and return to nature, i.e., decompose into elements found in nature within a reasonably short period of time after customary disposal.*
- *Compostable: ... all the materials in the product or package will break down into, or otherwise become part of, usable compost (e.g., soil-conditioning material, mulch) in a safe and timely manner in an appropriate composting program or facility, or in a home compost pile or device.*

2.6.6 International Organization for Standardization (ISO): The ISO 14021 standards define the terms "degradable" and "compostable" as follows:

- *Degradable: A characteristic of a product or packaging that allows it to break down so that the resulting materials can be easily assimilated into the environment without harmful effects.*
- *Compostable: A characteristic of a product or packaging or element thereof that, through an available, managed composting procedure, biodegrades and the material is converted into a relatively homogeneous and stable humus-like substance.*

The difference between the recyclability of a material and its actual recycling rate is explained in the ISO 14021 definition of the usage of the term "recyclable":

- *A characteristic of a product, packaging or component thereof that can be diverted from the waste stream through available processes and programmes, and can be collected, processed and returned to use in the form of raw materials or products.*

3.0 PERFORMANCE EVALUATION

The researchers surveyed a number of national and local QSRs and supermarket eateries to identify important performance characteristics of plates and bowls. These are intended to be minimum standards; plate and bowl users/purchasers may require items with better grease resistance and moisture resistance.

3.1 Grease Resistance

Grease resistance is an important characteristic of food plates and bowls for aesthetic, sanitation, and safety reasons. It is necessary to protect workers and consumers from grease and other hot liquids. Plate and bowl manufacturers employ several methods to provide grease resistance, including coatings on paperboard, paper, and starch and limestone plates and bowls, and the inherent impermeability of such materials as crystalline and expanded polystyrene.

The researchers identified three test methods for determining grease resistance. 3M® developed a test method for determining the grease resistance of their coatings. The American Society of Test Methods (ASTM) and the International Organization for Standardization (ISO) developed standard test methods for measuring grease resistance of paper products. Although they are designed for measuring the grease resistance of paper products, they can readily be applied to other materials, such as the starch and limestone composite or polystyrene. The ASTM and ISO methods are similar. Because the ISO test method is recognized worldwide, the grease-resistance performance criterion of this standard will use ISO 5634 (Attachment A).

The next important component of grease resistance is to determine how long a plate or bowl must resist grease. For single-use plates and bowls, the food is either eaten on premises or taken out for eating elsewhere. From the survey of plates and bowls from national and local chain restaurants, twenty minutes is estimated to be the longest period that hot food would normally be stored on or in such an item during consumption. In take-out applications, a customer also needs some time to transport the food.[1] Therefore, the performance standard will require that the package resist grease for at least 30 minutes.

3.2 Water Resistance

Single-use plates and bowls are often used to serve food with liquids. Therefore, the package should resist water at least during the time needed for transport and consumption. The researchers recommend modifying ISO 5634 Paper and Board - Determination of grease resistance to test for water resistance (Attachment B). The performance standard will similarly require that the package resist water for at least 30 minutes.

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[1] Transit time: A two-mile radius is the target market area for most quick serve restaurants (Dr. C. Costello, UT Hotel and Restaurant Management, pers. comm. November 19, 1998.) The standard assumption for travel times used in traffic models, on a national basis, is 20 miles per hour on local roads. This includes delays for traffic signals, etc. (Dr. F. Wegmann, UT Civil Engineering, pers comm, 12/3/98). This translates to 6 minutes of driving time. A total time of 10 minutes allows for additional time spent getting into the car from the point of purchase and out of the car at a place where the food is to be consumed.

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Attachment A

International Standard – ISO 5634

Paper and Board – Determination of Grease Resistance

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION~ORGANISATlON INTERNATIONALE DE NORMALISATION

Papier et carton - Détermination de l'imperméabilité aux graisses

First edition - 1986-12-15

UDC 673.3/.7 : 620.193.47 Ref. No. ISO 5634-1986 (E)

Descriptors : paper-, paperboards, tests, determination, oil resistance, test equipment. Price based on 4 pages

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national Standards bodies (ISO ember bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Esch member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. Draft International Standards adopted by the technical committees are circulated to the member bodies for approval be fore their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting. International Standard ISO 5634 was prepared by Technical Committee ISO/TC 6, Paper, board and pulps. Users should note that all International Standards undergo revision from time to time and that any reference made herein to any other International Standard implies its latest edition, unless otherwise stated.

0 Introduction

The resistance to the Penetration of fats, greases and oils by paper and board is of particular importance for certain packaging purposes, for example the packaging of food.

1 Scope and field of application

This International Standard specifies a method for the determination of the grease resistance of paper and board. The paper or board may be tested either creased or uncreased. The test is primarily intended for foodboard, greaseproof, vegetable parchment and similar products.

2 References

ISO 186, Paper and board - Sampling to determine average quality.

ISO 187, Paper and board - Conditioning of samples.

ISO 4046, Paper, board, pulp and related terms - Vocabulary.

3 Principle

The test pieces are placed on a glass plate, with or without a layer of cellulose wadding depending on the objective of the test, and dyed palm kernel oil is applied, together with a weight, to the upper side of the test pieces. The time elapsed until an indication of the penetration of the grease through the test pieces is noted. This indication may be visual or actual.

NOTE - Greases other than the standardized one may be used, in which case this fact is to be stated in the test report.

For determination of **actual penetration** of grease through the test pieces, the end Point is indicated by staining of cellulose wadding in contact with the test pieces.

For **visual observation** of the passage of grease through the test pieces, the end Point is determined when the eye tan detect spots of grease on the underside of the test pieces.

4 Definitions

For the purposes of this International Standard, grease resistance is described by two characteristics : "break-through" time (actual penetration) and "show-through" time (visual penetration).

4.1 break-through: The time elapsed between the application of the test grease, together with the weight, to one side of the test piece and the penetration of grease through the other side of the test piece.

NOTE - In practice, the time needed to penetrate the wadding is included; this is very short and therefore negligible.

4.2 show-through: The time elapsed between the application of the test grease, together with the weight, to one side of the test piece and visual detection of the first sign of grease on the other side, but before grease actually penetrates the surface.

NOTES

1 For many grades of paper and board, show-through time and break-through time are nearly identical.

2 Although break-through is the main characteristic of grease resistance, show-through may be of interest in special cases, for example in the study of plastic laminated foodboard.

5 Materials and apparatus

5.1 Standard grease consisting of palm kernel oil or another oil with the following properties:

- temperature of liquefaction: 27 to 29 °C;
- dynamic viscosity at 35 °C: 33,5 to 35 mPa-s;
- dyed with 0,25 % (m/m) Sudan red or a similar fat-soluble dye.

NOTES

1 Dyed palm kernel oil suitable for this test is commercially available as Merck 6981 or equivalent.

2 If the grease is lumpy, it should be homogenized before use with the aid of a stirrer or by mixing with a spatula.

3 The use of alternative oils may not give comparable results with those of palm kernel oil.

5.2 Cellulose wadding, made of bleached chemical pulp (see ISO 4646, term 6.149).

The Penetration time when measured with palm kernel oil is less than 15 s.

5.3 Glass plate, not smaller than 220 mm x 350 mm.

The plate shall be supported in such a way that the underside can be viewed in a mirror.

5.4 Mirror, placed beneath the glass plate (5.3) in such a way that the whole of the undersides of the test pieces can be viewed (see figure 1).

5.5 Creasing apparatus, as described in the annex.

5.6 Metal template, round or Square, for example 60 mm x 60 mm, and 2 to 3 mm thick, with a hole, diameter 30 mm in the centre.

The template is used to apply a specific volume of grease.

5.7 At least 10 test weights, 50 to 55 g, diameter 30 mm.

5.8 Ten metal rings, about 200 g, external diameter 65 to 70 mm, internal diameter about 55 mm.

6 Sampling and preparation of test pieces

Sample in accordance with ISO 186.

Condition the samples at 23 °C and 50 % relative humidity in accordance with ISO 187.

From the samples, cut at least 10 test pieces, about 60 mm x 60 mm, with the sides parallel to the machine and Cross directions. Mark the directions on the test pieces.

NOTE - If creasing is required, the procedure described in the annex should be followed.

7 Procedure

Carry out at least 10 determinations on the side to be tested.

Perform the tests in the atmosphere used to condition the samples.

7.1 Determination of the break-through

If only break-through is to be measured, place each test piece, with the surface to be in contact with the content of the package upwards, on a thin layer of cellulose wadding (5.2) on the horizontal glass plate (5.3).

NOTE - If it is not known which surface is to be in contact with the content of the package, test both sides.

Place the metal template (5.6) on the test piece. Press it firmly, and completely fill the hole with grease (5.1), bringing it into contact with the test piece. Start the timer and draw a straightedge over the top surface of the template, giving the layer of grease a plane upper surface and a uniform thickness. Remove the template and centre a metal ring on the test piece. Place a weight (5.7), centered on the layer of grease, on each test piece.

NOTE - If the test pieces are creased, place the template in such a way that the hole is centered over the intersection of the creases.

Examine the underside of the test pieces in the mirror and note the time which elapses until the first red stains are observed on the cellulose wadding. Note the position on the test piece if the test pieces are creased (for example: 45 min, CD crease).

Make observations at least at the following intervals:

every 1 min for the first 10 min;

every 2 min between 10 and 30 min;

every 5 min between 30 and 60 min;

every 10 min between 60 and 150 min;

every 30 min between 2 1/2 and 8 h;

after 24 h;

after 48 h (final inspection).

7.2 Determination of show-through

If show-through is to be measured, place the test pieces directly on the glass plate as shown in figure 1 and note the appearance of the first stain. Immediately and carefully, transfer the test pieces to a thin sheet of cellulose wadding and continue as in 7.1.

8 Expression of results

Calculate the mean and the range for the break-through time and show-through time if required.
Express the results as follows:

below 10 min: to the nearest 1 min;

10 to 30 min: to the nearest 2 min;

30 to 60 min: to the nearest 5 min ;

60 to 150 min: to the nearest 10 min;

2 1/2 to 8 h: to the nearest 30 min;

8 to 24 h: between 8 h and 24 h;

after 24 h: over 24 h;

after 48 h: over 48 h.

9 Test report

The report shall give the following particulars:

a) reference to this International Standard;

b) place and date of testing ;

c) identification of the sample and tested surface;

d) identification of the grease used in the test if other than Glass plate the prescribed palm kernel oil;

e) the testing temperature if other than 23 °C;

f) creasing, if carried out, and the force if other than 10 N/cm;

g) the break-through time (mean and range);

h) the show-through time (mean and range) if required;

i) any departures from the method or any other circumstances that may have affected the results.

NOTE - These examples are well past the end point.

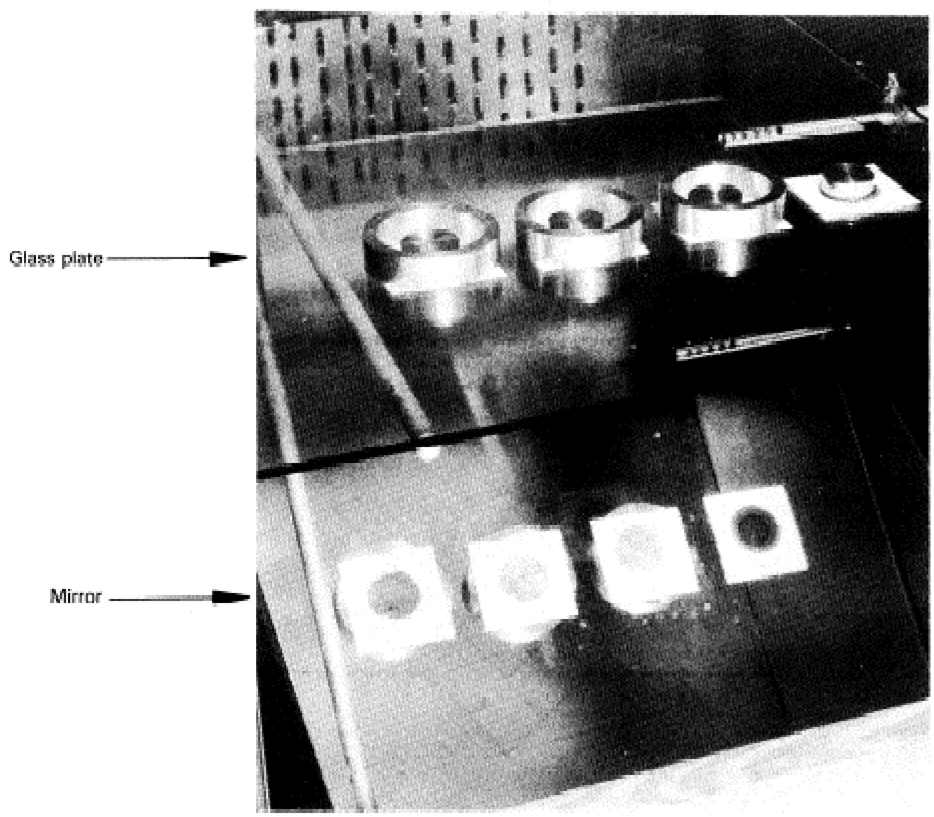


Figure 1 – Test assembly

Annex

Creasing

(This annex forms an integral part of the Standard.)

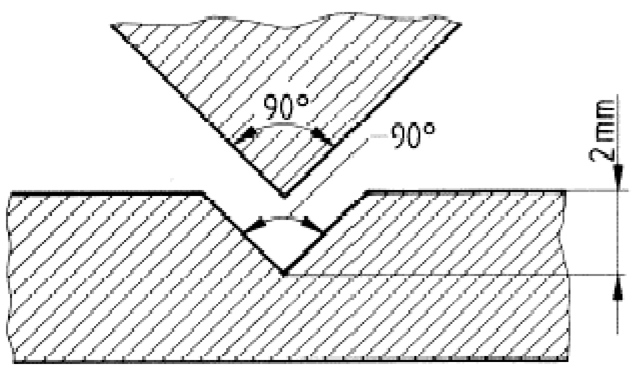
A.l Apparatus

Creasing bed, consisting of a flat plate in which a right-angled groove has been cut (figure 2) and a bar to fit the groove. The bar shall have a machined, but not cutting, edge (radius of curvature about 0,3 mm).

NOTE - Other creasing apparatus may not be used, provided that the reverse side of the crease is broken.

A.2 Procedure

Place the test piece on the creasing bed so that the machine direction is parallel with the groove in the bed. For folding boxboard and other nonhomogeneous materials, the test piece shall be placed with the outer sutface (the side not to be in contact with the content of the package) upwards. For homogeneous materials, such as greaseproof, five test pieces shall be creased one face up and five the other face up.



Produce a crease by pressing the bar into the groove with a forte of 10 N per linear centimetre of crease for 10 to 15 s. For practical purposes this may be achieved by loading the bar with a mass of 1 kg for each linear centimetre to be creased.

Make a second crease at right angles to and intersecting the first. After creasing, examine the reverse side of the test piece to ensure they are unbroken.

Repeat the procedure with all test pieces.

NOTE - 10 N/cm may not be sufficient to create a distinct crease in very thick boxboard. In this case, additional weights should be applied to the bar and the actual force reported together with the results.

Figure 2 – Creasing bed

Attachment B

Modifications to ISO 5634: Paper and Board – Determination of Water Resistance

The test method presented in ISO 5634 should be followed to test for moisture resistance with the following modifications:

1. Replace standard grease with distilled/deionized water.
2. Replace the fat-soluble red dye with a water-soluble red dye.

Attachment C

Table C1. Plates & Bowls Collected During Survey

Establishment/Product	Type	General Shape	Compart-mentalized?	Diameter (in.)	Height (in.)	Weight * (grams)	Flush Fill Volume^ (ml)	Material(s) **	Marked?	Top/inside coating? (Estimated)	Bottom/outside Coating?
EarthShell											
EarthShell Plate	Plate	Round	No	8.8125	0.9375	19	550	Starch, ls, fiber	No	Yes	Yes
EarthShell Bowl	Bowl	Round	---	1.8125	1.8125	12	400	Starch, ls, fiber	---	Yes	Yes
Obtained from Fast Food and Other Restaurants											
Buddy's Bar-B-Q	Plate	Round	Yes-3	10.25	1.25	14	920	EPS	No	Yes	No
Captain D's	Plate	Round	Yes-3	10.25	1.0625	9	720	EPS	No	Yes	No
Fazoli's	Plate	Round	No	8.875	1	10	570	EPS	Yes-6	Yes	No
KFC	Plate	Round	No	8.75	1	16	460	Paper	---	No	No
Long John Silver's	Plate	Round	Yes-3	10.25	1.25	14	920	EPS	No	Yes	No
Buddy's Bar-B-Q	Bowl	Round	---	5.875	1.75	3	380	EPS	Yes-6	No	No
Captain D's	Bowl	Round	---	3.9375	2.5	3	300	EPS	Yes-6	No	No
KFC	Bowl	Round	---	4.125	3.75	4	520	EPS	Yes-6	Yes	Yes
Shoney's (To go)	Bowl	Round	---	4.1875	3.25	4	410	EPS	Yes-6	Yes	No
Soup Kitchen ("half bowl")	Bowl	Round	---	4.625 (top)	2.25	4	380	EPS	Yes-6	No	No
Soup Kitchen - ("full bowl")	Bowl	Round	---	4.625 (top)	3.375	5	550	EPS	Yes-6	No	No
Wendy's	Bowl	Round	---	3.5625	3.375	10	370	Paper	---	Yes	Yes
Purchased at Bi-Lo and Kroger											
"Bi-Lo Foam Plates"	Plate	Round	No	"8.875"	0.875	5	480	EPS	No	No	No
"Bi-Lo Heavy Duty Plates"	Plate	Round	No	"9"	0.625	16	420	Paper	---	Yes	No
"Chinet Classic White Plates"	Plate	Round	No	"8.875"	0.8125	15	460	Paper	---	No	No
"Holiday Cool Plates"	Plate	Round	No	"9"	1	22	600	PS - not E	Yes-6	No	No
"Solo All Occasions Plates"	Plate	Round	No	"8.875"	0.6875	14	410	Paper	---	Yes	No
"Bi-Lo Designer Bowls"	Bowl	Round	---	6.34375	1.3125	8	350	Paper	---	No	No
"Bi-Lo Foam Bowls"	Bowl	Round	---	6	1.625	3	350	EPS	No	No	No
"Bi-Lo Plastic Bowls"	Bowl	Round	---	6	1.75	8	390	PS	No	No	No
"Solo Signature Colors"	Bowl	Round	---	7.1875	1.75	14	600	PS	No	No	No

Note: Only those products kept in the final survey are shown here; other products were eliminated from consideration due to size, shape and/or diameter or volume.

The weights should be accurate to within "1 gram. Limitation of scale was even units of grams. In most cases, items were weighed three times, weighing two different pieces, then weighing multiple pieces and dividing by the number being weighed.

^ The measurements should be accurate to within "10 ml. All items' volumes were checked/filled twice. "Flush Fill" volume was taken to be that volume at which the liquid contents (water) become flush horizontally with the top of the item.

** ls = limestone

--- = not applicable; 1 ounce (oz.) = 29.574 milliliters (ml); 1 ml = 1 cubic centimeter

Attachment D

Designation: D 6400 – 99
Standard Specification for Compostable Plastics[1]

This standard is issued under the fixed designation D 6400; 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 (e) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This specification covers plastics and products made from plastics that are designed to be composted in municipal and industrial aerobic composting facilities.

1.2 This specification is intended to establish the requirements for labeling of materials and products, including packaging made from plastics, as "compostable in municipal and industrial composting facilities."

1.3 The properties in this specification are those required to determine if plastics and products made from plastics will compost satisfactorily, including biodegrading at a rate comparable to known compostable materials. Further, the properties in the specification are required to assure that the degradation of these materials will not diminish the value or utility of the compost resulting from the composting process.

1.4 The following safety hazards caveat pertains to the test methods portion of this standard: *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 health and safety practices and to determine the applicability of regulatory limitations prior to se.*

NOTE 1—No equivalent ISO specifications exist for this standard.

2. Referenced Documents

2.1 *ASTM Standards:*

D 883 Terminology Relating to Plastics[2]

D 5338 Test Method for Determining Aerobic Biodegradation of Plastic Materials Under Controlled Composting Conditions[3]

D 6002 Guide for Assessing the Compostability of Environmentally Degradable Plastics3

2.2 *Organization for Economic Development (OECD) Standard:*[4]

OECD Guideline 208 Terrestrial Plants, Growth Test

2.3 *Association Francaise de Normalisation (CEN) Standard:*[5]

CEN/TC 261/SC 4 N 99 Packaging—Requirements for Packaging Recoverable through Composting and Biodegradation—Test Scheme and Evaluation Criteria for the Final Acceptance of Packaging (WI 261 236)

2.4 *ISO Standard:*[5]

ISO 14855 Evaluation of the Ultimate Aerobic Biodegradability and Disintegration of Plastics under Controlled Composting Conditions—Method by Analysis of Evolved Carbon Dioxide

2.5 *Government Standard:*[6]

40 CFR Part 503.13 Standards for the Use or Disposal of Sewage Sludge

3. Terminology

3.1 *Definitions*—Definitions appearing in this specification are found in Terminology D 883, unless otherwise noted.

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.

3.1.2 *compostable plastic*—a plastic that undergoes degradation by biological processes during composting to yield CO2, water, inorganic compounds, and biomass at a rate consistent with other known compostable materials and leave no visible, distinguishable or toxic residue.

3.1.3 *composting*[7]—a managed process that controls the biological decomposition and transformation of biodegradable materials into a humus-like substance called compost: the aerobic mesophilic and thermophilic degradation of organic matter to make compost; the transformation of biologically

1 This specification is under the jurisdiction of ASTM Committee D-20 on Plastics and is the direct responsibility of Subcommittee D20.96 on EnvironmentallyDegradable Plastics.
Current edition approved April 10, 1999. Published May 1999.
2 *Annual Book of ASTM Standards*, Vol 08.01.
3 *Annual Book of ASTM Standards*, Vol 08.03.
4 Available from Organization for Economic Development, Director of Information, 2 rue Andre8 Pascal, 75775 Paris Cedex 16, France.
5 Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.
6 *Code of Federal Regulations*, available from U.S. Government Printing Office, Washington, DC 20402.
7 *Compost Facility Operating Guide*, Composting Council, Alexandria, VA, 1995.

decomposable material through a controlled process of biooxidation that proceed through mesophilic and thermophilic phases and results in the production of carbon dioxide, water, minerals, and stabilized organic matter (compost or humus).

3.1.3.1 *Discussion*—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.

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 test methods appropriate to the plastic and the application in a period of time that determines its classification.

3.1.5 *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.

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

4. Classification

4.1 The purpose of this specification is to establish standards for identifying products and materials that will compost satisfactorily in commercial and municipal composting facilities. Products meeting the requirements outlined below are appropriate for labeling as "compostable" in accordance with the guidelines issued by the Federal Trade Commission.[8]

5. Basic Requirements

5.1 In order to compost satisfactorily, a product or material must demonstrate each of the characteristics found in 5.1.1- 5.1.3, and which are quantified in Section 6.

5.1.1 *Disintegration During Composting*—A plastic product or material will disintegrate during composting such that any remaining plastic residuals are not readily distinguishable from the other organic materials in the finished product. Additionally, the material or product must not be found in significant quantities during screening prior to final distribution of the compost.

5.1.2 *Inherent Biodegradation*—Alevel of inherent biodegradation shall be established by tests under controlled conditions, that are comparable to known compostable materials.

5.1.3 *No Adverse Impacts on Ability of Compost to Support Plant Growth*—The tested materials shall not adversely impact on the ability of composts to support plant growth, when compared to composts using cellulose as a control, once the finished compost is placed in soil. Additionally, the polymeric products or materials must not introduce unacceptable levels of heavy metals or other toxic substances into the environment, upon sample decomposition.

NOTE 2—For a better understanding of why these criteria are important, the reader should consult Guide D 6002 *Compost Facility Operating Guide*,[7] and CEN/TC 261/SC 4 N 99.

6. Detailed Requirements

6.1 In order to be identified as compostable, products must pass the requirements of 6.2, 6.3, and 6.4 using the appropriate laboratory tests, representative of the conditions found in aerobic composting facilities. Products and finished articles should be tested in the same form as they are intended to be used. For products that are made in multiple thicknesses or densities, such as films, containers and foams, only the thickest or most dense products need to be tested as long as the chemical composition and structure remains otherwise the same. It is assumed that thinner gages and lower densities will also compost satisfactorily. Similarly, if additives are present in test samples that pass testing, lower levels of the same additives are similarly passed.

6.2 A plastic product is considered to have demonstrated satisfactory disintegration if after controlled laboratory-scale composting, found in 7.2.1 of Guide D 6002, no more than 10 % of its original dry weight remains after sieving on a 2.0-mm sieve.

6.3 A plastic product must demonstrate a satisfactory rate of biodegradation by achieving one of the following ratios of conversion to carbon dioxide found in 6.3.1, 6.3.2 or 6.3.3, within the time periods specified in 6.3.3.1 or 6.3.3.2, using Test Method D 5338 as outlined in 7.3.1 and 7.3.3 of Guide D 6002:

6.3.1 For products consisting of a single polymer (homopolymers or random copolymers), 60 % of the organic carbon must be converted to carbon dioxide by the end of the test period (see 6.3.4), when compared to a known reference material as outlined in 7.3.2 of Guide D 6002.

6.3.2 For products consisting of more than one polymer (block copolymers, segmented copolymers, blends, or addition of low molecular weight additives), 90 % of the organic carbon must be converted to carbon dioxide by the end of the test period (see 6.3.4), when compared to a known reference material as outlined in 7.3.2 of Guide D 6002.

8 *Guidelines for the Use of Environmental Marketing Claims*, Federal TradeCommission, Washington, DC, 1992.

6.3.3 For products consisting of more than one polymer, each individual polymer component, present at more than 1 % concentration, must achieve the 60 % specification for homopolymers, as described in 6.3.1.
6.3.3.1 For materials that are not radiolabeled, the test period shall be no greater than 180 days.
6.3.3.2 If radiolabeled materials are used, then the test period may be as long as 365 days.

NOTE 3—While the end points of biodegradation may include incorporation into biomass or humic substances as well as carbon dioxide, no recognized standard test methods and specifications exist to quantify these outcomes. When these tests and specifications become available, this standard will be revised.

6.4 A plastic product can demonstrate satisfactory terrestrial and aquatic safety if it fulfills the following requirements:
6.4.1 The plastic or product shall have concentrations of heavy metals less than 50 % of those prescribed in 40 CFR Part 503.13, and 6.4.2 The plastic or product shall fulfill the requirements of the tests found in 7.5.2.2 and 7.5.2.3 of Guide D 6002, including the cress seed test for plant germination and a plant growth test following OECD Guideline 208.

7. Sampling
7.1 Sampling shall be conducted as indicated in the specified test method.

8. Specimen Preparation
8.1 Specimen preparation shall be in accordance with the specified test method.

9. Marking and Labeling
9.1 Marking and labeling shall conform to national and local regulations.

10. Keywords
10.1 biodegradable; compostable plastic; composting; degradable plastics; labeling