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Standard Guide for Determination of Biobased Content, Resources Consumption, and Environmental Profile of Materials and Products[1]

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INTRODUCTION

There is an increasing desire in United States and other parts of the world to use materials and products derived from biobased or renewable resources as a means of reducing dependency on fossil based resources and decreasing their environmental profile. Central to the determination of biobased content, resource consumption and environmental profile of materials and products is the origin and fate of the carbon contained in or released during their production, use, and disposal.

Both biobased and fossil materials have carbon as a common foundation. The amount of renewably fixed carbon utilized is a measure of the biobased resource content of a product. Carbon also represents a large part of a product's environmental profile. It is thus reasonable to use carbon and carbon equivalent to combine and track raw materials and energy consumption in the creation of a product.

It is very useful to know the biobased content of a material or product. However, knowledge of all the resources consumed and byproduct materials and energy released allows determination of its environmental impact and thus materially raise the understanding of the consequences of the creation of the product.

1. Scope

1.1 This guide covers a process to determine (*1*) biobased content of materials and products, (*2*) total resource consumption, both biobased and nonrenewable, in the form of raw materials and energy, and (*3*) an environmental profile, which would also include emissions and waste generated.

1.2 Reference to the use of factors to convert materials and energy to carbon equivalents are provided **(1-6)**[2]. In addition, the use of ISO standards to determine the material and energy inventories and an environmental profile of the products and materials is discussed. It is outside the scope of this guide to provide a detailed description of the use and application of life cycle assessment tools and conversion factors for the determination of a biobased material's environmental profile. Future ASTM International standards are being prepared to cover these subjects.

1.3 In the application of this guide, the protection of business confidential information is an important consideration. In general, the level of detail required to evaluate material and energy inputs and outputs can be reported without revealing proprietary unit process information. Unit processes can be treated as black boxes with inputs and outputs. If business confidentiality is still a concern, unit processes can be further combined or the final LCA (Life Cycle Assessment) results can be reviewed and certified by an external, independent expert with which the vendor will have the appropriate secrecy agreement.

2. Referenced Documents

2.1 *ISO Standards:*[3]

ISO 14040 Environmental Management-Life Cycle Assessment-Principles and framework

ISO 14041 Environmental Management-Life Cycle Assessment-Goal and scope definition and inventory analysis

ISO 14042 Environmental Management-Life Cycle Assessment-Life cycle impact assessment

ISO 14043 Environmental Management-Life Cycle Assessment-Life cycle interpretation

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

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.

2.2 *Presidential Orders:*[4]

13101: 9/16/1998 Greening the Government through Waste Prevention, Recycling, and Federal Requisition

13123: 6/3/1999 Greening the Government through Efficient Energy Management

2.3 *Legislative Act:*[4]

Farm Security and Rural Investment Act of 2002 (P. L. 107-171), Title IX Energy, Section 9002.

3. Terminology

3.1 *Definitions:*

3.1.1 *biobased carbon equivalent, B*—total biobased carbon used in the creation of the materials, including raw materials and biobased energy, where energy has been converted to carbon equivalent using well documented methods and conversion factors. *B* is thus the total biobased resource equivalent used in creation of the material.

3.1.1.1 *Discussion*—Examples of factors to convert a unit of energy into carbon equivalent are referenced in this guide. However, it is outside the scope of this guide to describe their use and application. This will be the subject of future ASTM International standards.

3.1.2 *biobased content, W(b)*—amount of biobased material as fraction weight or percent weight of the total material.

3.1.3 *biobased material*—organic material in which carbon is derived from a renewable resource via biological processes. Biobased materials include all plant and animal mass derived from CO_2 recently fixed via photosynthesis, per definition of a renewable resource.

3.1.4 *biobased product*—product generated by blending or assembling of biobased materials, either exclusively or in combination with non-biobased materials, in which the biobased material is present as a quantifiable portion of the total mass of the product. Biobased material in a multicomponent product should be measured on a component basis rather than on the whole product.

3.1.5 *environmental profile or environmental footprint*—environmental consequences of the creation of a material, measured in terms of impact indicators such as the generation or recapture of CO_2, biodegradability, recycling, and so forth.

3.1.5.1 *Discussion*—References are provided to international ISO standards for conducting life cycle inventories and environmental impact analysis. The specific applications of these ISO standards for determining an environmental profile of biobased products are outside the scope of this guide. This will be the subject of future ASTM International standards.

3.1.6 *fossil carbon*—carbon contained in materials presumed to represent remnants from prehistoric life, and thus representing nonrenewable resources, such as oil, gas, coal, and kerogen in oil shale. Fossil carbon age since fixation is measured in thousands and usually millions of years.

3.1.6.1 *Discussion*—Peat moss is not fossil carbon, but is usually considered nonrenewable.

3.1.7 *fossil carbon equivalent, F*—total of fossil carbon equivalent used in creation of the material, including raw materials and energy, where energy has been converted to carbon equivalents. *F* is thus the total fossil resource equivalent used in creation of the material.

3.1.8 *fraction biobased carbon equivalent or biobased resource content, E(B)*—fraction of total carbon equivalent attributable to biobased origin. $E(B) = B/(F+B)$, as fraction or percent.

3.1.9 *life cycle assessment (LCA)*—the collection and assembly of materials and energy input and output data including an evaluation of the potential environmental impacts of a specified product system. The categories of environmental impacts that should be considered include resource use, human health and environmental emissions, and ecological consequences.

3.1.10 *life cycle impact assessment (LCIA)*—the assessment of a product system's environmental profile through identification and evaluation of relevant impact categories.

3.1.11 *life cycle inventory (LCI)*—the collection and assembly of materials and energy input and output data for a specified product system. LCI is only one of the phases in conducting an LCA and is not an assessment of the environmental impacts associated with the product system.

3.1.12 *net biobased carbon equivalent, E(NB)*—amount of biobased carbon equivalent, less fossil carbon equivalent, used in the creation or manufacture of a material.

3.1.12.1 *Discussion*—Net biobased carbon equivalent is a measure of the relative consumption of biobased and fossil resources associated with creation of a material.

3.1.13 *product system*—for the purposes of this standard, the product system is the energy and material inputs and outputs from raw material acquisition through production of the biobased material or product. This phase in a product's life cycle is commonly referred to as "cradle-to-gate." "Cradle-to-grave" LCI and LCA, while important, are not being prescribed in this guide because the ultimate function unit or use of the biobased material could take many forms and have many different fates.

3.1.14 *renewable carbon equivalent*—carbon contained in material created from recently fixed CO_2 that qualifies as a renewable resource.

3.1.15 *renewable resource*—resource that replenishes or can be made to replenish on an essentially predictable time schedule, such as farm and forestry products and abundant wildlife. Old growth forests, rare species and all fauna and flora not regenerated on an essentially predictable time scale are not considered renewable resource. Generally the renewal cycle time is less than human life span (<100 years).

3.1.16 *total carbon equivalent or total resource consumption, E(T) = F + B—E(T)* represents the total resources required to create or manufacture a material, and is thus a measure of total resource demand. *E(T)* is expressed as weight of carbon per unit weight of finished material, since there is no defined molecular weight associated with the carbon equivalent of energy.

3.1.16.1 *Discussion*—Other sources of energy, such as wind, solar, hydroelectric, nuclear, and so forth, are reflected as reduction in the magnitude of *F* through appropriate changes in conversion factors for energy to carbon equivalent.

[4] Available from U.S. Government Printing Office Superintendent of Documents, 732 N. Capitol St., NW, Mail Stop: SDE, Washington, DC 20401.